NEDSI
Northeast Decision Sciences Institute

Book of Proceedings

Northeast Decision Sciences Institute 2019 Annual Conference

April 4-6, 2019
Philadelphia, PA

NE Decision Sciences Institute

Dear Colleagues:

Welcome to Philadelphia and to the conference headquarters for NEDSI 2019!

I am delighted to welcome conference participants from the northeast, other parts of the United States, as well as from countries in Europe and Asia, to share knowledge, reconnect with colleagues, and make new connections. Our conference theme is, "*Leveraging Innovation to Make Sustainable Business Decisions.*" We encourage participants to consider aspects of the theme in their discussions.

The main program features papers and panels across 14 different decision sciences tracks covering theoretical and applied business research, innovative practices in education, and cutting edge developments in industry. Each paper submission underwent a blind review process, with ratings and feedback provided to authors. Papers that were nominated by at least two reviewers for one of our "Best Paper" awards moved forward to a second round of reviews, which then decided the award winners in several categories. Congratulations to all the winners! During the conference, the best Undergraduate Poster presentations will be determined and award winners will be announced at the Gala Dinner Saturday evening.

Please join us for receptions and other social events on Thursday, Friday and Saturday. These are designed to allow you to mingle with your peers, unwind, have some fun and to network. Complimentary breakfasts and morning and afternoon coffee breaks are provided each day of the conference.

I hope you enjoy the conference and everything that Philadelphia has to offer. We look forward to seeing you at future NEDSI conferences!

Eric W. Stein
Program Chair, NEDSI 2019
Associate Professor of Management Science and Info Systems
Penn State

About DSI

The Decision Sciences Institute (DSI) is a professional organization of academicians and practitioners interested in the application of quantitative and behavioral methods to the problems of society.

Through national, international, and regional conferences, competitions, and publications, the Institute provides an international forum for presenting and sharing research in the study of decision processes across disciplines. The Institute also plays a vital role in the academic community by offering professional development activities and job placement services.

Five regional subdivisions in the United States, as well as regions representing Europe, Mexico, Asia-Pacific and the Indian subcontinent, operate independently within the Institute. Each region has its own elected officers and representative on the board of directors and holds annual meetings.

The Institute, an independent non-profit educational organization, is located in Houston, Texas, where it receives extensive support from the C.T. Bauer College of Business at the University of Houston.

About NEDSI

NEDSI is one of five U.S. regions that comprise our professional society, the Decision Sciences Institute (DSI). Our region encompasses the Northeastern United States. NEDSI holds an annual regional meeting each spring that features presentations of original research papers, Ph.D. and new faculty development seminars, cutting edge research innovation in the fields of Accounting, Business Education, Finance, HRM, Management, Marketing, MIS/DSS/Expert Systems and IT, Organizational Behavior, Operations Management, Strategic Management, Supply Chain Management, among others. Awards for "Best Paper" in several categories are given each year.

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Undergraduate Posters	**Doug Hales,** University of Rhode Island **Jennifer Swanson,** Stonehill College

NEDSI 2019 Conference Best Paper Awards

Best Application of Theory

"A HITS-Based Model for Location Decisions"
Jin Fang (Drexel University) and Fariborz Partovi (Drexel University)

David M. Levine Best Paper in Innovative Education

"**An Innovative Information Technology Educational Framework That Embraces Diversity and Inclusion"**
Stephen Richter (West Chester University), Jack Rappaport (Brilliance Consulting), Dennis Kennedy (La Salle University), Thomas Blum (La Salle University)

Richard Briotta Best Paper Award in Knowledge Management & Strategy

"UNIX Administrator Information Security Policy Compliance: The Impact of Knowledge Sharing Interventions on Trust, Bias, Threat Appraisal, and Coping Appraisal"
John Connell (Nova Southeastern University)

Best PhD Student Paper

"A HITS-Based Model for Location Decisions"
Jin Fang (Drexel University) and Fariborz Partovi (Drexel University)

Best Overall Conference Paper

"Corporate Inversions and the Cost of Equity: A Tale of Two Strategies"
Tianpeng Zhou (Hofstra University)

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Michele Welliver	Susquehanna University
Lan Xia	Bentley University
Gawon Yun	University of Rhode Island

NEDSI 2019 Undergraduate Poster Participants

OPERATIONS MANAGEMENT WITHIN CHICK-FIL-A
Steven Bouhadana (Rowan University), Joseph Bouhadana (Rowan University)

DESIGN OF WAREHOUSE LAYOUT CONSIDERING CONTENTION BETWEEN PICKERS USING AGENT SIMULATION
Erika Tajima (Tokyo University of Science), Koki Ueda (Tokyo University of Science), Aya Ishigaki (Tokyo University of Science), Masato Hamada (Data-Chef Co.,Ltd.), Wataru Kawai (Data-Chef Co.,Ltd.)

DESIGN OF A COOPERATIVE STRATEGIES FOR PLANNED TRANSSHIPMENT IN DECENTRALIZED SUPPLY CHAIN
Tomoki Oshima (Tokyo University of Science), Aya Ishigaki (Tokyo Unive)

CELEBRITY INFLUENCE ON FASHION CONSUMPTION
Chris Canales (Farmingdale State College), Hira Imtiaz (Farmingdale State College), Heather Kirkwood (Farmingdale State College), Ebru Ulusoy (Farmingdale State College)

THE ROAD TO SUSTAINABLE TRANSPORTATION IN SUPPLY CHAINS: A STAGE-LEVEL APPROACH
Meena Hotak (University of the District of Columbia), Evelin Turcios (University of the District of Columbia), Divina Grace Dayrit (University of the District of Columbia)

THE EVOLUTION OF BUYER-SUPPLIER RELATIONSHIPS
Loucace Ampe (University of the District of Columbia), Barbara Payne (University of the District of Columbia), Robert Spake (University of the District of Columbia), Shavon Sharpe (University of the District of Columbia)

THE PATH-DEPENDENCE OF REPUTATION REPAIR
Maya Gillett (University of the District of Columbia), Ashley Brown (University of the District of Columbia), Marcus Mottley (University of the District of Columbia), Walied Althunaian (University of the District of Columbia)

PROCESS ANALYSIS IN RADIOLOGY SERVICES AT A UNIVERSITY HOSPITAL
Allie Maistrelis (Eastern Connecticut State University), Nicole Silva (Eastern Connecticut State University), Fatma Pakdil (Eastern Connecticut State University)

NATIONAL HEALTHCARE SYSTEMS: A GLOBAL COMPARATIVE ANALYSIS
Sean DeVlieger (Eastern Connecticut State University), Fatma Pakdil (Eastern Connecticut State University)

PROCESS MAPPING IN RADIOLOGY SERVICES USING DMAIC PROCESS
Emily Vieten (Eastern Connecticut State University), Kaitlin Hohman (Eastern Connecticut State University), Fatma Pakdil (Eastern Connecticut State University)

FEASIBILITY AND MARKET ANALYSIS OF AUTISM SPECTRUM DISORDER IN EASTERN CONNECTICUT
Brendan Reynolds (Eastern Connecticut State University), Watson Joseph (Eastern Connecticut State University), Carrie Pichie (Natchaug Hospital Hartford HealthCare), Fatma Pakdil (Eastern Connecticut State University)

FEASIBILITY OF IMPLEMENTING ECT IN EASTERN CONNECTICUT
Megan Cole (Eastern Connecticut State University), Jacqueline Scanlon (Eastern Connecticut State University), Fatma Pakdil (Eastern Connecticut State University), Deborah Weidner (Natchaug Hospital Hartford HealthCare)

EEG LABORATORY PERFORMANCE ANALYSIS USING DMAIC PROCESS
Jenna Moreira (Eastern Connecticut State University), Daniel Huacho (Eastern Connecticut State University), Fatma Pakdil (Eastern Connecticut State University)

ANALYZING SURGICAL WAIT TIME IN AN OUTPATIENT SERVICE CENTER
Jamie Shoemaker (Eastern Connecticut State University), Anna Manser (Eastern Connecticut State University), Fatma Pakdil (Eastern Connecticut State University)

PREDICTING PROLONGED LENGTH OF HOSPITAL VISITS USING MACHINE LEARNING
Anthony Park (Bryant University)

PREDICTING VEHICLE DAMAGE USING MACHINE LEARNING TECHNIQUES
Matthew Bonas (Bryant University)

ANTHROPOMORPHIC DECLINE AND RISE OF REVERSE ANTHROPOMORPHISM: HOW GENERATION-Y SHUNS WHIMSICAL ADVERTISING
Dustin Scott (University of the District of Columbia), Robert Spake (University of the District of Columbia), Matthew Anderson (University of the District of Columbia), Jordan Fraser (University of the District of Columbia)

A COMPARISON OF PREDICTIVE MODELS IN PREDICTING FATALITY IN CAR ACCIDENTS
McKenzie Kozma (Bryant University), Rachel Cardarelli (Bryant University)

ARE YOU READY? STUDENT PREPAREDNESS FOR THE JOB SEARCH PROCESS
Emily Guyon (Bridgewater State Univerity), Kathleen Ferris-Costa (Bridgewater State Univerity)

ANALYSIS OF REUSE FULFILLMENT PROCESS USING CUMULATIVE CURVE
Anami Jinya (The University of Electro-Communications), Yoshihiro Suzuki (The University of Electro-Communications), Tetsuo Yamada (The University of Electro-Communications).

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March 22, 2019

Dear NEDSI Members and Guests,

Welcome to Philadelphia!

As the host institution for the annual meeting of the Northeast Decision Sciences Institute, I am honored to welcome you to Philadelphia for the 48th meeting of this prestigious conference. The program chair, Dr. Eric Stein and his team have put together an excellent program.

In addition to enjoying the many amenities of the city of Philadelphia, I hope you will take full advantage of all this conference has to offer. Whether meeting with long-term collaborators or making new acquaintances, take the opportunity to share your common interests and the passion you bring to the work you do. The theme of this year's conference - *Leveraging Innovation to Make Sustainable Business Decisions*, highlights the important contribution that decision sciences brings to organizations looking to incorporate more sustainable ways of doing business.

I wish you all the best of luck and offer my sincere wishes for a successful meeting. I, along with my colleagues at Penn State Great Valley, look forward to welcoming you to the City of Brotherly Love.

Sincerely,

James A. Nemes, D.Sc.
Chancellor and Chief Academic Officer

NORTHEAST DECISION SCIENCES INSTITUTE

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ACCOUNTING FINANCE, ECONOMICS - ABSTRACTS

Bond Price Reaction to a Change in Credit Ratings:
Does Ownership Structure Matter?

Key Words: Corporate Finance, Fixed Income

Both financial academics and financial practitioners have explored the issue of how bond prices react to credit rating agency (CRA) ratings changes. While one would expect a positive and negative price reaction to an upgrade and downgrade, respectively, the evidence has been choppy and mixed. Results were dependent on whether the bond issue was downgraded or upgraded, the degree of the ratings change, whether or not the CRA issued a change in "outlook" prior to the ratings change, etc. The research issue to be addressed here relates to how the ownership structure of the bond issue in question impacts a price reaction following a credit rating change. Ownership structure can matter for a variety of reasons. Apriori, one would not expect a large price impact on bonds with a high degree of hedge fund ownership as hedge fund investors are sophisticated and active stakeholders, i.e., the ratings change can be thought of as a "lagging indicator". On the other hand, a downgrade to "junk" on a bond with a high degree of insurance company ownership may facilitate selling activity (price declines) as insurance companies have regulatory restrictions on the amount of speculative grade bonds they can hold. This research will also address the price reaction of bonds with a high degree of individual ownership.

CHINA BELT AND ROAD INITIATIVE

ABSTRACT

The main purpose of this research is to investigate the causal relationships among the Small-Cap stock market behaviors of China and the other ten countries in Europe before and after the Belt and Road Initiative. The Granger causality test is used in this study by use of a leveraged bootstrap test developed by Hacker and Hatemi-J to examine the causalities. The data results show that two causalities are found before the Belt and Road Initiative and the number of the casualties increase to eight after the Belt and Road Initiative. It suggested that the China Small-Cap market improved its influence on the movement of the Small-Cap markets in European countries. This finding provides another prospect for the investor to take into consideration of the Belt and Road Initiative while building an investment portfolio.

CYBERCRIME ACTIVITY FINANCIAL DISCLOSURES: A PICTURE OF TRANSPARENCY ENHANCEMENT DURING THE PAST DECADE

Abstract

Swift adaptation of digital technology for financial transactions has led to a new avenue for exploitation by "white-collar" villains: cybercrime. High-tech crooks are the latest menace to security in the corporate arena. The rapid increase in computer interconnectivity has revolutionized the way organizations communicate and conduct business. It also has enabled a dramatic rise in criminal activity that manipulates digital functionality to garner illicit gains.

This research reports on a longitudinal study designed to examine how publicly owned companies have responded to recent calls for disclosure about financial impacts of cybercrime. It documents enhanced disclosures in financial statements during the past decade.

In 2007, the U.S. Government Accountability Office (GAO) conducted a major study of cybercrime. The GAO stated that cyber threats posed a significant danger of negative economic impacts that ranged into the billions of dollars annually. Recognizing that affected entities face a plethora of challenges in addressing cybercrime, the GAO's conclusion was that the precise cost of cybercrime is unknown because it is so rarely disclosed/reported by those impacted.

Early in 2011, the U.S. Senate Committee on Commerce, Science, and Transportation asked the U.S. Securities and Exchange Commission (SEC) to consider issuing guidance to registrants regarding their responsibility to disclose data on information security risks, including material computer network breaches and other malicious cybercrime attacks.

The SEC's Division of Corporate Finance, moving with unusual dispatch on this request, issued cybersecurity disclosure guidance on October 13, 2011. One of the most significant financial elements connected with the threat of cybercrime is the risk that these incidents have on company operations and the firm's financial outcomes. According to the SEC, successful cybercrime attacks create substantial economic costs and a number of other negative consequences. These untoward results include outlays for remediation, increased cybersecurity protection expenditures, lost revenues, litigation threats, and reputational damages.

This study examines whether firms in the U.S. retail merchandising industry—the target of high-profile cyber-attacks—disclose their assessment of cybercrime risks to stakeholders in annual reports filed with the SEC. Data for years 2010 through 2017 were gathered from 10-K filings for all publically traded domestic companies with 2010 sales that exceeded $1 billion. Currently, this is a nearly $7 trillion sector of the U.S. economy. The study group includes firms that accounted for more than half of all the revenues generated in the retail sales market.

The firms studied all have a fiscal year end dates subsequent to October 13th and would have known about the SEC guidance for cybersecurity risk disclosure starting with financial reporting for year 2011. The year prior to the SEC action (i.e., 2010) is included as part of the analysis so that an assessment can be made regarding the impact of the SEC guidance announcement.

This research makes a contribution to our understanding of how firms react to non-mandated disclosure guidance that is promulgated by the SEC. Since financial markets are well known to impound decision-relevant disclosures in an efficient manner, cybercrime risk assessments provided by management in publicly available venues like Form 10-K should assist investors in making economically rational trading decisions. The outcomes of this study help us understand the impact that SEC reporting guidance has on the voluntary disclosure posture of registrants.

Keywords: cybercrime, cyber security, financial disclosure, reporting transparency

Innovating Education by Teaching the Financial Crisis Process to College Level Students

ABSTRACT

Ten years after the 2008 US financial crisis, many people in the United States still deny that economic and financial collapse was imminent.

Because of this, in the United States, it is necessary to provide College-level students with an awareness that financial crisis is an economic and financial event that must be considered a part of daily life. Students must examine financial crisis with an interdisciplinary focus which includes economics, finance, and accounting. In some other nations, students are educated to view financial issues, including the possibility of crisis, as a part of everyday life. For example, in Spain, the University of Cantabria has substantial experience in running a program which integrates accounting and economics with knowledge of the nation's financial system.

In the United States, the denial of the financial crisis reflects an ignorance of the nation's economic and financial reality. The absence of new scholars who examine economic, financial, and accounting phenomena from an interdisciplinary perspective has increased the need to educate new generations that can help transform the United States from a debtor nation to a lender nation with a stronger currency.

Therefore, it is vital to innovate an undergraduate major regarding the nation's financial system, including the concepts of systemic risk and the process of financial crisis. In this manner, the nation can educate individuals who can help organizations maintain their sustainability, despite the tremendous impact of potential financial crisis. Financial crisis offers an opportunity to innovate in education and find new ways to support organizational resilience to financial turbulence.

Insights into Firms with Disclosure of Material Weaknesses in Internal Control

Lydia N. Didia and Susan F. Havranek

In response to accounting frauds and scandals in the early 2000s, the U.S. Congress, in July of 2002, passed the Sarbanes Oxley (SOX) Act. SOX applies mainly to publicly traded companies and their auditors. Congress passed SOX, along with other measures, to increase transparency and restore investors' confidence in the financial markets. As we pass fifteen years of SOX, in action, and there are rumblings of loosening the rules, it seems prudent to examine whether there have been changes to internal control weaknesses being reported now as opposed to during the early years of SOX.

SOX changed assessment and reporting requirements for accountants and management. For instance, section 404 of SOX requires that the management of public companies include their assessment of the internal control over financial reporting in the annual report. This same section also requires the auditors' attestation on the effectiveness of the company's internal controls over financial reporting.

There have been multiple studies on internal control disclosure. Several authors have examined the effect of internal control weaknesses on audit risk and audit fees (e.g., Albring, Elder, & Xu, 2018; Ettredge, Li, & Sun, 2006). While others focused on identifying the determinants of internal control weakness (Ashbaugh-Skaife et al. 2009; Ashbaugh-Skaife et al. 2007; Doyle et al. 2007; Ge and McVay 2005; Hermanson and Ye 2009)

Ge and McVay (2005) examined the characteristics of companies that reported internal control deficiencies from August 2002 through November 2004. Their study shows that computer industry had the highest number of internal control deficiencies followed by the service industry, then the bank and insurance industry in the third highest and Drugs and Medical Equipment with fourth highest. The current study uses data from Audit Analytics to examine the characteristics of companies with internal control deficiencies reported by Management during the period of 2012 – 2018. Following Ge and McVay (2005) and Frankel et al.(2002) industry classification scheme, we classify material weaknesses by industry. Some firms reported multiple internal control deficiencies in a single period resulting in 24,207 deficiencies and 6,959 firms. Descriptive statistics show that the following five industries lead in internal control weaknesses: Service Industries (17.37%), Computer (11.11%), Drugs (9.89%), Retail (9.13%), and Mining and Construction (8.30%). Comparing the results to Ge and McVay (2005) study show that the Banks and Insurance industry have moved out of the top five. The Mining and Construction industry is now amongst the first five in material weaknesses, and increase from 2.9% in the Ge & McVay study to 8.3%. The percentage of Service Industry companies with internal control weaknesses increased from 11.4 % to 17.37% while the percentage of Computer companies dropped from 21.4% to 11.11%. Both Drugs and Retail

industries percentages remained within 2.5%. We further analyzed the cause of the Mining and Construction industry internal control deficiencies.

Further, following Ge and McVay (2005) methodology, we categorized the disclosed internal control deficiencies into nine major deficiency types: Account-Specific, Training, Period-End Reporting/Accounting Policies, Revenue Recognition, Segregation of Duties, Account Reconciliation, Subsidiary-Specific, Senior Management, and Technology Issues. This study also provides a detailed breakdown of the Account-specific issues. The results show that training and segregation of duties are still amongst the top in the internal control problem. Technology problem is another deficiency that have increased over the years. The implications of this research for firms and auditors are discussed in the paper.

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Title of the Paper: Sequential Auctions with Allocation Using Lottery Mechanism

Farooq Sheikh

In this research we propose a transaction model based on the sequential auction of multiple units of identical object to be sold in a sequence of two auctions using the Vickrey-Clark-Grove mechanism; the objects are assigned to winners in the earlier sequence using a lottery process. We show that using this novel device, the auctioneer can increase its expected profits in comparison to the conventional sequential auction using the typical Vickrey-Clark-Grove mechanism. We identify the conditions when this result will hold. A key result of this paper is to show that, contrary to existing results on temporal prices of sequential auctions, the prices in the proposed auction are increasing in time, a phenomenon commonly observed in case of products sold via the revenue management process. Thus the proposed auction model can be construed as one that offers a potential explanation of the microeconomics of the revenue management process and identifies conditions for its usefulness.

Sustainability Efforts, Index Recognition and Stock Performance

Abstract

We examine the performance of firms identified as those that conduct their operations in a sustainability consistent manner relative to those that are less inclined to do so. Specifically, we examine the return performance of firms appearing in or disappearing from the Dow Jones Sustainability North America Index for each year from 2005 through 2016. Our sample consists of 1428 firm-year observations that appeared in the index over this time period. We find consistent evidence that sustainability portfolio excess returns are positive and significant for 12 months to 24 months after firms are first added to the sustainability index. This finding is robust to portfolio formations that are equally weighted or value weighted. The finding is economically significant as the annualized abnormal return ranges from 4.33% to 6.58% over periods ranging from 12 to 24 months after entering the sustainability portfolio. Indeed, the evidence shows that an integrated selection procedure that augments financial considerations with high ESG standards produces superior investment returns. Moreover, firms that have continuous membership in the Dow Jones Sustainability index also exhibit positive excess returns 12 to 24 months after first entering the sustainability index. Regardless of using a value weighted or equally weighted portfolio construction approach the abnormal returns are statistically and economically significant ranging from annualized returns of between 4.57% and 6.04% over the 12 to 24-month period after entering the sustainability portfolio. This indicates that a persistent dedication to meeting challenging ESG criteria over a longer period of time does not hinder performance.

The methodology used entails finding the calendar-time abnormal returns for our sustainability portfolios. We first subtract the return of the control portfolio from the return of our sustainability firms to estimate the characteristics-adjusted excess returns for individual sustainability firms. The average excess return for the sustainability portfolio is then computed for month t. Following this step, the time-series average of this characteristic-adjusted monthly excess return is calculated for the sustainability portfolio over a J-month holding period. This method is designed to control for stylized factors in assessing stock performance.

In addition to relatively stronger performance for the sustainability portfolio, we also observe several notable characteristics for sustainability firms compared with the control firms.

First, our sustainability firms are larger than the control firms. However, the book-to-market ratio shows no significant difference between our sustainability firms and control firms. Second, we see no significant difference in return on assets while we find that sustainability firms show a higher return on equity than control firms. Sustainability firms show a higher level of operating cash flow and a lower level of cash balance compared to control firms. Interestingly, we find that sustainability firms use significantly higher financial leverage than control firms, as shown in debt over total asset ratios.

In addition, we present the average of characteristics for the Dow Jones Sustainability North America Index firms across industries. The Fama and French 12-industry classification approach is followed. Several interesting observations for sustainability-centric stocks compared with their industry peer are made. First, our sustainability firms are larger than their industry peer averages while their book-to-market ratio is lower than their peer ratio. This implies the superior performance for sustainability-centric stocks are not driven by a small-firm effect or a high book-to-market effect. Second, sustainability firms generate more profits than the industry average for both profitability measures, return on assets and return on equity compared to the industry. Third, sustainability firms exhibit a higher level of cash flow and higher financial leverage than the industry average while they maintain a lower level of cash balances.

THE U.S. REAL ESTATE RECOVERY FROM THE FINANCIAL CRISIS AND ECONOMIC RECESSION: A DECADE LATER

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ABSTRACT

The paper reviewed the recovery of the US Real Estate Market in general and with focus on the following states: California, Florida, Connecticut, and New York to determine the status of the US Housing market a decade after the financial crisis. We examined among other things, home value index, median list, sale price and number of new homes sold in United States. We also examined economic factors including unemployment rates, income growth rates, and interest rates will also be studied to determine the correlation between these variables and the real estate market recovery. There is evidence that the overall U.S. housing market has recovered but the recovery has not been at a uniform rate and some communities still lack recovery. The national home value index has increased by about 30 percent since 2009, while the median price listing has increased by 25 percent. The states that recorded the highest home price gain between 2012 and 2017 are Nevada 66 percent, Washington 57 percent, California 57 percent, Oregon 54 percent, Colorado 51 percent, Michigan 48 percent, Utah 47 percent, Florida 46 percent, Florida 46 percent, Idaho 46 percent and Georgia 41 percent. Some states lagged with very low home prices appreciation rates, such Alaska, Oklahoma, Vermont, and Connecticut with 12 percent, 12 percent, 11 percent and 5 percent respectively.

A closer examination of the data relating to the selected states revealed the following:

The housing market in California was greatly affected by the financial crisis. Between 2002 and 2007, the median sales price for Los Angeles homes skyrocketed from $261,000 to $610,000, representing a 134 percent growth rate. The median sales price steadily declined throughout the recession, reaching a low of $320,000 in 2009. However, the market experienced a rapid recovery and surpassed pre-crisis levels in 2015. As of August 2017, the median sales price in Los Angeles stood at a strong $779,000. Another housing market indicator is the number of homes sold over a period. Throughout 2007 and 2008, during the peak of the financial crisis, the number of monthly sales in Los Angeles steadily declined from 2,710 to 1,278. Sales lingered around this low level until 2009, when they began increasing and eventually reached 2,406. Since 2009, monthly sales in Los Angeles have been fluctuating but have remained between 1,800 and 2,800. Sales in August 2017 were at the upper end of this spectrum at 2,697.

The housing market in Miami, Florida, was also heavily impacted by the financial crisis.[1] Between 2002 and 2007, the median sales price for Miami homes jumped from $132,000 to $300,000, achieving a 127 percent growth rate. The median sales price then declined sharply between 2007 and 2011, dropping to a low of $129,000. This was the lowest median sales figure in Miami since 2002. While the market has been steadily strengthening since that historic low, the median sales price has yet to surpass levels reached during the height of the housing bubble. As of August 2017, the median sales price in Miami was $285,000. Although the median sales price of homes in Miami would suggest that the area has almost fully recovered from the financial crisis, the monthly sales figures in Miami remain at record-low levels. During the height of the housing boom, 8,670 Miami

homes were sold in a single month. During the recession, this monthly sales figure fell to 1,877. Since 2009, sales have been slightly increasing but, as of August 2017, only stand at 3,004.

The housing market in Hartford, Connecticut, took a large hit during the financial crisis and has been experiencing a slow recovery. From 2002 to 2007, the median sales price for Hartford homes rose from $94,500 to $169,000, representing a 44 percent growth rate. This was a modest advancement compared to the high levels of growth attained by Los Angeles and Miami over the same period. It is obvious Hartford market experienced an extreme and prolonged recession. The median sales price gradually declined between 2007 and 2015, when a historic low of $87,500 was recognized. Housing prices have been increasing slightly since 2015 but have yet to reach levels even remotely resembling those attained during pre-crises years. As of August 2017, the median sales price in Hartford stood at a low $120,000. Just as the median sales figures indicate that the Hartford housing market is a long way from achieving a full recovery, the sales numbers in the area remain at low levels. Between 2002 and 2006, the number of monthly sales rose from 99 to 195. Sales then took a downward turn, reaching a record-low of 31 in December 2011. Monthly sales have since been improving slightly but, as of August 2017, have only climbed to 81.

The housing market in New York experienced a slight hiccup in advancement during the financial crisis, but for the most part, has maintained a strong upward trend over the past fifteen years. Between 2002 and 2008, the median sales price for New York City homes rose from $401,000 to $1,150,000, achieving a 187 percent growth rate. The New York City housing market then experienced a period of minor decline until 2012, when the median sales price fell to $897,530. The market has since been on the rise, and as of August 2017, the median sales price for New York City stood at a record high of $1,412,500. Meanwhile, monthly sales in New York City have been extremely volatile over the past fifteen years. Between 2002 and 2008, monthly sales generally

followed an upward trend, climbing from a low of 3 to a high of 2,294. However, sales prices fluctuated greatly during this period, and frequent declines in sales were recognized. Between 2008 and 2009, the New York City housing market took a large hit as the monthly sales figure dropped to 680. Sales have since moderately increased, but as of August 2017, only stand at 874.

We also examined some of the actions taken by government and economic developments that may have ignited this recovery where applicable and tried to identify the causation for the lag in total recovery of the real estate sector in some states.

It is clear from the real estate and economic data that certain areas of the country are recovering at faster rates than others. For instance, median sales prices have been increasing at higher rates in California, Florida, and New York than in Connecticut.

Current sales figures are much lower relative to the pre-crisis figures in Florida than in other areas.

Foreclosures, though in decline, are still much more prevalent in Florida and New York than in California and Connecticut.

The unemployment rate is down to pre-financial crisis rate and lower.

Per capita personal income is now higher than the pre-crisis figure.

Given the economic statistics and the paucity in real estate sales, it is our opinion that the real estate market has not fully recovered.

ACCOUNTING FINANCE, ECONOMICS - PAPERS

A Comparison of the Keynesian and the Monetary Theories Of Balance of Payments Adjustment

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Abstract

In this study, we develop a way to test for the two theories, the Monetary and the Traditional, in explaining exchange rate

determination. The approach we develop has two components to it. The first is a test of the appropriate signs. That is, the two theories disagree on the signs of the determining variables. Thus, depending on the sign of the regressors, we can prove the one, or the other. The second sub test is one which has to do with the speed of adjustment. Specifically, importance should be depicted in a quicker speed of adjustment. On that issue, if real(monetary) variables are faster, then it supports the traditional (monetary) view.

I. **Introduction**

There has been an extensive amount of literature on the determination of exchange rates. Three good surveys are by Peter Isard in 1978, Hedrick in 1987, and by Magee in 1976.

The traditional theory of exchange rate determination is a theory that has existed since the beginning of this century. Many famous financiers have worked to establish the traditional approach to the determination of exchange rates. Some of them are Sidney Alexander (1852), John M. Keynes (1823), Fritz Machlup, James E. Meade (1851) and Joan Robinson (1947). Since the traditional point of view relates to a keynesian mode, the name that we may use to describe it ·is "the Keynesian Approach". As we have analyzed however elsewhere, the term keynesian does not do justice to the view which we shall call traditional. (Malindretos, 1984). TheTA approach includes the Portfolio Balance approach (Branson, 1968) the international Fisher effect (Cumby and Obstfeld, 1981), the balance of payments view (Einzig, 1970), the forward exchange theory (Keynes, 1923) and the speculative view (Grubel, 1965).

II. **The Traditional Approach to ER Determination**

We can divide the TA to ER determination into two subtheories. The reason is that there exist two different international accounts in the balance of payments and both

influence the ER. Those two accounts are the trade balance of goods and services and the other is the capital account.

The fundamental variable which affects the ER in the TA is the trade balance of goods and services. But, since part of the services account is composed of investment flows, it is best to refer to the trade balance (TB) only. The TB influences the ER due to the supply of, let us say, dollars versus the demand for dollars. The supply of dollars .is engendered by a rise in imports and the demand for dollars by a rise in exports. The variables which determine the TB of a nation are the income level, the money supply and the price level of the domestic products versus the foreign products.

The purchasing power of a nation relatively to the other determines its TB. Purchasing power of the nation is determined by its income and its monetary policy. The higher the income of a nation is the greater its purchases of imports are and the greater the deficit of the TB is or the lower the TB surplus is. Economic expansion thus worsens the TB of the nation. This induces the ER to devalue. The same result is achieved if the money supply of the focus nation expands. Residents of the focus nation will have a higher income, and so they will buy more imports and thus worsen the TB of their nation and cause the ER to depreciate.

Secondly, the price level of the nation relatively to the rest of the world affects the competitiveness of the

nation. If the nation has a rise in its price level, then it becomes less competitive than the rest of the world (ROW), and so it exports less while it imports more. This will worsen the TB and consequently make the focus currency depreciate. If, on the other hand, the price level falls or rises less than the rest of the world, the focus nation will become more competitive, and it will improve its TB and its currency will appreciate.

The TA states that an important determinant of the ER is the capital account or the account of flows of international securities. A fundamental variable of security flows is the rate of interest. Rising rates of interest domestically will tend to attract more funds to the focus nation.and induce the domestic currency to appreciate. Falling interest rates will induce an a depreciation of the currency.

III. The Monetary Approach to ER Determination

The Monetary Approach (MA) has concentrated on the official reserves transactions balance (ORTB) almost exclusively. The MA revolves around the supply of and the demand for money. An excess supply of money domestically will induce an outflow of it to the ROW and have the BOP worsen and the currency depreciate. An excess demand of

money, on the other hand, will cause the currency to appreciate since it causes an inflow of funds domestically.

A monetary expansion (tightening) of the focus nation will ceteris paribus make the currency depreciate (appreciate), since it will create an excess supply of (demand for) money. A rise (fall) in the interest rates domestically will cause the ER to depreciate (appreciate) because the demand for money will fall (rise). This is in exact opposition to the traditional conclusions and the mechanism is different in the context of adjustment.

If the income level of the focus country rises (falls) the ER will appreciate (depreciate). The reason for this happening is that in case that the income level rises (falls) the ctemand for money rises (falls), and this causes the currency to appreciate (depreciate). As far as the price level is concerned, the mechanism of adjustment according to the MA works in the same fashion that the income level does. If the price rises (falls), the demand for money rises (falls) and the currency appreciates (depreciates). This is in direct contrast to the conclusions of the TA.

Finally, the ORTB influences the ER as follows. If the ORTB improves (worsens), the currency appreciates (depreciates). This occurs because if the ORTB improves (worsens) there is an influx (efflux) of funds.

IV. **Review of the Literature on Comparison of the Two Theories of International Finance on Exchange Rate Determination**

A. The Traditional theory of ER Determination

The TA to ER determination has been tested thoroughly, (Isard, 1976). A few notable studies of the different divisions of the TA are: Cumby and Obstfeld (1981) of the international Fisher effect, Grubel (1965) of the speculation view.

B. The MA to ER Determination

The Monetary approach to exchange rate determination is a relatively new theory developed since the early sixties. The financiers who are associated with the monetary approach are people like Rudiger Dornbusch, Jacob Frenkel, and Harry Johnson (1976), Arthur Laffer (1982), and most importantly Robert Mundell (1968). However, some argue that the monetary approach existed even before the traditional approach did in the seventeenth and eighteenth centuries. A few of the studies of the MA to ER determination are by Frenkel (1976), Bilson (1978), Hedrick (1978), Humphrey and Lawler (1978) and Girton and Roper (1977).

c. A Comparison of the Traditional and the Monetary Theories of ER Determination

The two views of international finance seemingly describe the same issues. But there are big differences between them. These differences are the reason that the two views disagree so much on their conclusions and on policy recommendations. The two views have a discord on their assumptions, their emphasis on real versus monetary variables, and their emphasis on international accounts (Malindretos, 1991).

A. The Discord on the Assumptions of the Two Views of International Finance.

The MA has four assumptions which are the bedrock upon which the rest of the theory is based. Those are, in an increasing order of importance, the following: (Malindretos, 1988) .

1.- There exists full employment of inputs.

2.- Purchasing power parity holds true.

3.- Money markets are the essential markets to consider.

4.- General equilibrium of all markets exists.

The MA survives unscathed even in the absence of the first two assumptions. The fundamental assumption of the MA are the last two. Those two assumptions are necessary and sufficient.

B. The Discord on the Emphasis of Real Versus Monetary variables by the Two Views of International Finance.

The TA has the same philosophical view as the Keynesian theory of income domestically. That is, the TA like its predecessor, the Keynesian theory of income emphasizes real economic variables. The real economic variables that the TA analyzes as important determinants of the ER are the income, relative price, and governmental spending variables. The TA believes that the above variables are the key ones to use *in* order to explain the determination of the currency's value. In fact, any monetary variables such as the price level or the money supply must go through real variables to influence the ER. The price level, for example, must affect the international accounts by inducing a real change, ie, an enhancement of competitiveness where the focus nation's products become cheaper in comparison to the foreign nation's products. The money supply induces a change *in* the international accounts, finally, by its influence on the income of the nation and consequently on the importation of the nation and on the ER finally.

Thus, in the TA the transmission mechanism occurs mainly through real variables. Monetary variables are definitely of secondary importance. If monetary variables alter, they will influence the ER only after they affect real variables which, *in* turn, will affect the international

accounts which, in turn, will influence the ER. The influence of monetary variables upon the ER is indirect while the influence of real variables on the ER direct. If real variables influence the ER directly and monetary variables influence it indirectly, then real variables are the important variables and monetary variables are the less important variables in ER determination a la TA. (Malindretos, 1984)

The MA, on the other hand, claims superiority for monetary variables as monetarism claims for the domestic determination of income. Monetary variables such as the price level, the money supply and the interest rate are the fundamental variables in influencing the ER. In the MA the price level .does not have to affect the competitiveness of the nation which is a real concept but can influence the ER by first influencing the demand for money, and then influencing the international accounts and the ER. The same transmission mechanism holds true *in* the case of the interest rate. The money supply, lastly, affects the balance of payments directly. All monetary variables affect the ER directly without having to travel through real variables.

Real variables, however, have to indirectly influence the ER. If income, for example, altered, it would not affect the ER by affecting the international accounts first and then the ER, but it would need to first influence the

money market according to the monetary approach. After it would alter the demand for money, it would influence the ER.

The same approach applies to governmental spending. If it were to alter, the influence would have to travel through the money market and then affect the ER. Therefore, in the MA real variables have a clearly secondary position to monetary ones.

C. The Discord on Accommodating Versus Initiating International Accounts and the Two Views of International Finance (Kemp, 1975)

The third important difference between the TA and the MA is the emphasis on different international accounts. The TA puts its weight on the merchandise trade balance. It feels that the TB is the autonomous account. It views the official reserves transactions balance as simply an accommodating account. The implication is that the TB would have a closer relationship to the ER according to the TA. The coefficient of determination between the TB and the ER would exceed that of the ORTB and the ER.

The MA says the exact opposite. The most important account according to it is the ORTB, and it would be the account which is autonomous. The TB would adjust to the whims of the ORTB. If this is true, then the more important determinant among the two accounts is the ORTB. According

to the monetary approach, the ORTB would have the closer correlation with the ER than the TB would have.

The former analysis brings out the point that the TA emphasizes the TB which is the real account and the MA emphasizes the ORTB which is the monetary account. Again we see that the essential variables for the TA are real variables and the essential variables for the MA are the monetary variables.

V. The Model

We have a model for the ER according to the TA and another model according to the MA. The basic model that we used is the. Almon polynomial distributed model. (Almon, 1965) The reasons for our choice were (Dutta 1975):

1.- The polynomial distributed model is not very restrictive. The pattern is loose enough so that is can depict the true relationship between the regressors and the regressand.

2.- We can separate the adjustment lags for the diverse regressors.

3.- We can use ordinary least squares in combination with the Almon polynomial distributed lag model (Pindyck and Rubinfeld, 1981.)

Another interesting approach we could have used is the one by Lee et al (1987). We hope to soon use this view in further econometric work that we are undertaking.

The country that we choose to examine is sweden during the time period 1976 to 1989. We choose sweden because it is a developed small country which has good statistics. Also, we choose 1976 to 1982 because this period of time as one of managed floating. Managed floating started around 1972 with the demise of the Bretton Woode System. A few years would have passed by 1976 and thus experience gained by the swedish policy makers.

A. The Model According to the Traditional View

The model for the TA is (Isard, 1978)

$$ERe = a_t + \sum_{j=1}^{n} b_j PR_{t-j} + \sum_{j=1}^{n} c_j P_{t-j} + \sum_{j=1}^{n} d_j M_{t-J} + \sum_{j=1}^{n} e_j I_{t-j} + \sum_{j=1}^{n} f_j TB_{t-j} + \sum_{J=1}^{n} gORTBt\text{-}j + Ut$$

where ERt= the exchange rate at time period defined as Swedish Krona given per u.s. dollar.

PR = industrial production of sweden minus industrial production of the world.

p = price of exports minus price of imports in an index form

M = money supply of Sweden minus money supply of the world in absolute units. (non index form)

I = world interest rate minus domestic interest rate.

TB = Trade Balance of goods and services of sweden

ORTB = The official reserves transaction balance of Sweden.

aj = constant

bj = the industrial production coefficients

cj = the price of exports minus the price of imports coefficients.

dj = the money supply coefficients

ej = the interest rate coefficients

fj = the trade balance coefficient

gj = the official reserves transactions balance

coefficients ut = an error term.

B. The Model According to the Monetary View

The monetary model of ER determination would be similar to that of the TA model: (Magee, 1976)

$$ER = a_t' + \sum_{j=1}^{n} b_j' PR_{t-j} + \sum_{j=1}^{n} c_j' P_{t-j}' + \sum_{j=1}^{n} d_j' M_{t-j}' + \sum_{j=1}^{n} e_j' I_{t-j}' + \sum_{j=1}^{n} f_j' TB_{t-j} + \sum_{j=1}^{n} g_j' ORTB_{t-j} + U_t'$$

C. The Model: Introduction to Empirical Comparison

The tests that we shall use are of two kinds. The first test is that of signs and the second test is that of speed of adjustment.

1. The Test of Signs

The first and less important test that we shall use is a comparison of the signs of the regressors in the two equations.

2. The Test of Speed of Adjustment

This test is more definitive than the first one. A similar approach is used by Malindretos (1991). The

quickness of adjustment of the ER should differ depending on which variable is altering. More specifically the TA would argue that since real variables are more important than monetary variables they should affect the ER faster than monetary variables would in case that both independent variables alter. In contrast to that, the MA would argue that monetary variables would jolt the ER before real variables would do so, since monetary variables are the key culprits of an disturbance.

Real variables are the industrial production, and the trade balance of goods and services. Monetary variables are the interest rate,the price level, the money supply and the official reserves transactions balance.

VI. conclusion

This study gives evidence that we can compare the two approaches of exchange rates, the current account versus the monetary approach. Specifically, they argue that we can design an empirical model to test the two views. The two tests are first the test of signs and second, the test of speed of adjustment.

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A CRITIQUE OF THE MONETARY APPROACH TO EXCHANGE RATES AND INTERNATIONAL PAYMENTS

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The debate over the relative merits of the monetarist and so-called Keynesian approaches to domestic income determination is in the process of spilling over into balance-of-payments and exchange rate determination theory. In order to preclude in balance-of-payments theory the quasi-polarization of professional views that has taken place in closed-economy macro-economic theory and that impedes the advance of economic analysis, this paper offers a critique of the monetary approach to the balance of payments (hereinafter simply the **Monetary Approach**). It identifies those features of the Monetary Approach that can usefully be retained in, as well as those that detract from, a pragmatic core theory of balance-of-payments adjustment and exchange rate determination. [1]

It is, of course, necessary to provide a version of orthodoxy with which to compare the Monetarist Approach. The absorption approach is defined as Orthodox theory. It finds one of its most sophisticated versions in an article written by the leading protagonist of the Monetary Approach [15]. Orthodox theory emphasizes the balance on goods and services or the current account as the vehicle for adjustment. A change in the relevant balance will be achieved through a change in the price-competitiveness of the tradable goods of the focus nation in international markets. This change in price-competitiveness is usually deemed to be achieved by an international depreciation (devaluation) of the focus-country currency, but it could be affected by differential rates of inflation in different countries with the deficit country having prices that rise less rapidly or fall more quickly than those in the rest of the world. An improvement in the balance on goods and services can be achieved by the imposition of tariffs or non-tariff barriers, but such actions are mere variations on the theme of changed price-competitiveness.

An improvement in the balance on goods and services can also be achieved by a domestic deflation away from full employment in the deficit nation. This is unacceptable as anything but a short-term expedient. Neither of these alternatives to changes in price competitiveness is considered in this paper. Because of the induced income-effects resulting from a change in the balance on goods and services, "expenditure-switch" instruments must be accompanied by “expenditure-reducing” mechanisms if the effect of the change in price-competitiveness is not to be dissipated. In fact, no deficit will be self-sustaining in perpetuity unless fed by continuous domestic credit creation to replace the outflow of funds and ultimately, the exhaustion of reserves will force the cessation of credit creation. However, deficits can go on for a protracted period, as can surpluses if outflows of funds (inflows) are neutralized by the authorities.

The model is almost always presented as though the elasticities of demand and supply fulfilled the requirements of the Marshall-Lerner condition though this assumption is sufficient but not necessary. Provided that (long-term) capital flows are independent of the instrument variables that bring about a change in the balance on goods and services, a suitable combination of expenditure-switch and expenditure reduction will generate a larger surplus on the balance on goods and services and an improvement in the overall balance of payments.

The emphasis on the absorption model is avowedly on the balance on goods and services; and the key assumption, as the Monetary Approach will emphasize, is the independence of capital transactions from the instrument variables affecting the goods-and-services balance. The absorption approach identifies two kinds of disturbances: stock disturbances and flow disturbances. Stock disturbances are changes in balance-sheet variables and are inherently temporary and self-curing. Flow disturbances, provided that their monetary effects are neutralized, do not involve any automatic cure for the deficit. The basis of the

[1] Students of Howards. Eilts will be grateful for the immunity to the virulent disease of polarity that he provided them. In Ellis' monetary seminar at Berkeley there was never any question that money mattered, but its omnipotence was also firmly rejected.

analysis is in the sense that it incorporates adjustment through time, period or short-run analysts, but even in [05] this dimension is not fully developed. The possibility that a devaluation can be offset is considered explicitly when the offsetting force is a change in the income level and only implicitly when the force is a gradual neutralization of the original policy combination of expenditure-switch and reduction.[2]

The proponents of the Monetary Approach [22], [31] do point out that their model does not provide the total explanation and hedge in the introduction to the exposition with wise caveats. Most likely, the major source of concern with the Monetary Approach is that its emphasis on its incompleteness is excluded from the theoretical analyses and, therefore, from the policy conclusions drawn. The Approach, in consequence, always seems to be a more substantial contribution than it, in fact, is. The inspiration for the Monetary Approach was a period in a chronically-defrelt nation (the United Kingdom) when an inappropriate monetary policy was a major contributor to the chronic deficit- this, despite the fact that the British authorities seemed to allocate to monetary policy, the primary concern for the elimination of balance-of-payments deficit. Unfortunately for the British, the balance-of-payments seemed to comprise only a secondary target for monetary policy which was primarily concerned with preservation of acceptable conditions (stability) in the gilt-edged market [7, pp. 149-150]. Conflict between the two targets overstrained the single instrument and the balance-of-payments was made hostage to the gilt-edged market. This is tantamount to saying that the rate of interest appropriate to payments policy had exceeded the socially-imposed limitation on the range of interest rate variation.

While orthodoxy fell into disrepute in the 'sixties', particularly in Great Britain, it is probably a fair comment that the cause of the trouble lies far less with sensible interpretations of the orthodox prescriptions and an awareness of the incompleteness of orthodoxy than with a lack of determination on the part of policymakers to face unpleasant realities. This applies no less to the United States than to Great Britain. In the United States, the Vietnam War began a period of grossly inappropriate fiscal and monetary policy.

This paper seeks to examine the contributions that the Monetary Approach provides to the development of a general or core theory of the balance of payments. The paper will also provide a rationale for discarding some of the more extreme statements that protagonists of the Monetary Approach are, from time to time, seduced into making in the professional literature. Section I offers a succinct summary of the essentials of the Monetary Approach. Section II considers the problem of the methodological framework suitable to an assessment of policy-influencing analyses of fnternatlona1 payments adjustment and evaluates the Monetary Approach by this standard. Section Ill reviews six features of the Monetary Approach within its own methodological framework, and Section IV summarizes both the positive contributions of the Approach and how it falls short of establishing itself as the core or general theory of the balance-of-payments.

[2] One of the more discouraging things about the literature of the Monetary Approach is the tendency to cast orthodoxy in what must appear to be a deliberately oversimplified way that was a more apt description of orthodoxy before [15] rather than after that article had been written. This shortcoming is very clear in [17] and in [22, fn. 5].

SECTION I

The Monetary Approach is being elaborated upon at a speed that does credit to the industry and imagination of its proponents, so that no statement about the Approach will be up to date. Recent articles seem to be more elaborations than developments of the basic theme so that this summary will not misrepresent the essentials however much it may fall to do justice to the elegant niceties that are in the process of development or are undergoing publication lag. For present purposes the essence of the Monetary Approach is deemed to be represented by five articles [16], [19], [20], [22], [31].

The first crucial distinction between the Monetary Approach and orthodoxy relates to the measure of payments imbalance. Orthodoxy (as defined above) may be said to emphasize the basic balance given that long-term capital flows can be assumed to be independent of the instruments used to affect the balance on goods and services.[3] The Monetary Approach uses a definition that includes below the line all transactions that have a direct effect on the money supply. The Monetary Approach includes short-term capital movements as an integral part of the theory and, indeed, places considerable emphasis on them. The Monetary Approach is usually presented in a world of fixed exchange rates, but it can be adapted to a system of flexible rates [22].

The second very distinctive difference between orthodoxy and the Monetary Approach is the assumption made about the price sensitivity of the balance on goods and services. The orthodox approach is mainly concerned that the Marshall-Lerner condition be fulfilled and therefore assume a positive but less than infinite elasticity of substitution between domestic and foreign goods. The Monetary Approach assumes, albeit with an avowal of heroism [16], that the elasticity of substitution between domestic and foreign goods is infinite:

> *"…at least among the advanced industrial countries, industrial competition is so pervasive that elasticities of substitution among the industrial products of the various countries approximate more closely to infinity than to the relatively low numbers implicit in the standard model. Another more sophisticated justification is derivable from the general framework of the monetarist approach, namely that changes in relative national price levels can only be transitory concomitants of the process of stock-adjustment to monetary disequilibrium and that in the longer-run analysis of balance-of-payments phenomena among growing economies, attention should be focused on long-run equilibrium price relationships which for simplicity can be taken as constant" [16, pp. 26-7].*

This assumption derives in spirit from Graham and Elliott [10], [5]. The state of affairs depleted by the assumption of infinite elasticity of substitution is shown in Figure 1. There, two ordinary offer curves are drawn showing the potential international trade equilibria for a focus nation and the rest of the world. Both nations have manufacturing sectors in which real or opportunity costs of production are constant. There is a price ratio that will make the two equal and the intersection of the offer curves is not a point but a range of finite duration.[4] As a consequence, the terms of trade are fixed in static analysts. The presumption that they remain constant in growth setting is not necessary for the Monetary Approach [22].

The final major assumption of the Monetary Approach derives from standard domestic monetarism: that the demand for (and to a lesser degree, the supply of) money is a stable function of a limited number of variables. As a derivative assumption, the Approach assumes that the authorities in a nation are incapable

[3] In fact, this independence is overstated in the text. What matters is that the relationship shall be small or not easily defined In terms of variables and, particularly, unreliable in the time dimension.

[4] This question of intersecting offer curves over a range is developed for a multi-con1n0dlty analysis in Ll2, Ch.5].

of neutralizing a continuing inflow or outflow of money from the international sector and, therefore, that any balance of payments surplus or deficit affects the monetary base of the focus economy.

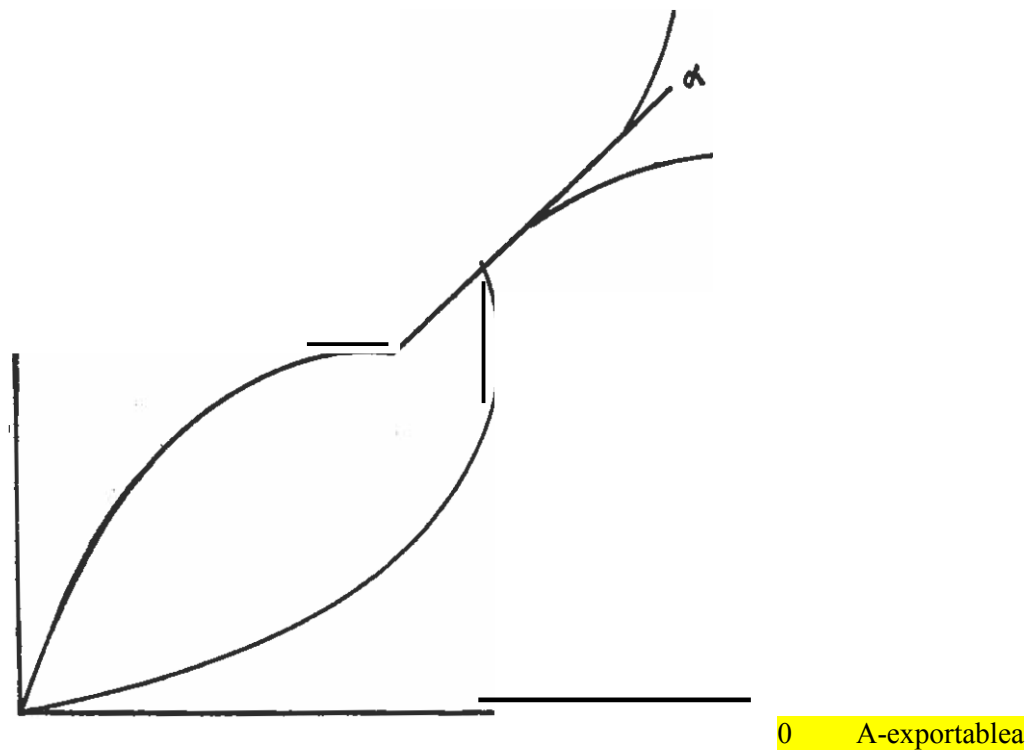

Figure 1

Unchanging net Barter Terms of Trade.

In this figure, goods that are intramarginal relative to manufactures provide the nore usual curved segnients of the offer curves. In the terms of trade improve to the point X o( ) that manufactured goods in perfectly-elastic supply can be export e r.1, the offf"r r.urve 1 •!! COM<!R Rrt a i ght (for both countri.es). Ultimately, when foreign demand reaches a point at which even manufacturing' goo .qs enco\mter increasinCJ costs of production, the offer curves again become curved. In a free trade world, there will be a range of intersection of the two offer curves. In this range, anjustments in the structure of trade can take place without any change in the net barter terms of trade (or, given constant domestic price levels) in the rate of exchange. If both nations A and B imposed tariffs on each other's manur:actures, the assumption of a range of intersection (infinite elasticity of substitution) becomes less tenable because the offer curves would have different slones according to Meade's construct [JI J . For a discussion of features affecting the vilzme of two-way trade see [12. ,ch. 11] and are

From these assumptions, it is possible to spell out the main mechanism by which the Monetary Approach sees balanced international payments being established. The analysis is long-run equilibrium and the demand for real money balances is given. From a position of equilibrium, posit an increase in the domestic component of the monetary base in the focus country. Immediately, money will be in excess

supply and economic units will exchange the surplus money balances for goods or for assets. Probably, this extra demand for goods and assets will spill over onto domestic products and assets in the first instance. However, the prices of these goods and assets will increase, making them uncompetitive with foreign goods and assets, and the newly-created money will spill over to cause a deficit in the balance of payments as foreign goods and assets are acquired net.

However, as the balance of payments moves into deficit, the monetary base of the focus economy is reduced and the excess creation of domestic credit is partly negated. ey means of a stock-adjustment process, the excess monetary creation is progressively wrung out of the focus economy by spilling over into the foreign sector. Thus, the Monetary Approach is, in terms of the disturbances categorized in [15], a stock disturbance and the approach is a stock-adjustment. This finiteness of the adjustment process is contrasted in the Monetary Approach with the seemingly infinite duration of the elasticities approach. Of course, the elasticities approach is capable, in the absence of disturbing forces, of infinite duration if payments are balanced since such a position is a full equilibrium and equivalent to the monetary equilibrium perceived by the Monetary Approach.

The disturbance is perceived to disappear gradually in accord with the stock adjustment model in [26]. There is no distinction drawn between surpluses on current account and surpluses on capital account and all that matters is that the demand for money be made equal to the available supply of real money balances. The same mechanism holds when the domestic credit base is not expanded to the appropriate amount. The shortage of real balances leads to a reduction in the demand for goods and assets. The first effect of this reduction is to cause domestic goods and assets to weaken in price, but a current-account surplus and an inflow of funds on capital account will restore the desired level of real money balances. By restricting domestic monetary creation, foreign funds are attracted to the focus nation and international reserves are accumulated. This process also has finite duration. The Implications of the Monetary Approach are summarized in the following list:[5]

1. Devaluation of a national currency reinforced by an adequate amount of domestic monetary stringeuy will generate a transitory surplus in international payments rather than a long-lived or permanent surplus.

2. The surplus will create an inflow of international reserves which will feed the devaluation-induced excess demand for money balances. In the process, the effect of the devaluation will be eliminated.

3. Devaluation is merely a substlture (within a system of fixed rates of exchange) for a "more carefully controlled monetary policy".

4. Relative contraction of the domestic credit base will serve as a perfect substlture for a devaluation by creating a temporary payments surplus.

5. Devaluation coupled with monetary expansion can, if the latter is vigorous enough, create a larger deficit instead of the sought-after surplus.

One final feature of the Approach deserves mention. There is, potentially, a significant difference between the validity of the Approach if it is regarded as a preventive designed to ensure that the national monetary authorities do not unduly expand the domestic credit base, than if it is conceived as a cure by

[5] 5rhts fist was derived from [17] and [20].

which monetary stringency will eliminate an existing deficit.

SECTION II

This section considers the yardstick by which a theory of the balance of payments should be judged. Archibald [2] defines a statement as being scientific if it can be tested empirically against an alternative theory. The theory with the better explanatory power is regarded as a superior statement and the other explanation is discarded. However, these discarded statements are not refuted and, on Mayer's evidence [27], may regain superiority at a later time.[6] Unfortunately empirical proof of the superiority of the Monetary Approach over the absorption approach or vice versa, is not feasible: balance-of-payments deficits and surpluses are subject to too many disparate influences for a clear superiority of either theory to be substantiated empirically.

The purpose of a theoretical statement is to set out with complete precision, hypotheses that may serve as a basis for policy action or inaction. In order, in turn, to improve society's material well-being, the discipline of economics operates in a stochastic universals fact is the essence of Archibald's preference for the comparability of theories over the more absolute criterion of Popper of refutation or absolute disproof of a theory as a test of a scientific statement. An economic theory is subject to error if (a) it attributes an incorrect causal link between elements in the theory, or (b) if the group of elements (explanatory variables) is not the appropriate set of variables or is not properly specified for describing the behavior of the dependent variable.

The first problem is unlikely long to stand the test of time in a world of publish and/or perish. An incorrect causal link is also likely to be internally inconsistent and refutable on the grounds of logic rather than empiricism. But it is possible that the group of independent variables is incorrect or incomplete. Often a series of empirical tests will narrow down the set of theories and will generate some reliable statement that will serve as the accepted explanation. There is a real possibility of multiple criteria for the comparison and vector dominance may not exist [2, p. 2951]. A still more serious problem is that, in very complex hypotheses, the population of alternative theories can be quite large. If the test of a theory is to be relative explanatory power, there is the phantasmagoric possibility of an interminable set of explanatory variables which, because of their own interdependencies, mire the analyst down in a sea of minutiae. Clearly, complexity has a very real cost if only because it reduces the possibility that a definitive conclusion can be generated.

Now, the purpose of economic theory is not to recreate the real world. That world is too complex and too subject to minor aberrations for a true reproduction to have analytic value. Theory's task is to simplify, to identify the dominant interdependencies and to isolate those interdependencies in such a way that the crucial relationships and the functional, causal links stand out in sharp focus. The emphasis on the main causal relationships make possible an analysis of the effect of a specified disturbance upon the working of the economic system.

There is a finite amount of complexity that can be handled at a single time by any organism, be that organism computer and econometric model or human brain, and mathematical and literary model. The greater the degree of simplification of an analysts, the more readily can the effects of the disturbance upon the excluded variables and, in this way, prohibits any examinations of the feedback of such effects upon the included variables. The more inclusive a theory, the further down the scale of importance are the

[6] See also the citation from Haavelmo cited in [23, 27] to the effect that the functional form of a relationship may not be tnvartDnt to the actual values of the variables involved.

relationships that are included, and the more specialized must that theory be. The need for specialization follows from the fact that to make a theory more inclusive on a general or non-specialized basis would require that every ramification of the theory be developed to the same degree of inclusiveness. Specialization notwithstanding, the more inclusive the theoretical base the greater is the inherent complexity of the analysis and, the greater the complexity, the less likely are exact solutions to be obtainable or clear cause-and-effect relationships to be identifiable.

However, if complexity presents difficulty, so too does simplification. Clearly, any simplification of the real world courts the dangers of eliminating from the analytic tool-kit an element that is important to the problem at hand. The reliance of neoclassical theory upon the automatic tangency toward full employment as a reason for a lack of concern with the problems of unemployment or adjustment is an obvious case in point. For this reason, the simplifying assumptions of any body of theory must always be explicitly spelled out and an investigator must never fail positively to consider the relevance of this theoretical framework based on those assumptions for his immediate task or problem. No single theoretical model can be suitable for all conceivable analyses of such a complex phenomenon as the real world. Such a model would defy comprehension by a single organism and would frustrate the goal of theoretical analysis.

Given that both simple and complex models have their disadvantages, there exists the very real and pertinent question as to what constitutes the most appropriate degree of complexity or simplification. As will be seen, the solution to the problem revolves around the purpose of the theory. Since balance-of-payments analysis is a problem in aggregative or macro-economic theory, the problem of the appropriate trade-off of simplicity for complexity can be considered in that context.[7] A theory consists of a network of interrelationships among sectors together with a set of specifications of the causal links within that network. A macro-economic system consists of several main areas that are interdependent. Each of these main sectors possesses its own internal interrelationships or second-generation subsectors, third generation subsectors and so on. The distinction between a main sector and a subsector is that a subsector's degree of interdependence with its fellow subsectors exceeds by a substantial margin the interdependence that it enjoys with other main sectors. Any such interdependence with other main sectors is achieved primarily on a collective basis through its own main sector.

Consider, for example, the simplest Keynesian model. This comprises two main sectors (private and government) and two second-generation subsectors of the private sector (consumption plus investment). In a world with an unemployment rate of 23 percent and a liquidity trap, this degree of complexity could be considered sufficient. To clutter up the model with sterile variables would tend merely to reduce the starkness of the relationship between the level of government expenditures and the level of resource utilization. The standard Keynesian model deals with less drastic conditions and has to include another main sector (the monetary sector), second generation subsectors in the government sector and third-generation subsectors in the private sector. A second means of distinguishing between a main sector and a subsector relates to policy goals: a main sector has a goat set for it that allows it to contribute to national goals; a subsector's goal, if any, is defined in terms of how it will contribute to the performance of its main sector.

The degree of complexity of a theory can be described in terms of the number of main and subsectors included in the analysis. The inclusion of a sector or subsector is likely to involve little more than the elimination of a simplifying assumption--though not alt assumptions have the same "coefficient of simplification". The trade-off between simplicity and complexity for macro- models is easily seen. The

[7] What follows is developed somewhat more fully in [ti, Ch.I].

less inclusive the theory, the easier is the mechanism to perceive and the more easily can appropriate policy be formulated. The inclusion of third-generation subsectors will complicate the analysts but may add little light to the policy-formulation process provided by the simpler theory. The addition may even detract from the analysts and make the solution more obscure. The more simplified the theory, the greater is the danger that it will inadvertently omit some key interrelationship and generate a bad policy. The key to the inclusion or omission of a subsector is clearly the quantitative importance of the subsector for the target variable--directly or indirectly. This distinction has recently been expressed lucidly and succinctly:

> *"…It is basically the Ricardian method of analysts that Keynes has revived. The most typical indication of this is to be found in the directness with which Keynes proceeds to state his assumptions. Like Ricardo, els always looking for fundamentals. He singles out for consideration the variables he believes to be… the most important. All the others giving rise to unimportant implications--though, as he says, they are always 'kept at the back of his head' for the necessary qualifications--are for immediate purposes, frozen out by simple assumptions" [33, pp. 43-31].*

But the stochastic quality of the real world in which international payments adjustment must take place, makes the simplicity-complexity tradeoff too narrow an analytic framework. It implies a world of certainty. The international economic system is subjected to a series of disturbances--some real, some monetary; some major, some minor; some se1f-cancelllng and others mutually reinforcing; some favorable and others unfavorable. The crucial difference is the distinction between real and monetary disturbances since they affect the ultimate solution to a payments deficit differently.

As defined by Hilton Friedman [8], real disturbances come from changes in "the 'real' conditions determining international trade, such as the weather, technical conditions of production, consumer tastes, and the like". Contrasted are the monetary disturbances: changes "in monetary conditions, such as divergent degrees of Inflation or deflation in various countries". Real disturbances change the structure of relative prices--including the terms of trade--while monetary conditions do !!,g.!. change the terms of trade once balanced payments have been restored. There is no reason to expect the system to react in the same way to the two different kinds of disturbance nor is there any reason to expect that any automatic balancing mechanism as may exist will react quickly enough so that the effects of one disturbance will have been incorporated into the system prior to the impact of a succeeding disturbance.

Another important analytic dimension is that the optimum policy response to different disturbances is not the same [11, Ch.SJ and [1?]. Monetary disturbances require a quick positive policy that neutralizes the disturbances lest a Kaldor-effect be created.[8] Real disturbances may require immediate adjustment or riding out the disturbance through financing. Anyone who doubts the importance of real international disturbances may consider the following partial list from the last quarter of a century or so: the Korean armistice; the formation of the E.E.C.; the spurt of multinationals and the consequent transfer of technology; the enlargement of the E.E.C.; product surges (Jetliners); the increase in the world demand for grain; the Vietnam war; nationalizations of extractive foreign subsidiaries; changes in political allegiance and O.P.E.C. These real disturbances cannot ordinarily be foreseen and payments policy must therefore operate in a reactionary way.[9]

[8] A Kaldor-effect is the misallocation of investment in response to an incorrect exchange rate, see [21]. The eventual re-establishment of payments balance then creates a real disturbance.

[9] Small real disturbances can be taken care of by the flexibility that derives from an economy's normal growth process. In a dynamic setting, real disturbances must be limited to those of sufficient magnitude that they exceed the capability of the economy to incorporate them smoothly. This is similar to the corridor concept in [25].

It's potentially important, then, for a theory of balance-of-payments adjustment to be able to incorporate reaction to possible real disturbances. For such a purpose a simplicity-complexity continuum is not adequate and a second dimension must be added. This plane of uncertainty is shown in Figure 2. The plane of uncertainty is drawn as a square. The top-left corner depicts utter simplicity (.). Moving rightward from complexity gradually increases until complete complexity (.£:) is attained. Moving vertically downward from us, complexity increases to maximum uncertainty (mu). The bottom-right corner represents the real world (rw). Complexity is measured by the number of variables and the complexity of the relationships. Uncertainty is measured by the degree to which the system allows for disturbances and emphasizes short-run adjustments. It is useful to conceive of a third dimension rising outward from the plane toward the viewer. This dimension would measure the definitiveness of results of theories located at different positions on the plane. In the corner maximum definitiveness is obtained. From this point the surface would slope downward gradually to cc and sharply to -mu and having zero value at the bottom-right corner.

The definitiveness of a theory is another way of describing its elegance and this may in part explain the temptation to use theories in the upper part of the plane. aut, for short-run policy problems at least, such analyses have relatively little public value. Given the existence of real disturbances, a core theory of the balance-of-payments must have an uncertainty dimension. The actual choice of position on the plane still has a subjective element and the optimum position, if it were subject to definition, would vary with the frequency and magnitude of real disturbances. The greater the degree of uncertainty required by conditions, the less definitive are the conclusions of the theory but the more quick1y-reversible are the policy stances that derive from the theory.

The remainder of this section attempts to locate the relative positions of the absorptions approach to balance-of-payments adjustment and the Monetary Approach on the plane of uncertainty. It is the relative positions that are important since absolutes have little meaning except for points on the upper edge that indicate theories to be devoid of an uncertainty dimension. The question then is, which of the two theories' position better suits the requirements of a core theory of payments adjustment? Once that decision has been reached, there remains the possibility that features of the rejected theory may usefully be incorporated into the other so that the location of the joint theory is still better suited to the purpose of the formulation of balance-of-payments policy stances. The location of a theory on the plane is made by a review of the important assumptions of the theory.

----------rC

Figure2

The**Plane**ofUncertainty.

Note:Itistobeexpectedthattherewillbearangeofpragmatism**spreading** diagonallyfromtheuscornertowardtherw corner.

Generalequilibrium**analyses range**alongthe-.££**edge.**

The absorption approach can be fairly easily located since it is not very rigidly defined in its essential form and since it operates in a period-analysis framework that allows it to be used in a short-run context. The period analysis frame of reference allows the theory to incorporate spasmodic adjustments in circumstances and therefore allows the policy implications to be worked out for new situations involving either real or monetary disturbances. The absorption approach does not provide a clear-cut answer to every conceivable situation but it does recognize the possibility of payments imbalances being incurred, by intent or accident, and it does recognize that ultimate adjustment to a real disturbance involves real factors. The absorption approach has a relatively simple form but additional variables can be added as circumstances require. The position of orthodoxy on the plane is, then, approximately half-way down from us toward mu and, say, one third to the right toward££· The - of the - rs small.[10] Definitiveness theory. When you add to the basic absorption theory, the location moves to the right and the definitiveness decreases still further.

The Monetary Approach has four major assumptions. First is the inability of the monetary authorities in the focus country to neutralize an inflow or outflow of funds that derives from a payments surplus or deficit. Second, the demand for real money balances is stable. The third basic assumption is the constancy of the relative prices of tradable goods in the two "countries" and the consequent flexibility of the terms of trade. The fourth assumption is, in a way, the product of the three already listed: that the Monetary Approach requires long-run general equilibrium as its analytic framework.

The alleged inability of the monetary authorities to neutralize the effect on domestic monetary base of a large flow deficit in perpetuity is beyond dispute. However, a small outflow can be neutralized for a protracted period by simply drawing on the accumulated stock of international reserves. There is no automaticity of the non-neutralization of a monetary outflow except as a long-run phenomenon. If the authorities were able to identify the causes of the deficit and are willing to obey the precepts of the Monetary Approach, the non-neutralization is likely to be undertaken voluntarily. An inflow of funds, a

[10] The first derivative of definitiveness of results to uncertainty is clearly negative. Intuition suggests that the second derivative is also negative.

payments surplus, is subject to neutralization in perpetuity provided that the inflow is less than the absolute increase in the monetary base needed by the growth of the focus economy. However, this is slightly misleading since the rest of the world would (in the absence of the creation of international liquidity through gold-mining of SDR creation) would be forced to cease neutralization of its monetary outflow sooner or later. But, this would take a very long time. The assumption of non-neutralization effectively removes the Monetary Approach from the realm of short-term analysis simply because nations can and do choose to use official reserves deliberately to finance a deficit. Given the uncertainty faced by the authorities about the future and the various possible sequences of future events (including cyclical factors), non-neutralization may well be perfectly justifiable in the short run for disturbances that are expected to be transitory [11, Ch. 5].[11]

The stability of the demand for real balances is also a long-run relation and the assumption also therefore consigns the Monetary Approach to a long-run setting. The stability of the demand for real balances has never been verified over a short-run period of adjustment. The whole question of what money balances to hold depends, in part, upon future expectations and the future is, inevitably, uncertain. It is unlikely therefore that the demand for money balances is stable over a short-run period or that such a relationship will ever be empirically verified. The whole problem of uncertainty in economic variables is lucidly considered in [29, pp. 64-71]. But, the assumption of the interrelationship between real balances and the acquisition of goods and assets implies that, in true monetarist tradition, the mechanism by which money supply affects aggregate demands for goods and assets is direct.

There is an equally persuasive body of thought, summarized in [14], that would argue for an indirect effect. It may well be that the difference between the two schools is as much a matter of the time horizon involved as of any other dimension. But, if the demand for money is not definable in the short run, then the ability of the Monetary Approach to prescribe policy analyses for transitory disturbances is negligible. By extension, then, the Monetary Approach would seem to assume either that nations are willing to subject themselves to a quasi-automatic response to short-run phenomena (with all the attendant costs) or that nations should deliberately depart from the long-run indications of the Approach when the future course of event is thought to be reversible. This posture leaves a need for a short-run policy analysis.

The assumption that there exists an infinite elasticity of substitution between domestic tradable and foreign goods at the margin, implies that the net barter conunodity terms of trade are constant. It further implies a disregard of income effects. The question immediately raised is whether or not the Monetary Approach can deal with real disturbances.[12] The Monetary Approach relies upon the demand for real balances as the dominant behavioral force in the economic systems. This reliance immediately casts all alternatives to holding real balances into a composite entity. Ignoring the fundamental difference between assets and absorbable goods as alternatives to money holdings temporarily, and considering only goods, the Monetary Approach decrees all goods to be one composite.[13] The notion of composite goods was fully developed in f37] and achieves its usefulness at the fairly substantial cost of assuming away all changes in the mix of goods making up the composite. This is a very important cost when the object of analysis is an aggregate phenomenon such as balance of-payments adjustment. Changes in the supply or demand functions for international goods are both Important and frequent. It is these changes that constitute real

[11] The lack of applicability of the Monetary Approach in the short run is acknowledged in [31].

[12] There is some claim that [31] deals with a real disturbance--a protective tariff Imposed by the focus country. The analysis is disappointing as it offers nothing more than an argument to show that the short-run surplus has a finite duration. Nothing is said about the relative price-level changes, terms-of-trade effects and on the way in which these repercussions will impinge upon the output-mix and gains from trade of the focus nation.

[13] See Section Ill subsection (ti) below.

disturbances [8] and the core theory of the balance-of-payments must be able to indicate the process of adjustment to a real disturbance. Further, if the theory is to have policy relevance, then it must be able to compare the social cost or desirability of the "passive" or "natural" process of adjustment through the working of monetary forces with the costs or desirability of an interventionist approach.

By neglecting the possibility of changes in the composite good (that is, in the mix of goods traded internationally), the Monetary Approach eliminates real disturbances from its domain. At the same time, it eliminates changes in the terms of trade, in the global gain from trade and its division and in the level of real income.[14] To some degree, the possibility of real disturbances seems to be circumvented by the assumption of the unchanging net barter terms of trade (infinite elasticity of substitution). In terms of Figure 1, analysis along these lines neglects the effects of a change in the demand for or supply of one of the intramarginal goods.It also omits the possibility of a change in the mix of output of the marginal goods and of a change in the production conditions in those goods. The latter possibility involves a change in the terms of trade. An upward shift in the domestic demand schedule of an intramarginal import will change the curvature of the focus country offer curve in Figure 1 and reduce its gain from trade (unless foreign supply be perfectly elastic to output). This causes a reduction in real income even though the terms of trade may remain constant. Such a disturbance can affect the focus-country rate of interest as well as its income and opens a Pandora's Box of repercussions that can only be definitively allayed in the comfort of a general equilibrium solution.

Another subcategory of real disturbance consists of a variation in the rate of direct foreign investment which may not be sensitive to marginal changes in price levels or In Interest rates.[15] If a component of the balance-of-payments is subject to variation as a result of exogenous forces, then the combination of the interest-sensitive capital account and the current account must act in an offsetting way. Changes in the flow of direct foreign investment may be too short a duration for the general equilibrium approach to portray the adaptation process. The Monetary Approach really confines itself to a world in which only monetary disturbances are likely to occur. In this it has a good ally [24]. But the core theory of balance-of-payments adjustment must be able to offer to the world something more than a statement that monetary discipline will prevent and monetary correctives will cure problems caused by monetary laxity. The suitability of a theory cast in a general-equilibrium framework for the core theory of a policy-oriented area has been considered sufficiently frequently in the preceding paragraphs as to warrant to separate consideration at this point. In terms of Figure 2, the Monetary Approach is located on the upper edge of the plane (Indicating a complete absence of uncertainty) and is only negligibly, if at all, to the right of the position of the orthodox theory.

SECTION III

This section considers certain aspects of the Monetary Approach within its own analytic framework. Six features are assessed: (I) the sensitivity of the capital account in toto to the demand for real balances; (II) the question of a nation's international net worth and its effect on the adjustment problem and the ultimate

[14] This neglect of real disturbances is quite common. R.G.D. Allen [I, pp. S-71] cites mathematical convenience as the reason for preferring continuous to period analysis. The legitimacy of this preference must surely depend upon the frequency and importance of real disturbances and the emphasis placed on adjustment as opposed to evolution. But see also fn. 9 above.

[15] See Section Ill, subsection (t), below, 1.

equilibrium; (III) the possibility that the demand for a national currency is indeterminate in a world in which multi-national enterprise is quantitatively important; (IV) the possibility of a sudden crisis in financial markets; (V) the behavior of the system when the monetary conditions and the real conditions are not compatible; and (VI) asymmetries in the implementation of the Monetary Approach. Many of the problems raised by these different points find their roots in different kinds of disturbances that might be called "real". To this extent, this section is an extension of the discussion of real disturbances and their implications for the Monetary Approach. However, these features do give rise to disturbances that are conceptually different and better treated separately.

(I) The Capital Account. One of the great contributions of the Monetary Approach is that it has shifted the focus of attention from the goods-and-services balance featured in the elasticities approach [35] and from the basic balance that underlies most analyses of the absorption approach [11]. This reliance upon the "monetary ba1ance" is an improvement if only because the balance-of-payments is a cash-flow concept and must always be seen as such. This refinement has not been achieved without cost. The crucial mechanism by which monetary tightness (ease) improves (deteriorates) the balance-of-payments is by reducing the net outflow on current account at people reduce their consumption to restore their real money balances and by a simultaneous net inflow on capital accounts funds flow in to the focus nation to seek the higher yields available on assets there. The capital account responds to the exercise of the monetary instrument in the same direction as the goods-and-services account.

This description of capital account behavior is valid for short-term capital flows which must be sensitive to interest rate changes even if solid empirical proof of the determinants of these flows is difficult to obtain. If rates of exchange are fixed and faith exists in the viability of the parities, there is no reason to suppose that international short-term capital flows do not respond to changes in relative interest rates. This is the link between the Monetary Approach and Hundell's work in the 'fifties' [30]. What holds true for short-term funds will also apply to long-term assets that fulfill the requirements of portfolio analysts. For such assets to be traded from a resident of one country to a resident of another, an efficient set of secondary markets is prerequisite so that the assets retain some known degree of liquidity. Long-term financial assets will be bought by foreigners when their yield rises and foreign exchange will flow into the focus nation. In fact, it is the "residence" of the funds rather than that of the owner that is important. It makes no difference to the Monetary Approach whether the inflow of funds is a repatriation of funds previously held abroad by residents or whether the asset is acquired by a foreign resident.

But the capital account consists of a wider range of transactions and assets. In addition to private short-term capital movements and movements of long-term assets, there exist direct investments and government loans. The latter are politically-motivated and little can be said about the geographic dispersion of the flow or its constancy through time. Direct investments are, in this age of multi-national enterprise, a problem of a different order of magnitude for the Monetary Approach. Two studies [3], [7] have shown that Hundell's suggestion that, in a world of fixed exchange rates, monetary policy may be used as the balance-of-payments instrument no longer holds true when direct investment is introduced and is defined as being sensitive to income levels in different nations.

The existence of direct investment flows must weaken the theoretical basis for the Monetary Approach if these flows are indeed independent of the variables that determine the behavior of short-term flows and on which the whole Monetary Approach depends. There is some evidence, though far from conclusive [7], that direct capital flows react perversely to the causal direction exerted by monetary variables on short-term capital. It is true that direct investments do generate partially offsetting flows of exports [11, Ch.7], but these induced flows are not constant through time and it is a serious question as to whether there is value in working with models which rely on these flows or net flows necessarily being in stock-

or flow-equilibrium. To some degree direct capital flows will respond "properly" to monetary variables. Not all funds required for subsidiary creation or expansion are equity funds sent from the parent corporation. Equity can be floated in the host country and debt capital raised in nations with tower interest costs (if the capital markets are permitted to lend to foreign subsidiaries). Even so, outflows of equity capital are likely to vary through time quite importantly, and for payments balance to be achieved it is necessary that the current and portfolio capital accounts (including short-term capital) offset the direct investment outflow. Variations in this flow are most usefully seen as real disturbances because they require greater or less stringency of the instrument variables.

(II) International Net Worth. As was noted ln the previous section, the Monetary Approach makes no distinction between funds owned by foreign residents or citizens and those owned by residents or citizens of the focus nation.[16] Nor does the Monetary Approach distinguish between net inflows or outflows on current account and those on capital account. Provided that the analysts is concerned only with cash flows, the distinction has no immediate importance; but the neglect of the sub-account balances has implications for the future of the nation's balance of payments if its international net worth is affected by the means by which payments balance is achieved. 'International net worth' is defined as the sum of all international assets minus the value of all international liabilities. International assets comprise portfolio assets (including short-term assets) that represent claims on foreigners, real assets that represent tangible assets owned abroad by citizens and monetary assets such as gold and convertible currencies owned by citizens (including the foreign-exchange authority). International liabilities comprise real assets owned at home by foreigners, portfolio assets issued by residents and owned by foreigners and monetary liabilities owed to foreigners. If payments balance is achieved by attracting foreign capital--either repatriated, domestically-owned capital or newly-attracted foreign-owned caplta1--the international net worth will be different than if the balance were achieved by running a surplus on goods-and-services account. Future net flows on interest- and-dividend account are determined by international net worth (as well as by the mix of assets and liabilities and their yields).

By virtue of its emphasis on equilibrium solutions, the Monetary Approach does not delineate any behavioral pattern that might characterize the relative importance of the goods and-services and capital accounts in the adjustment process. The question is if, from a position of payments balance on both current and capital accounts, the domestic credit base were to be expanded, what proportion of the ultimate total deficit will be achieved on goods and services and what on capital account? In extremis, if all of the excess money balances flowed over to acquire foreign assets, then the international net worth of the nation would rem in unchanged. If the yields on these assets were repatriated, the international net worth of the nation would slowly improve. In contrast, if all excess money balances were to spill over onto imported goods, the international net worth would deteriorate by the cumulative total deficit. What is important here is the relative size of the propensities to acquire goods and to acquire non-monetary assets

[16] The concept of residence presents problems when dealing with the capital account but the problem is not solved by changing the definition of inflow and outflow to one of citizenship. When dealing with transactions on goods-and- services account, residence is clearly the appropriate factor determining the categorization of expenditures on international goods. If a person buys a foreign-made good and is a resident of the focus-country, it may be presumed that the normal pattern of expenditure is on focus-country goods and that the source of income is denominated in the focus-country currency. Regulations governing capital movements apart, the residence of the owner of short-term (or long-term) capital flows is not seen as Important. Citizenship may be a better guide, but what is needed is a concept of “permanent residence". What matters In determining an international payments equilibrium is whether funds are located In a country (or denominated In ? currency) other than their "permanent residence” because this will sooner or later affect international flows of dividends and interest. The remarks made here on international net worth should be read with this question of definition in mind.

out of excess money balances. This relationship is crucial in determining the character of the deficit and would be almost impossible to verify empirically. Further, there is little hope that the relationship will remain constant through time or be independent of the magnitude and duration of the excessive creation of the domestic credit base. Finally, there is negligible hope that the relationship will be quantitatively identical for positions of excess and deficient money balances.[17]

The implications of the tack of concern of the Monetary Approach with the composition of international flows can be illustrated in another way. Flow- of-funds tables must include "current receipts accruing during a period as a source of funds or current expenditures as a use, except insofar as the difference between the two is Included as a source of funds on capital account" [34, p.17]. This query raises the very penetrating question as to why (domestic) monetarists have never adapted flow-of-funds accounting to their theory (or vice versa). One possible explanation is that the flow-of-funds framework is short run and monetarism finds comfortable expression only in long-run equilibrium. Indeed, domestic monetarism lacks the ability to explain the short- run steps of the adjustment process [4]. The Monetary Approach does not omit any element in the international flow of funds but, by falling to distinguish closely between balance-sheet Items and income-statement items, it disguises (or glosses over) a distinction of substantial importance.

(III) The Possible Indeterminacy of the Demand for Money. The whole basis of any version of monetarism rests on the assertion that "the demand for and the supply of money are stable functions of a limited number of variables" [22, pp.15-16]. Given the assumptions made by the Monetary Approach, there may be grounds for doubting the stability of the demand-for-money function--at least in the short run. These doubts do not derive from the usual arguments of economists who believe that the effect of money balances on economic behavior is indirect rather than direct [14], but derive instead from the postulates of fixed relative prices measured in unchanging numeraires and fixed exchange rates given the absence of monetary disturbances. The doubts persist under a system of flexible exchange rates and monetary disturbances provided that foreign- exchange and forward markets are perfect.

Grant the assumptions that the focus country's price level is pegged to the world price level and must move rigidly in line with it, and that a fixed- exchange-rate regime exists. Under these conditions foreign money is completely interchangeable with domestic money and will, conversion costs apart, serve equally well to satisfy the three purposes of money balances. Therefore, what the Monetary Approach posits is the existence of a stable demand function for money, but this is not necessarily the same thing as a stable demand function for a single national currency. In a world of national firms and private citizens and rudimentary integration of national capital markets, this would constitute merely an analytic flaw of negligible operational significance be· cause most money holders simply would not view foreign currencies as feasible or reasonable substitutes for transactions balances or- even for precautionary and speculative balances.[18] But, transnational and multinational enterprises have now become quantitatively important forces in the world economy to the point that their money balances constitute a noteworthy segment of the demand for money in individual nations. Because they control money balances in different nations, they are likely to be indifferent under the assumptions made about the location of their marginal balances. To the extent that the money balances of these firms are important in a nation, the demand-for-the-national-currency function is less likely to be stable in the short run or the medium run.

[17] The Implication of this point is not that it is impossible to incorporate changes in international net worth into the Monetary Approach. The problem here is that the changes would have to be artificially restricted to some constant rate of growth and that is not appropriate to such a variable phenomenon as the balance of payments.
[18] Monetarists do not normally endorse this trichotomy.

(IV) Financial Crises. The Monetary Approach relies upon the assumption that national capital markets are perfectly integrated. The Approach also falls to distinguish between current flows and capital flows to the extent that it could, in line with Hundell's analysis [30], conceive of a current-account deficit being financed by an inflow of short-term funds. There is then built into the Monetary Approach the assumption that financial markets work perfectly and are not subject to self-reinforcing shifts in relationships after some critical value has been reached. A financial crisis is the result of an abrupt shift in relationships in response to some threshold level being reached or in response to some external disturbance. Disturbances cannot exist in equilibrium and vice versa, so the Monetary Approach does not countenance the existence of financial crises. This is a weakness of the Approach insofar as its findings are used to cure a deficit-- that is to allow for contraction of the domestic monetary base to work its cure upon the balance of payments-- but it is not a weakness if the Approach is seen to be couched exclusively in terms of the prevention of excessive expansion of the domestic monetary base.

(V) Incompatibility of Real and Monetary Conditions. There is a serious question as to whether monetary variables can force an economy to adjust to real disturbances. This is very similar to the question as to whether, if real conditions and monetary conditions are not compatible, holding monetary forces constant will bring the real conditions into conformity with the monetary variables. Harry Johnson [18] seems to imply that monetary conditions do have the power to bring the real sector into the conformity needed for equilibrium. Consider Johnson's statement [18, p. 35]:

> *The 1930s disaster has as its root cause the implosion of the international reserve base, namely liquidity provided by gold supplemented by international reserve use of credit- based national moneys, notably sterling and the dollar.*

According to this statement, the crisis of the 1930s was a monetary phenomenon triggered by the disintegration of a part of the national-currency component of the international reserve base. There is no mention of any previous real disturbance nor of any incompatibility between the extant real and monetary conditions. Yet, the crisis of the 1930s was the supreme example of a real disturbance. True, the effects of the disturbance were suppressed by unemployment and short-term monetary expediency for ten years.[19] The real disturbance that underlay the crisis of the 1930s was World War I. The international monetary system never did adapt to that disturbance--the break-up of the Austro Hungarian Empire, the changed international net worths of different nations and the changed price levels--instead monetary expedients were used to suppress the real symptoms. For a disturbance of this magnitude, monetary factors had to adapt to the real factors when peacetime returned.

Again in [18], the recent payments crisis (1971) is attributed to "an explosion of the international reserve base" caused by large and increasing outflow of dollars. Presumably, the implicit diagnosis is that the cause of the recent payments crisis was due to unsuitable differential rates of expansion of the domestic credit base and real disturbances played no part. It is also possible to explain the recent monetary crisis as the product of a series of self-reinforcing real disturbances. During the period from the devaluation of the main European currencies in 1949 until the 'sixties', the United States was faced with anti-trade biased growth in the European Economic Community.

From 1958 on, direct foreign investment was growing and was speeding up the transfer of technology from the United States to the rest of the world. Foreign subsidiaries were linking up with United States-based sales organizations to increase imports substantially. The payments crisis was caused by the failure

[19] For an excellent analysis of this period see [38].

of the U.S. authorities appropriately to adjust their international competitiveness to the degree necessary. In this they were inhibited by the requirements of domestic economic goals and by the international role played by the dollar in the Bretton-foods system. This is not to deny that the United States did not sacrifice its international target to domestic'-goals in the late 'sixties' and early 'seventies', and that monetary policy was from the viewpoint of international balance excessively expansionary. But the whole diagnosis cannot be laid at the door of a single economic dimension (real or monetary) to the exclusion of the other.

This position on the part of the international monetarists is the more surprising in view of the position taken by Milton Friedman on the inability of monetary measures to affect a permanent cure for a real malady [9]. Like Wicksell, Friedman emphasized differences between the monetary rate and the real rate and perceived differences between the two to be a major source of trouble. But according to Friedman, the monetary rate had to accede to the requirements of the real sector.

The question of the degree to which monetary factors can influence real factors so as to recreate a disequilibrium situation is still not answered. It is reasonable to suggest that monetary factors cannot reestablish an equilibrium out of a situation that is in flagrant disequilibrium--as for example In the 1930s. However, what if the disequilibrium is only a minor one? In this, Leijonhufvud's concept of a corridor is usefu1[25]. He argues that a system can reassert itself from a shock or disturbance if the disturbance is relatively small but that after some critical size, the displacement becomes too great (the corridor is exceeded) and the system's stability is lost. Monetary influences may be able to remedy a disequilibrium situation if they are capable of continuing to transmit signals to the real sector without the financial system collapsing under the strain. What is at issue here is the distinction between prevention and cure.

Monetary factors are capable of preventing incompatibility from arising and they are capable of preventing a monetary disturbance.[20] But once the incompatibility exists, the ability of monetary factors to guide the economy back to the appropriate stance depends upon the resilience of the international financial system. This limitation of the Monetary Approach must be laid bare if the Monetary Approach is not to be seen as a mechanism that says merely that monetary factors can create monetary disturbances and monetary factors can be used to reassert the status quo ante.

(VI) Asymmetric Reactions. The Monetary Approach posits that the international payments of a nation can be brought into balance by appropriate changes in the money supply of the focus nation and that there is no significant difference between a devaluation and a reduction in the money supply. The complete substitutability of a change in the domestic credit base and a change in the exchange rate is an oversimplification since it neglects the inter- and intranational wealth distribution effects of the two policies and because it assumes that national economies react to decreases in the money supply ln the same way as they react to increases in the money supply--put in more monetarist terms that the reaction to excess real balances and deficient real balances is symmetric. Here again the Monetarist Approach is weakened by its equilibrium framework. The ultimate result of two different policies may be identical but the social cost and dislocation involved In the process of adjustment may be quite different. (11 1 pp. 84-5].

[20] The distinction here is a subtle one. A monetary disturbance occurs when the real factors do not change and the monetary variables do. The prevention of an Incompatibility may involve the movement of real factors with monetary factors standing still-this act of prevention Involves the monetary variables changing with the real factors

The differential wealth effects are analytically obvious even though it may be impossible to verify them empirical or to assess the magnitude in terms of either the final equilibrium or on the adjustment path. The most important distinction between a reduction in the domestic money supply and a devaluation-depreciation is that the latter involves a partial default on debts··to both domestic and foreign creditors--whereas the re-establishment of a lower domestic price level and an appropriate degree of monetary stringency prevents such a partial default--interest-rate effects on capitalized values aside, the purchasing power of debt is the same as before any monetary disturbance.

The more important distinction between the two alternatives cures for a deficit pertains to the different ability on the part of an economy to adapt to decreases in the money supply. Both instruments reduce the money supply measures in terms of foreign exchange or some other constant numeraire-- devaluation does so without reducing the supply of domestic currency and monetary stringency reduces the monetary base. The passivity of the central bank in the face of a deficit (that is allowing the deficit to affect the domestic credit base and to reduce it to the appropriate level) involves both the reduction of prices of non-tradable goods measured in domestic currency and tightened monetary conditions.[21] Reductions In the money supply impose two strains on the economy that do not exist when the money supply is being in-creased or not reduced: the financial system becomes short of liquidity and is more likely to collapse, and people (particularly wage-earners) are generally considered to have money illusion and to resist cuts in real income imposed by cuts in money incomes more strongly than if the cuts are imposed by constant money wages and increased prices. If the character of the economic system is such that some positive rate of increase in money wage-rates is considered socially mandatory in each year, a reduction in money wages is likely to inflict a heavy adjustment cost on the economy. It is also probably true to assert that if the money supply has been increased disproportionately, the financial system will have been tempted to reduce its liquidity to a minimum and therefore be faced with a reduction in liquidity at a time when it can least afford it. The viability of a fractional-reserve system would be severely tested under such conditions.

This asymmetry in reaction implies two things. First, devaluation-deprecation is a much less painful way of reducing the money supply (measured in terms of wage-units or constant purchasing power. This argument is analogous with the recommendation that an increase in the money supply is a more effective way of reducing the rate of interest than a reduction in the price level and the money wage-rate [23, pp. 266-9]. Second, the strain imposed upon the financial system is much more likely to cause what Leijonhufvud describes as an effective demand failure by imposing on the economy a disturbance of a sufficient magnitude that the "corridor of stability" is exceeded [25].

SECTION IV

Section II of this paper developed the concept that the proper degree of complexity in a piece of economic analysis depended very directly upon the purpose of that analysis. Theories concerned with macroeconomic policy are inevitably concerned with the process of adjustment. Given that macroeconomic policy-oriented analyses relate to the process of adjustment and not to the conditions that hold after the realization of the policy goal, such analyses must include all of those variables that can be expected to change independently of the theory during the period of adjustment. These variables will

[21] This Is true in the static model in which no real growth takes place and no concomitant increase in the money supply is required. In a growth economy, the money supply could stilt Increase absolutely even though money were becoming tighter. Clearly, a reduction in the money supply implies a sizeable deficit, a fast elimination of the deficit or some combination of the two. The text is expressed in terms of the tatlc model for ease of exposition.

inevitably influence the process by which the economy is to achieve its prescribed target. The introduction of an uncertainty dimension was, in consequence, seen as mandatory for macro-economic policy-oriented analyses.[22]

The introduction of uncertainty combined with a large number of variables may preclude determinate and precise policy solutions being obtained. This lack of determinacy merely demonstrates a limitation of economics 2 discipline or science and does not denote any lack of quality in the theory itself. While there is no hard and fast rule by which the requisite degree of complexity can be defined and there is a range of choice open to the analyst, the failure to include uncertainty does preclude a theory from being described as policy-oriented if it has a short-run macro-economic context. But the failure to include an uncertainty dimension does not mean that a piece of analysis is not productive and valuable.

Methodology in economics has so far failed to distinguish the various categories of analyses sufficiently finely. It is not only desirable, it is necessary to distinguish clearly between policy-oriented analyses and those theories that provide insights on which policy-oriented analyses can draw and upon which they must rely. This second category of theories, usually devoid of uncertainty, can be called “basic analyses”. Frequently this type of analysis will be set in a general equilibrium framework. It need not be static but any dynamism will be constrained to fit into a schema of moving and continuous equilibrium. Basic analyses must be careful not to imply a degree of direct relevance that they cannot possess and should recognize explicitly the basic quality of the theory so that neither the reader nor the analyst is misled.

The distinction between the two kinds of analysis can be made clearer by referring to Joan Robinson's plaint that modern orthodoxy has stifled the true intent and character of Keynes' General Theory [36]. Modern orthodox Keynesianism can be said to have pushed the policy-oriented model backwards (upwards in terms of Figure 2) into a basic analysis. Whatever important contributions so-called Keynesian orthodoxy has produced have to be weighed against the cost of sacrificing the flexibility of the policy-oriented model for the stolidity of basic analysis.

The Monetary Approach is an example of valuable basic research and makes important contributions that can usefully be incorporated into the core or general theory of balance-of-payments adjustment. The emphasis on the official settlements or monetary balance and the relationship between monetary restraint and an increase in the level of International reserves represent significant improvements over the "elasticities approach." There is a danger that by concentrating on the overall balance the Approach will fall to indicate whether or not any fundamental disequilibrium exists in the real sector or in the monetary sector but that problem can be taken care of by observing the trend of the basic balance [11, p. 207]. But the most important contribution of the Monetary Approach is the emphasis that it puts upon the avoidance of monetary disturbances by prevention. Prevention means that monetary policy shall never be used by a nation's authorities for domestic purposes without reference to its effects on the balance-of-payments. There is an ever present need to guard the attractiveness of money holdings in a certain currency as well as the competitiveness of national industries and, to the extent that the equation of exchange will prevail whenever full employment is attained, monetary policy must always have its international payments implications explicitly laid bare. The Monetary Approach also has a value in the determination of global inflation because of its emphasis on relative rates of monetary creation in different nations and in the need

[22] There are, of course, areas of policy-analysis for which general equilibrium is quite suitable. These are usually resource-allocation or income- distribution problems when the policy stance is literally Incapable of change during a period of adjustment. An example of such policy-oriented analyses would be the work on tax-incidence by E. R. Rolph and others in the 'fifties.'

to avoid the neutralization of a devaluation-depreciation by allowing excessive monetary growth after the event.

The Approach calls more strongly than the orthodox model for international consultation on an even harmonization of balance-of-payments policies, monetary growth rates and other policy measures. This surely is a major contribution in a world in which nation states guard their independence jealously and often try to subvert the social discipline of the market mechanism in the short run. The weakness of the Approach is that it is not policy-oriented analysis because it fails to include the necessary uncertainty dimension and is unable realistically to integrate adjustment to real disturbances within its framework. The price paid by the Approach in terms of the restrictiveness of its assumptions is too high: composite goods, disregard of international net worth considerations, the underlying suggestion that monetary factors can divert or dominate real factors and the failure of the theory to recognize the independence of the goal-setting process by independent nation states. All of these assumptions simplify the Approach too greatly for it to be installed as the core theory of balance-of-payments adjustment that must apply in the hurly-burly of the short run.

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A Method of Developing a Simulation for US Income Tax Returns

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Introduction

We live in an era where large amounts of data are collected everyday, and used by organizations and researchers for greater insights. Sometimes data cannot be made available due to privacy issues, regulatory constraints, or complexity of data. Even with the large amounts of data available, simulated data can provide researchers with a strong realistic dataset for analysis across domains and well-crafted simulated data can be used to develop new theories, examine policy changes, and review the effects of behavioral changes.

The aim of this paper is to propose and test the development of a simulation for use in the business domain, specifically in the field of accounting and taxation. The need for simulation data in business has been demonstrated and proposed for teaching cases in accounting (Sledgianowski and Petra, 2018), managerial accounting (Koeplin, 2005), and interactive game simulation in accounting (Milner et al., 2008). The purpose of any simulation is to provide a clearer understanding of an environment and the effect of changes to that environment (Sargent, 2013). By developing a system whereby simulated tax returns for any given year can be produced, students of taxation and policy makers will benefit by being able to conduct repeated testing on returns using different stratifications such as adjusted gross income (AGI) , filing status, or state where the return is filed.

Drawing from statistical and economic theory regarding the various components of a tax return, which are primary elements on any economy, such as income and number of dependents, we create distributions using the prevailing economic theories about income using information regarding most recent tax returns available from the Internal Revenue Service (IRS) Statistics of Income (SOI) division. We create a simulation system to produce 147,000 tax returns, representing approximately 1% of the population, and validate the output. The results of the methodology and validation are presented below.

Literature Review

Simulation Theory

Simulations attempt to model the "real world" for researchers in a way that can help identify the effects of changes to an ecosystem or highlight naturally occurring phenomena (Banks et al, 2005). Simulations can be quite rich in providing analysis however it has its detractors. Researchers have argued about the benefits and the disadvantages of using simulations. Further validating simulations can be problematic (Sargant, 2013), and others have discussed concern with the validation of economic models and social science models (Kliendofer et al. 1998).

The role simulations play in providing insights to test theories and ideas, identify bottlenecks, and experiment with different conditions can be invaluable in a different number of business settings including accounting (Shannon, 1998), but, there is a paucity of simulation use in fields such as accounting and taxation where academics rely on a posterior data to teach or analyze effects. There are increasing calls for more active learning techniques in accounting, where simulations and simulated data can be easily leveraged (Libby, 1991; Phillips and Graeff, 2014). In their review of curriculum resources available for integrating Big Data and information technology into the accounting curriculum, Sledgianowski, Gomaa, and Tan (2017) found limited curriculum resources, including data sets, available to demonstrate changes in tax policy. Grummel (2003) argues that policy makers must estimate the effects of changes in tax policy in order to determine the worthiness of such policies.

The physical sciences such as physics, biology and astronomy utilize simulations widely due to the cost or impractical nature of physical experiments (Banks et al, 2004). In social sciences there is a growing trend to use simulations to identify human behavior under varying circumstances such as individual behaviors in population, financial and social policy interventions, and analyzing information flows among interactions (Gilbert and Troitzsch, 2005). In business, the use of simulations has expanded to identify traditional customer segmentation (Burns and Gentry, 1992), personality and culture in organizations (Chatman and Barsade,1995), and decision making (Farias, 1998). Economists have used simulations to further understand the effect of economics of sustainable energy systems (Ketter et al., 2013), and regional impact of monetary policy in economies at large, (Fishkind, 1977), and the effect of household behavior and prices (Gottwalt et al., 2011). Information economics uses electronic auction simulations to test theories regarding auctions such as first price auctions, group buying and Dutch auctions (Neugebauer and Selten, 2006; Pelaez et al., 2013).

Simulations can be classified as a numerical algorithm or system that can describe the behavior of an economic system (Shannon, 1998). The key to a simulation is appropriately modelling the stochastic portion of the simulation (Kellner et al., 1999). For example, a successful simulation of tax returns would closely identify a series of stochastic distributions and use these as inputs to produce a series of returns thereby modelling the entire population of United States individual

tax return filings. These input distributions would include the distribution of income, filing status, filing state, number of dependents, etc. Some distributions are continuous and bounded, such as income, while others are discrete, such as the number of exemptions and filing status. Therefore, to effectively model all tax returns, the final simulation must take into account the different distributions for these items coalesced from previous research and tie them to the statistical information provided by the IRS about the entire set of returns.

The Statistics of Income (SOI) is a program of the IRS with the mandate to produce annual statistics of the application of tax code as it affects various strata of the United States including individuals, profit and not-for-profit businesses, estates, etc (SOI-Tax-Stats). The information provided by SOI includes categorical data of anonymized individual tax return filings. For our simulation, we used the information provided about adjusted gross income (AGI), filing state, and filing status, along with other line item information. Using this information, our goal is to identify the distributions that make up the key components of each return in an effort to produce a very large simulated data set of returns. The following presents our evolving methodology on how we have proceeded to create the data set.

Methodology

Our approach to creating a simulated data set involved utilizing the information provided by the IRS SOI. However, the IRS SOI does not provide any information on the statistical distributions, and therefore we used relevant literature to inform how the simulation could be created. There were two primary goals for the simulation. The first goal was to accurately model the AGI distribution, and the second was to model categorical, or binned, items such as filing status, states, deductions, exemptions and dependents.

AGI Distribution

In order to create valid simulated tax return data, first we need to understand the distribution of the Adjusted Gross Income. Over the last couple of decades, researchers conducted many studies to better understand how income is distributed. McDonald (1984), studied the relationship between macroeconomic variables and income inequality using the Generalized Beta Distribution of the Second Kind (GB2) as a means of modeling income. GB2 is a continuous probability distribution with 4 parameters, μ, σ, ν, and τ, which describe the location, scale, skewness and kurtosis. Dastrup et al. (2006) studied the impact of taxes and transfer payments on the distribution of income in 13 countries, and found that total income follows a Generalized Beta of the First Kind (GB1) distribution, but the fit of earnings data was better represented by GB2. Other researchers have studied the GB2 distribution for income and have found that it significantly outperforms other nested forms of beta distribution for modelling the United States income data.

The IRS provides limited information on AGI by presenting tabular information in a group format

with associated mean of AGI and total number of tax returns in each bin. The bins for AGI are referred to as the “AGI Stub”, which represents the size of adjusted gross income within a particular range. The distribution of income, or any other statistical parameter, is not provided by the IRS. Therefore, we infer the distribution of Adjusted Gross Income will follow the same distribution as income, more specifically, earnings, since the AGI is derived from income. Using this premise, we create our AGI dataset using GB2; however, the parameters to the GB2 are not known, thus, we developed a method to identify the appropriate parameters. Since the US income is generally a left bounded, right skewed distribution, GB2 distribution could be considered as a good fit to model the US income data.

In order to create GB2 parameters, we developed a set of iterative steps using simulation techniques in R to create the dataset. There are 10 bins of income provided by IRS, in which each bin represents the total gross income for a specific range for a given tax year (**15in54cmcsv.csv** - Individual Income and Tax Data, by State and Size of Adjusted Gross Income, Tax Year 2015). Our first step was to produce sample returns for each of the bins. Thus, within each bin we produce a sample with a uniform distribution, using the min and max of each bin, i.e. AGI amount for the bin. Using the `runif` function in R, we populated the number of returns required for each bin as given by the IRS, and the minimum and maximum of the income for each target bin. Since, the tail of the last bin, income greater than $1MM, is unknown, i.e. the maximum amount in the largest bin is unbounded, we did not simulate any returns for this bin during this first stage. This step is repeated n-times, where n is a simulation parameter, creating n sets of simulated returns for each bin. We compare the total dollar amount of returns in each simulated bin, with the total dollar amount for returns in each bin reported from the IRS. The final set of returns in each bin is chosen from the set which has the smallest difference in terms of dollar amount.

The complete dataset which contained all randomly produced returns for bins 2-9, was fed into the `ml.fit.gb2` function to calculate the parameters of the GB2 distribution. The GB2 parameters μ, σ, ν, and τ, which are respectively referred as shape1, scale, shape2, and shape3, are then used to generated a random dataset using the `rgb2` function in R representing the AGI data. This dataset is left bounded at zero and unbounded from the right, therefore, it contains the last bin of data which was left out in the first step. We repeat the process of creating GB2 distributed random returns n-times and compare the total AGI amount of all the bins less than $1MM with the original total AGI amounts for the same bins provided by IRS. The goal was to chose the sample that has the closest total dollar amount of AGI to the total AGI estimation reported by the IRS. Figure 1 graphically demonstrates how the GB2 distribution with the identified parameters align to the uniform distribution,derived from the IRS tabular information.

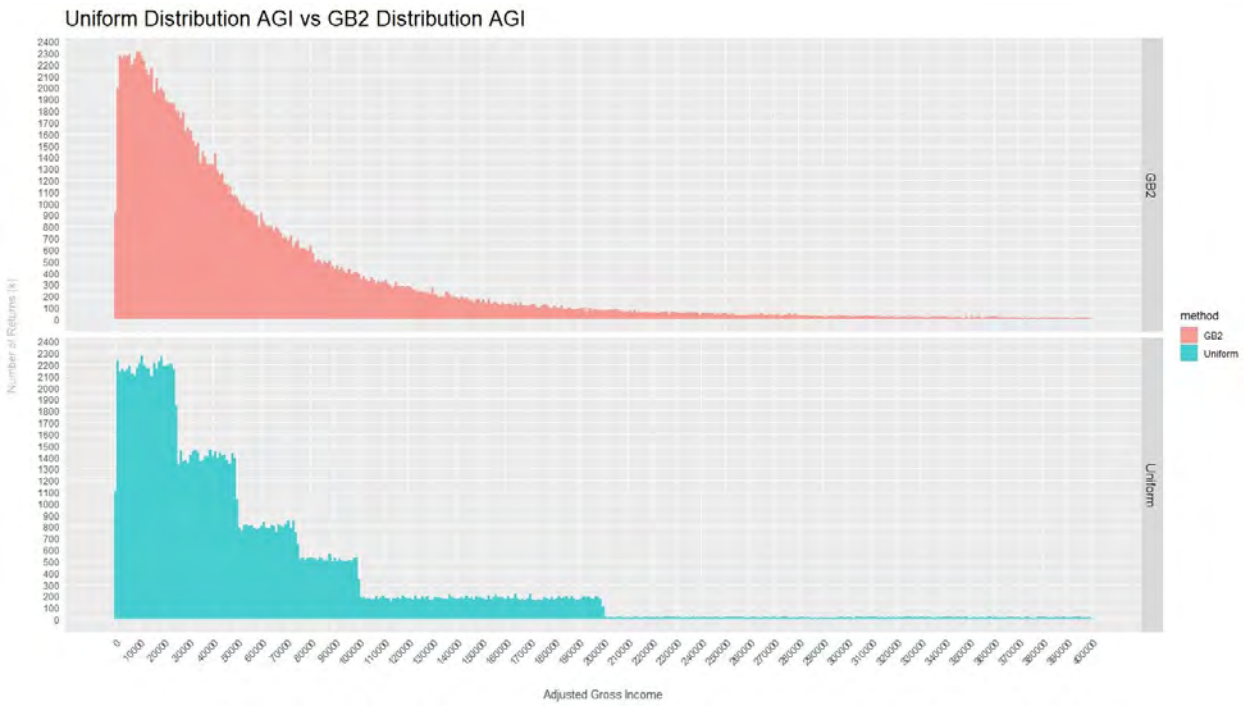

Figure 1: Graphical comparison of the GB2 dIstribution to the estimated uniform distribution for income

We compared the full results of our simulated set with the information from the IRS. The results determined that the majority of errors for GB2 dataset are related to the tail, i.e. incomes greater than $200K. We combined the returns less than 200K from the GB2 dataset with the returns between $200K and $1MM from the uniformly distributed random data, in an attempt to reduce the tail end errors. This new dataset was fed again into `ml.fit.gb2` function again to produce new GB2 parameters. Using the new parameters, we produced a complete simulated AGI dataset. We repeat this process of creating GB2 distributed random returns n-times and compare the total AGI amount of all the bins less than $1MM with the original total AGI amounts for the same bins provided by IRS.

Once the simulated final set is identified, for bins 2-9, the returns with amount of zero, i.e. “No Adjusted Gross Income” was added to the final simulated dataset based on the total number of returns with no adjusted gross income provided by the IRS. The final AGI Dataset, which has the minimum difference we call the Golden AGI dataset. This final sample follows a GB2 distribution matching a similar distribution of US income as the literature indicates. Table 1 provides an overview of the performance of the individual distributions and then the combined distributions.

AGI STUB	Actual	Uniform	ER	GB2	ER	GB2 + UNIF	Error

2	113,014,218	107,818,588	4.6%	113,707,924	-0.6%	117,774,798	-4.2%
3	564,191,288	576,645,783	-2.2%	52,390,8485	7.1%	536,601,048	4.9%
4	1,269,641,505	1,313,434,013	-3.4%	1,289,491,691	-1.6%	1,306,280,477	-2.9%
5	1,226,659,619	1,246,305,955	-1.6%	1,250,658,878	-2.0%	1,293,363,680	-5.4%
6	1,119,853,093	1,131,336,682	-1.0%	1,063,883,334	5.0%	1,038,155,400	7.3%
7	2,480,181,406	2,747,496,519	-10.8%	2,450,950,121	1.2%	2,291,438,404	7.6%
8	1,544,179,196	1,905,039,448	-23.4%	2,024,710,802	-31.1%	1,811,441,744	-17.3%
9	583,356,220	647,013,538	-10.9%	679,115,171	-16.4%	565,138,139	3.1%
Total	8,901,076,545	9,675,090,527	-8.7%	9,396,426,406	-5.6%	8,960,193,691	-0.7%
10	1,450,665,049	N/A	N/A	470,322,029	67.6%	403,167,304	72.2%

Table 1: Comparison of Dollar Values in AGI Stub buckets between distribution

Binned Items (e.g. Discrete Items)

The Golden dataset only reflects the US Adjusted Gross Income in total for each bin. However, the aim of this simulation is to produce a dataset with more granular information at the state level, and filing status, along with other metrics for deductions and adjustments. The **15in54cmcsv** file provided by the IRS, contains the total dollar amount and total number of returns for each state per income level. In order to determine the number returns for each state, we ran a proportional allocation process, in which for each state we calculated the percentage of returns, and the AGI dollar amount at a state level. We used an iterative process to ensure the total amount within each AGI / state bin has the least error, in comparison with the actual data, in a similar fashion to the iterative process we ran on previous steps.

The 15in54cmcsv file also divides each AGI / state bin into four different filing statuses (Single, Married Filing Joint, Married Filing Separate, Head of Household). The same process, as above, was used to calculate the total dollar amount of returns for each filing status. Other binned items, for example, items such as State and Local Income Tax (SALT) deduction, real estate tax deduction, mortgage interest paid deductions, charitable deductions, etc., are calculated based on the mean provided for each AGI/state bin. Not every deduction in the tax form is applicable to every return. Only a proportion of the returns have some of these itemized deductions, which were estimated and identified based of the probability provided by the IRS. Since the IRS does not provide any parameters for these deductions, we can not identify a reasonable distribution for these binned items, and therefore, based on the probability of a return having the stated deduction, we attempt to flag returns using a binomial distribution. For instance, some states do not have SALT deduction and therefore returns for those states will get zeros for the amount of State and Local Income. The process of flagging returns for each item in the tax form was used to identify returns with the applicable items within each AGI bin. We used `rbinom` function in R to create flags for applicable items for each return based on the percentage of returns having a specific itemized deduction and filled the value for the deduction based on the mean provided in the **15in54cmcsv** for each item for the AGI / state combination.

The number of exemptions is comprised of multiple pieces derived from filing status and number of dependents. For a particular filing status, there exists a minimum number of exemptions. For instance, a single filing status would only have 1 exemption. Therefore, some of the exemption values which are based on filing status are predetermined and do not require any distribution calculation. However, the number of dependents is a discrete variable, which follows a poisson distribution (Jennings et al., 1999) and therefore the number of dependents is calculated based on this distribution.

Our final simulated result set produced 147K simulated returns form across all 50 states in under 15 minutes. The Appendix provides a table showing the performance of our simulation against the IRS reported measures by each AGI bin. Further, we provide a table with the performance of NY, CA, and CT. Finally, we provide a sample record from the simulation.

Discussion and Limitations

Using the literature review and analytical methods we were able to successfully complete a simulation of the US tax returns across varying states and filing status. Our error rates for most of the buckets were less than 5%, and we are optimistic in our approach that we will be able to further refine the error rates and provide a very robust and accurate sample set of returns for use in case study and policy analysis.

Limitations

The tail of the distribution provides one of the most significant challenges. Previous research has demonstrated the challenge of the higher income, right tail, and thus researchers show that a power-law, Pareto distribution, might be an alternative (Singh and Madalla, 2008). The challenge includes the unbounded nature of the right tail, coupled with a different shape (Singh and Madalla, 2008). Additionally, the IRS does not provide any information other than descriptive measures for some of the binned items, e.g. SALT Deduction, and therefore more research is required to determine if any possible distribution could be uncovered, which will strengthen the simulation result set.

The aim of the simulation is to produce a significant dataset that could be used for teaching and possibly for examining policy changes. Our small samples, 147K returns found some issues with smaller bins, such as high end earners in states, with small percentages of filings for a given filing status. Therefore, additional efforts are being explored to meet the challenges of ensuring a certain number of returns available within these buckets. Our current approach focused on ensuring the minimal error of a sum AGI dollar value for each bin. This sacrifice caused the issue of smaller than predicted number of returns for some small bins. Therefore, we are examining ways of rectifying this issue.

Additional research and testing should be conducted on the GB2 distribution and the parameter estimates. While our efforts have been clear in identifying the best parameters for the GB2 distribution, we encourage additional research on the use of this distribution and possibly see how other factors such as GDP, unemployment, etc. could impact the distribution and therefore the results.

Conclusion

The resulting simulated dataset represents a strong move forward toward the development of simulated data in accounting. Thereby, allowing for better training through the development of case studies and learning exercises, as well as testing and validating policy changes to determine the possible effects of those changes. This paper focuses on how the simulation was developed and provides a model for the development of other simulations. It is essential for researchers in analytics to use fundamental knowledge of distributions in order to properly identify the stochastic portion of line items on the tax return to be simulated. We further believe this approach could be leveraged for other obfuscated data such as healthcare claims, in which government entities only provide aggregated, binned information, for which the distributions are not provided or readily known.

APPENDIX

Appendix 1: AGI STUB From IRS Definition (2015)

AGI STUB	Definition
0	No AGI Stub
1	‘Under $1’
2	'$1 under $10,000'
3	'$10,000 under $25,000'
4	'$25,000 under $50,000'
5	'$50,000 under $75,000'
6	'$75,000 under $100,000'
7	'$100,000 under $200,000'
8	‘$200,000 under $500,000’
9	‘$500,000 under $1,000,000’
10	‘$1,000,000 or more’

(Source: 15incmdocguide.doc - irs.gov)

Appendix 2: Comparison of Actual Returns / Simulation (US)

AGI STUB	Actual	Simulation	Error
2	113,014,218	115,159,189	-1.9%
3	564,191,288	529,537,320	6.1%
4	1,269,641,505	1,313,372,561	-3.4%
5	1,226,659,619	1,270,202,315	-3.5%
6	1,119,853,093	1,055,053,077	5.8%
7	2,480,181,406	2,402,095,486	3.1%
8	1,544,179,196	1,832,762,349	-18.7%
9	583,356,220	627,196,855	-7.5%
10	1,450,665,049	502,302,088	65.4%

(in US dollars)

The table above shows the tax return cumulative dollar amount for each AGI STUB for 147K returns and compares these values to the simulated returns. We provided the error rate for each of the AGI Stub buckets

Appendix 3: Comparison of Actual Returns / Simulation (NY, CA, CT)

New York

AGI STUB	Actual	Simulation	Error
2	7,763,544	7,817,792	-0.7%
3	35,130,853	33,216,257	5.4%
4	76,039,110	77,397,913	-1.8%
5	78,326,064	80,167,184	-2.4%
6	70,814,434	64,127,972	9.4%
7	167,667,604	162,534,537	3.1%
8	115,024,969	134,611,613	-17.0%
9	51,488,125	48,580,301	5.6%
10	199,755,393	44,478,528	77.7%

(in US dollars)

California

AGI STUB	Actual	Simulation	Error
2	12,337,767	12,423,307	-0.7%
3	63,480,036	67,758,915	-6.7%
4	148,424,996	147,161,392	0.9%
5	146,475,591	139,489,257	4.8%
6	114,481,108	126,874,038	-10.8%
7	307,059,700	322,901,931	-5.2%
8	302,555,613	250,406,351	17.2%
9	100,208,721	94,489,429	5.7%
10	82,538,011	255,186,461	-209.2%

(in US dollars)

Connecticut

AGI STUB	Actual	Simulation	Error
2	1,235,343	1,330,922	-7.7%
3	5,344,230	5,000,547	6.4%
4	13,402,509	13,146,341	1.9%
5	14,875,742	15,177,946	-2.0%
6	14,419,990	13,371,925	7.3%
7	38,235,748	36,085,325	5.6%
8	28,201,691	37,321,681	-32.3%
9	12,817,951	12,757,631	0.5%
10	41,362,815	16,235,645	60.7%

(in US dollars)

The tables above show the tax return cumulative dollar amount for each AGI STUB for given states and compares these values to the simulated returns. We provided the error rate for each of the AGI STUB buckets

Appendix 4: Sample tax return from the simulation (NY)

Line Item or Field in Tax Return	Value of Field
1040:38 AGI amount	7899.20
States	NY
Filing status	MARS1 (Single Filing Status)
Schedule a (itemized/ standard)	itemized
1040:40 Total	6442.74
1040:40 standard deduction amount	0
Schedule A:5a State and local income taxes amount	0
Schedule A:6 Real estate taxes amount	6442.74
Schedule A:10 Mortgage interest paid amount	0
Schedule A:19 Charity amount	0
1040:12 Business or professional net income (less loss) amount	0
Schedule E:32 Partnership/S-corp net income (less loss) amount	-2059.74
1040:35 Domestic production activities deduction amount	0
1040:6d Number of exemptions	0
exemption amount	0
1040:6c Number of dependents	0
1040:52 Number of returns with child tax credit	0
1040:52 Child tax credit amount	0
1040:43 Taxable income amount	1456.46
1040:44 Tax	145.65
1040:56 Income tax amount	145.65
1040:56 Income tax amount with negative numbers	145.65

(all amounts in US dollars)

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Title: Changes in Companies' Non-GAAP Reporting Behavior in Response to SEC Rule Revisions.

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ABSTRACT

The purpose of this paper is to explore the current extent of non-GAAP income reporting by publicly traded companies and the possible impact the 2010 change in Regulation G and S-K has had on corporate reporting behavior. Our sample is comprised of those companies listed in the Standard and Poor's (S&P) 100 for the year 2014. We collected the 4th quarter earnings releases of these companies for the years 2010 through 2016 to study their reported annual non-GAAP income disclosure, if any. We show that the relaxation of Regulation G and S-K in 2010 appears to have resulted in more frequent reporting of non-GAAP income measures.

INTRODUCTION

A non-GAAP financial measure is a numerical measure that adjusts the most directly comparable GAAP measure reported on the audited financial statements. Non-GAAP financial measures are not a required disclosure but are often reported in the Management's Discussion and Analysis section of a company's quarterly, 10-Q, or annual, 10-K, financial report filings. They also can be reported in earnings releases and other forms of communication a company uses to provide additional insight into its business beyond that found in the financial statements prepared according to US GAAP. Non-GAAP measures are not subject to audit; however, they are regulated by the SEC. Public companies must comply with Regulation G which addresses all non-GAAP financial disclosures as well as Item 10(e) of Regulation S-K, which addresses non-GAAP information included in SEC filings. Therefore, there is additional regulation imposed on non-GAAP disclosures in the 10-Q or 10-K filing. Common non-GAAP financial measures are earnings before interest, taxes, depreciation and amortization (EBITDA), adjusted EBITDA, and non-GAAP Income. These measures often parcel out different aspects of a company's operations and/or remove the effects of large, unusual, and/or non-recurring transactions. (PWC, 2014). The calculation of these measures is highly subjective and is not necessarily comparable across industries or companies.

REGULATORY BACKGROUND

The SEC issued its *Final Rule on the Conditions for Use of Non-GAAP Financial Measures* in 2002, effective March 28, 2003. They adopted a new disclosure regulation, Regulation G, which would require that public companies which disclose non-GAAP financial measures to include the most directly comparable GAAP financial measure and a reconciliation of the disclosed non-GAAP financial measure to that most directly comparable financial measure. Within this rule, the SEC adopted amendments to Item 10 of Regulation S-K and S-B and Form 20-F to provide additional guidance to public companies that report non-GAAP financial measures in their SEC filings. They also amended Form 8-K which applies to earnings releases and similar announcements. (SEC, 2002).

The Rule specifically noted, "For purposes of Regulation G, a non-GAAP financial measure is a numerical measure of a registrant's historical or future financial performance, financial position or cash flows that (1) excludes amounts, or is subject to adjustments that have the effect of excluding amounts, that are included in the most directly comparable measure calculated and presented in accordance with GAAP in the statement of income, balance sheet or statement of cash flows (or equivalent statements) of the issuer; or (2) includes amounts, or is subject to adjustments that have the effect of including amounts, that are excluded from the most directly comparable measure so calculated and presented." The Rule also stated that public companies must not, "exclude charges or liabilities that required, or will require, a cash settlement" or "adjust a non-GAAP performance measure to eliminate or smooth items identified as non-recurring, infrequent or unusual, when the nature of the charge or gain is such that it is reasonably likely to recur within two years, or there was a similar charge or gain within the prior two years." (SEC, 2002).

"Regulation G and the amendments to our rules are intended to ensure that investors and others are not misled by the use of non-GAAP financial measure," and that the reconciliation of the non-GAAP financial measure with its most directly comparable financial measure, "will help investors and market professionals to better evaluate the non-GAAP financial measures presented." The SEC believes that the reconciliation "will provide the securities markets with additional information to more accurately evaluate companies' securities and, in turn, result in a more accurate pricing of securities." (SEC 2002).

In 2010, the SEC's Division of Corporation Finance updated and significantly moderated its Compliance and Disclosure Interpretations (C&DIs) related to non-GAAP financial measures, indicating there will be fewer objections to the disclosure of such measures in SEC filings. The SEC was concerned that companies were not providing meaningful information to investors due to the original stricter guidance. In particular, the original Rule made it difficult for a company to justify and defend the disclosure of a non-GAAP financial measure that excludes a recurring item. The modified CDI specifically stated, "The fact that a registrant cannot describe a charge or gain as non-recurring, infrequent, or unusual, however, does not mean the registrant cannot adjust for that charge or gain. Registrants can make adjustments they believe are appropriate, subject to Regulation G and other requirements of Item 10(e) of Regulation S-K." (EY, 2010).

The relaxation of the Rule opened up a doorway for companies to determine what is appropriate to exclude from GAAP earnings in arriving at a non-GAAP financial measure. Growing concern over the inconsistency, lack of comparability and possible misleading effects of non-GAAP measures led the SEC to revisit the guidance. SEC Chair Mary Jo White discussed the topic in a December 2015 Speech at the AICPA National Conference.

> "Another financial reporting topic of shared interest and current conversation is the use of non-GAAP measures. This area deserves close attention, both to make sure that our current rules are being followed and to ask whether they are sufficiently robust in light of current market practices. Non-GAAP measures are allowed in order to convey information to investors that the issuer believes is relevant and useful in understanding its performance. By some indications, such

> as analyst coverage and press commentary, non-GAAP measures are used extensively and, in some instances, may be a source of confusion.
>
> Like every other issue of financial reporting, good practices in the use of non-GAAP measures begin with preparers. While your chief financial officer and investor relations team may be quite enamored of non-GAAP measures as useful market communication devices, your finance and legal teams, along with your audit committees, should carefully attend to the use of these measures and consider questions such as: Why are you using the non-GAAP measure, and how does it provide investors with useful information? Are you giving non-GAAP measures no greater prominence than the GAAP measures, as required under the rules? Are your explanations of how you are using the non-GAAP measures – and why they are useful for your investors – accurate and complete, drafted without boilerplate? Are there appropriate controls over the calculation of non-GAAP measures?" (White, 2015).

The frequency of non-GAAP (or "pro forma") reporting continued to increase despite preliminary evidence that regulatory intervention led to a decline in non-GAAP disclosures. In particular, the Sarbanes–Oxley Act of 2002 (SOX) and Regulation G (2003) impose strict requirements related to the reporting of non-GAAP numbers. More recently, the SEC placed heightened focus on non-GAAP reporting and declared it a "fraud risk factor." (Black et al., 2017)

In May 2016, the SEC issued new CDIs and amended others reflecting the unease with the proliferation of the reporting of non-GAAP financial measures as well as the types of adjustments being made to GAAP measures. Key provisions of the new guidance include:

- Certain adjustments may violate Regulation G because they cause the presentation of the non-GAAP measure to be misleading even though they are not expressly prohibited by Regulation G.
- A non-GAAP measure that adjusts a particular charge or gain in the current period for which similar charges and gains were not adjusted in prior periods could violate Regulation G.
- A non-GAAP financial measure that is adjusting only for non-recurring charges when there were also non-recurring gains in the same period could violate Regulation G.
- A non-GAAP financial measure may not be presented with greater prominence than the most directly comparable GAAP measure. Examples of non-GAAP presentations that are more prominent and may violate Item 10(e) of Regulation S-K include:
    - Presenting a full income statement of non-GAAP financial measures, even if the presentation is used to reconcile these non-GAAP measures to the most directly comparable GAAP measures.

- Presenting a non-GAAP measure that precedes the most directly comparable GAAP measure or omitting the comparable GAAP measures from an earnings release headline or caption.
- Presenting a non-GAAP measure with the style of presentation (e.g., bold or larger font) that emphasizes the non-GAAP measure over the comparable GAAP measure.
- Describing a non-GAAP measure as "record performance" or "exceptional" without at least an equally prominent descriptive characterization of the comparable GAAP measure.
- Excluding a quantitative reconciliation with respect to a forward-looking non-GAAP measure in reliance on the "unreasonable efforts" exception in Item 10(e) of Regulation S-K without disclosing that fact and identifying the information that is unavailable and its probable significance in a location of equal or greater prominence.
- Providing a discussion and analysis of a non-GAAP measure without a similar discussion and analysis of the comparable GAAP measure in a location with equal or greater prominence.

- The prohibition of adjusting a non-GAAP financial performance measure to eliminate or smooth items identified as non-recurring, infrequent or unusual is based on the description, not the nature, of the charge. It would not be appropriate to say that a charge or gain is non-recurring if it is reasonably likely to recur within two years or there was a similar charge or gain in the prior two years.

- Free cash flow is a liquidity measure and must not be presented on a per share basis. A clear description of how this measure is calculated, as well as any necessary reconciliation, should accompany the measure.

- Registrants should provide income tax effects on its non-GAAP measures depending on the nature of the measure, such as a liquidity measure or performance measure. Adjustments to arrive at non-GAAP measures should not be presented net of tax, rather, the income tax adjustment should be presented separately. (SEC, 2016).

LITERATURE REVIEW

Research in the area of non-GAAP income reporting has explored changes in reporting behavior pre and post regulatory enforcements, value relevance of and market reaction to the non-GAAP income disclosure, and opportunistic non-GAAP earnings management. Our research focuses on changes in the reporting behavior of publicly traded companies. Our work extends Nicholas et al. (2005) and Webber et al. (2013). Nichols et al. (2005) study the earnings releases of companies reporting pro forma (i.e. non-GAAP) results from 1999 through 2004, specifically focusing on the items included in pro forma adjustments and their frequency, the magnitude of the adjustments compared to GAAP, and the rationale for the adjustments. The authors findings indicate pro forma adjustments show significantly higher earnings compared to GAAP earnings and that the magnitude of such differences is highly material.

Webber et al. (2013) examines the extent to which S&P 100 companies disclose non-GAAP income measures in their annual earnings releases. They find that the number of S&P 100 companies disclosing a non-GAAP income measure increases significantly from 44% to 60% during their period of study. They identify repetitive adjustments for the same item in multiple years for about half of the companies reporting non-GAAP income. Those adjustments are restructuring charges, net gains/losses on sales of tangible assets, net gains/losses on sales of financial assets, impairment charges, litigation costs, costs associated with business combinations, and amortization of intangible assets. The authors note that several companies refer to the use of non-GAAP earnings to "evaluate 'ongoing' operating trends". They conclude that a change in tone at the SEC has led to more frequent reporting of non-GAAP performance that had previously been considered to be "potentially misleading".

Much additional research has been performed to evaluate various aspects of non-GAAP income reporting. Bradshaw et al. (2002) show that, over the past 20 years, there has been a dramatic increase in the frequency and magnitude of cases where "GAAP" and "Street" (i.e. non-GAAP) earnings differ. They find a strong tendency towards the reporting of a Street earnings number that exceeds the GAAP earnings number. Afterman (2005) discusses the replacement of pro forma financial information by the "non-GAAP" financial measure with the issuance of Regulation G and Item 10(e) of Regulation S-K in January 2003 as well as the increased use of non-GAAP metrics resulting in more guidelines issued by the SEC. Marques (2006) finds the probability of disclosure of non-GAAP earnings declines in 2003, but the probability of disclosure of other non-GAAP financial measures has an accelerated decline after the SEC intervention. Entwistle et al. (2006) document significant shifts in pro forma reporting for S&P 500 companies between 2001 and 2003. They find that the proportion of firms reporting pro forma earnings declines from 77 to 54 percent and that pro forma is used in a less biased manner by 2003. In addition, firms present pro formas in press releases in a much less prominent and less potentially misleading manner in 2003.

Kolev et al. (2008) find that, on average, exclusions are of higher quality (i.e., more transitory) following intervention by the SEC into non-GAAP reporting. However, when they decompose total exclusions into special items and other exclusions, they find evidence that the quality of special items has decreased in the post-intervention period suggesting that managers shifted more recurring expenses into special items after the SEC regulation. Heflin et al. (2008) find the 2003 regulations resulted in modest declines in the frequency of special and other item exclusions and a decrease in exclusion magnitude. The authors conclude that the regulations reduced firms' willingness to use non-GAAP earnings to indicate permanent earnings. Campbell et al. (2009) find that, post-Regulation G, the proportion of companies disclosing non-GAAP financial measures decreased only moderately and that the most common pre-Regulation G categories of adjustments changed. The authors also note that non-GAAP terminology is inconsistent amongst companies.

Black et al. (2012) find that the regulation of pro forma reporting has increased the average quality of pro forma earnings disclosures by removing the more misleading disclosures. The authors contend that the quality of pro forma reporting has improved following SOX. Baumaker et al. (2014) examine press releases following Regulation G and find that while managers generally provide some information about transitory gains in the earnings announcement, there is

great variation in the disclosure. For example, most managers mention the gain in the earnings announcement but few report non-GAAP earnings per share that excludes transitory gains. The percentage of reporting is significantly lower than in the pre-Regulation G period. Parrino (2016) contends that the appropriate use of non-GAAP financial measures can enhance investor understanding of a company's business and operating results, however, the relatively permissive SEC attitude towards the use of non-GAAP measures in recent years has led to increased reliance on non-GAAP measures by companies in a manner the SEC views as inconsistent with its rules.

Black et al. (2017) find that firms reporting non-GAAP earnings in the post-SOX period are less likely to exclude recurring items incremental to those excluded by analysts. They also find that some firms exclude specific recurring items "aggressively". King (2017) discusses the problems associated with the use of non-GAAP corporate earnings measures and that the disclosure of non-GAAP measures reduces the investor's ability to compare companies' financial results. Bond et al. (2017) find that both *Regulation G* and C&DIs are associated with an increase in the quality of non-GAAP earnings exclusions. The authors define quality exclusions as those that are more transitory and have less predictive power for future operating earnings.

Black et al. (2018) contend that more recent SEC C&DIs may be too restrictive in terms of the types of non-GAAP disclosures and recommend a relaxation of the current enforcement of Regulation G. The authors support FASB proposals for greater "disaggregation" in the GAAP income statement to provide increased transparency in non-GAAP reporting and believe the PCAOB should require auditors to be more involved with the non-GAAP disclosures.

HYPOTHESES

First, we surmise that the liberalization provided by the 2010 change in Regulation G would result in an increase in number of companies reporting non-GAAP earning measures over the subsequent year or two. It seems reasonable that it would take some time for the impact of the regulation change to be reflected in corporate behavior. Second, we predicted that after this initial response, without any additional externality of consequence, the number of companies reporting non-GAAP earning measures would level off.

We formalize these hypotheses as follows:

$$1)\ Ho: p_{2012} \leq p_{2010}$$
$$Ha: p_{2012} > p_{2010}$$

$$2)\ Ho: p_{2016} = p_{2012}$$
$$Ha: p_{2016} \neq p_{2012}$$

Where p_{year} represents the proportion of companies that reported non-GAAP earnings in that year.

DATA

We collected the annual non-GAAP earnings disclosures, where reported, from the 4th quarter earnings releases of companies listed in the 2014 S&P100 for the period 2010 through 2016. The

S&P 100 Index, a sub-set of the S&P 500, measures the performance of large cap companies in the United States. The Index comprises 100 major, blue chip companies across multiple industry groups (S&P Dow Jones Indices, 2018). We selected the year 2014 as the reference year for the companies comprising the S&P 100 as it is the midpoint in the period of study, following the approach taken by Webber et al. (2013).

We used the data from the companies' earnings releases because they provide a relatively less-regulated disclosure compared to those found in the 10-Q or 10-K, due to the additional regulations imposed on SEC filings by Item 10(e) of Regulation S-K**.**

Finding the press releases was a significant manual exercise. We first looked on each company's web page; in many cases we could find a link to recent press releases. When this approach failed, we did a web search, typically looking for the press release in Business Wire (https://www.businesswire.com) or PR Newswire (https://www.prnewswire.com/). We were successful in finding all but four of the press releases covering the time span of our study.

RESULTS

Table 1 summarizes the reporting behavior of the S&P 100 companies over the period of study. Note again that our "base year" was 2014, so not all years have 100 companies in the sample.

One immediate observation is that the percentage of companies disclosing non-GAAP earnings appears to increase substantially from 2010 to 2011 and again from 2011 to 2012, and then levels off. Roughly 50% of the companies disclose on one or more non-GAAP earning measure in 2010 and this number rises to almost 75%.

Row		2010	2011	2012	2013	2014	2015	2016	Total
1	Companies acquired, in bankruptcy, not in existence or filing not found	6	3	2	3			1	15
2	Companies not disclosing non-GAAP information	17	12	12	10	10	8	7	76
3	Companies disclosing non-GAAP measures other than annual earnings	26	21	16	16	18	17	21	135
4	Companies disclosing annual non-GAAP earnings measures	51	64	70	71	72	75	71	474
5	Companies disclosing non-GAAP measures in addition to annual earnings	35	42	45	45	45	49	44	305
6	Companies not disclosing non-GAAP measures other than annual earnings	16	22	25	26	27	26	27	169
7	Sample Size	94	97	98	97	100	100	99	685
8	% Companies disclosing non-GAAP earnings	54%	66%	71%	73%	72%	75%	72%	69%

Table 1: Sample Data Set Indicating Disclosure of Annual Non-GAAP Information

Figure 1 graphically represents the percentage of companies disclosing non-GAAP earnings over time.

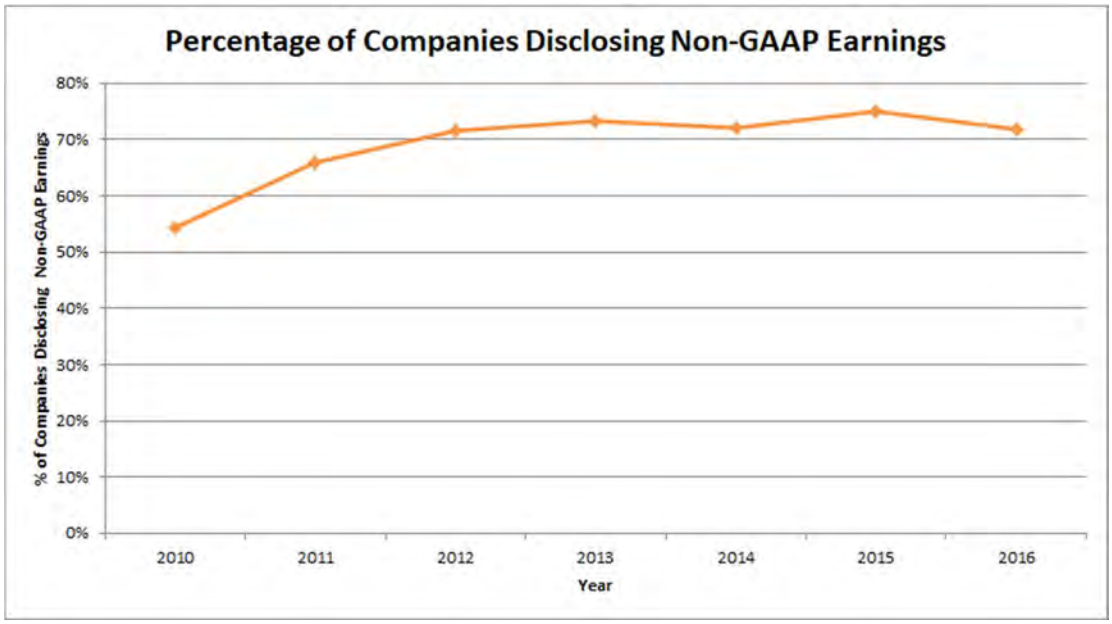

Figure 1: Percentage of Companies Disclosing Non-GAAP Earnings

Table 2a provides summary statistics on Sales, Total Assets, Market Capitalization, and GAAP Net Income for all companies in our sample. Tables 2b and 2c do the same, separately, for non-GAAP earnings reporters and then companies not reporting non-GAAP earnings. Table 2b also provides summary statistics on non-GAAP Net Income.

	2010	2011	2012	2013	2014	2015	2016
All S&P 100 Companies	97	97	98	98	100	100	99
Sales							
Median	32,778	36,793	34,412	35,299	35,093	33,678	34,350
Mean	52,342	57,988	57,009	58,132	59,034	57,197	57,409
Assets							
Median	52,240	55,201	61,142	64,010	62,474	66,725	72,688
Mean	178,436	184,456	191,235	196,201	198,822	198,648	206,009
Mkt Cap.							
Median	47,983	51,085	56,944	75,025	86,084	81,212	87,170
Mean	75,381	75,324	86,369	102,347	113,461	112,955	122,498
GAAP Net Inc.							
Median	3,228	3,709	3,254	4,404	4,033	4,542	4,240
Mean	5,239	5,913	5,690	6,595	6,131	5,453	5,876
Minimum	-2,238	-2,649	-12,650	-20	-5,403	-23,119	-5,763
Maximum	30,460	41,060	44,880	37,037	39,510	53,394	45,687

Table 2a: Descriptive Statistics for All Companies in Sample (in $millions)

	2010	2011	2012	2013	2014	2015	2016
Companies Reporting Non-GAAP Earnings	51	64	70	71	72	75	71
Sales							
Median	32,134	38,644	33,757	35,935	34,866	32,639	31,360
Mean	51,295	55,881	45,799	49,884	55,579	53,817	55,153
Assets							
Median	58,493	60,864	63,680	67,994	66,860	68,026	72,688
Mean	101,048	140,896	136,157	172,907	141,131	136,310	108,198
Mkt Cap.							
Median	55,082	52,950	54,865	75,653	76,267	81,885	83,724
Mean	76,194	72,970	76,914	96,772	102,360	99,532	106,770
GAAP Net Income							
Median	3,488	3,757	2,963	4,535	3,734	4,442	4,059
Mean	5,114	5,373	4,431	6,048	5,199	4,415	4,998
Minimum	-1,097	376	-12,650	8	-5,403	-23,119	-5,763
Maximum	19,864	20,213	16,978	22,003	22,074	24,083	24,074
Non-GAAP Net Income							
Median	3,975	4,514	4,361	4,680	4,610	4,085	4,750
Mean	5,721	6,051	6,044	6,491	6,605	6,196	6,152
Minimum	764	-132	695	559	582	-1,724	-3,308
Maximum	17,885	18,217	28,496	26,957	27,886	21,687	22,328

Table 2b: Descriptive Statistics for Companies Reporting Non-GAAP Income (in $millions)

	2010	2011	2012	2013	2014	2015	2016
Companies Not Reporting Non-GAAP Earnings	46	33	28	27	28	25	28
Sales							
Median	33,074	32,282	44,176	31,045	37,538	39,174	36,031
Mean	53,502	62,073	85,036	80,656	67,918	67,339	63,129
Assets							
Median	41,607	41,117	44,119	42,953	53,611	54,600	69,560
Mean	264,235	268,937	328,928	257,455	347,170	385,662	454,031
Mkt Cap.							
Median	43,373	49,546	59,021	73,720	92,702	79,590	93,247
Mean	74,480	79,890	110,884	117,009	142,006	153,222	162,379
GAAP Net Income							
Median	2,946	3,292	4,316	4,274	4,795	4,587	5,176
Mean	5,378	6,963	8,836	8,091	8,529	8,566	8,101
Minimum	-2,238	-2,649	-39	-20	-1,750	-6,692	-3,302
Maximum	30,460	41,060	44,880	37,037	39,510	53,394	45,687

Table 2c: Descriptive Statistics for Companies Not Reporting Non-GAAP Income (in $millions)

Perhaps most relevant, comparing the median market capitalization and median assets of companies that report non-GAAP earnings to the entire data set, indicate there does not appear to be much difference on these measures, as per figures 2 and 3 below.

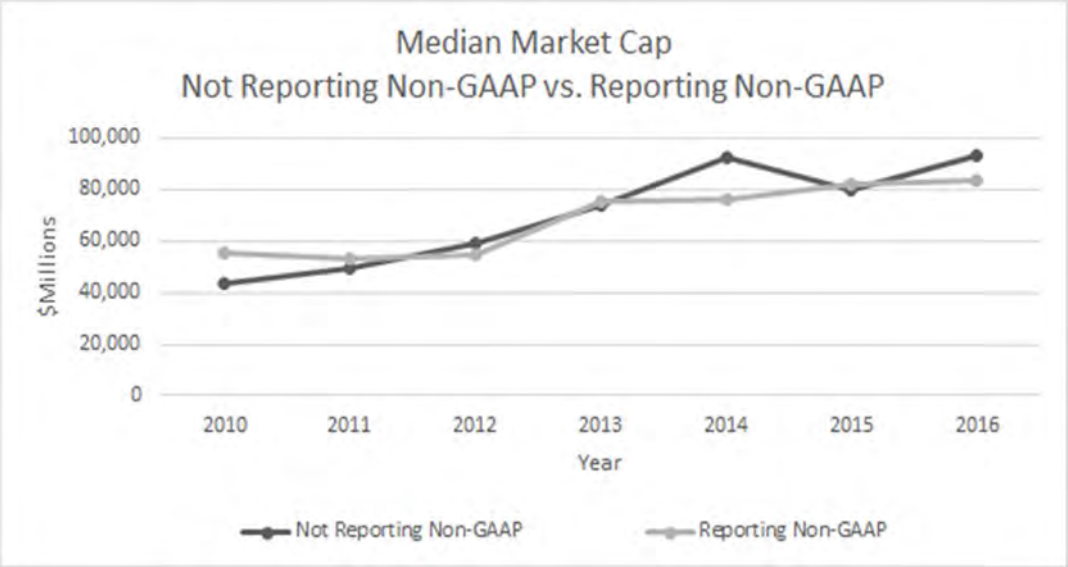

Figure 2: Median Market Capitalization of All Companies and Non-GAAP Earnings Reporters

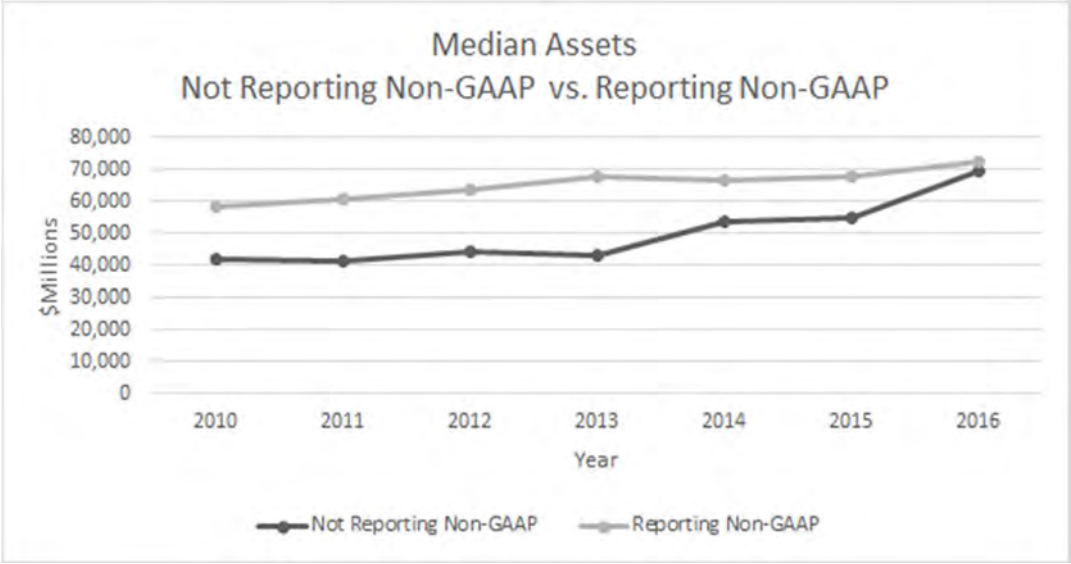

Figure 3: Median Assets of All Companies and Non-GAAP Earnings Reporters

RESULTS - TEST OF HYPOTHESES

As noted previously, we were interested in testing the following hypotheses

$$1)\ Ho: p_{2012} \leq p_{2010}$$
$$Ha: p_{2012} > p_{2010}$$

$$2)\ Ho: p_{2016} = p_{2012}$$
$$Ha: p_{2016} \neq p_{2012}$$

Where p_{year} represents the proportion of companies that reported non-GAAP earnings in that year.

Given our expectations, a one-sided hypothesis tests would be in order for the first case. However, as the two samples used in each case are not independent, we used McNemar's test (Sheskin, 2011) which is a test of equality of proportions.

The results of the hypothesis tests are as follows:

- Case 1: Null hypothesis rejected. (McNemar's chi-squared = 11.636, df = 1, p-value = 0.0006467. We can halve the p-value for the one-tailed equivalent.)

- Case 2: Null Hypothesis not rejected. (McNemar's chi-squared = 0.066667, df = 1, p-value = 0.7963.)

We conclude that the jump in companies reporting non-GAAP earnings after the liberalization of Regulation G and S-K is statistically significant, and that there is no statistically significant

change once these values "stabilize" in 2012. Of course, this analysis cannot establish a causal relationship between the 2010 ruling and company behavior.

FUTURE WORK

Our future work will revolve primarily around looking at the adjustments companies make to arrive at non-GAAP earnings measures. Our analyses will identify those adjustments that are the most frequently reported by our sample companies.

An important aspect of the adjustments, to both investors and the SEC, is whether a particular adjustment is material. While others (Webber, 2013) used Gray's index to calculate materiality, we
propose using a more straight-forward calculation of adjustment / |GAAP net-income| as is used in business practice. We will look to see if there is any correlation between the materiality of an adjustment and the adjustment category it is in.

To gain insight into what type of companies use non-GAAP adjustments, we will analyze adjustments by industry sector.

Finally, we will look at other aspects of companies to see if values like size (assets or market capitalization) or GAAP earnings are predictors of usage of non-GAAP earnings measure.

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CHANGES IN IMPORT VOLUMES FOR SMALL PORTS IN THE U.S. AFTER THE PANAMA CANAL EXPANSION

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Working Draft
March 2019

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ABSTRACT

This study utilizes public data to address a potential indirect effect that the expansion of the Panama Canal may have on the import volumes of relatively smaller ports. The increase in the number of mega vessels going through the canal after its expansion makes relatively larger ports much more attractive to shippers, which could shift the traffic of relatively small- and medium-sized vessels to ports in the Gulf and the Atlantic coasts that are unable to accommodate mega vessels.

Preliminary results show weak evidence for the Panama Canal expansion increasing import volumes for smaller ports in the Atlantic or Gulf coasts. When, we control for the presence of larger ports in the same state as smaller ports, we find that the expansion of the canal increases import volumes for smaller ports in the Atlantic compared to their counterparts in the Pacific, but only if they have a large port within the same state. For smaller ports in the Gulf, import volumes increased after the canal expansion compared to small ports in the Pacific, but only if they have larger ports in a nearby state.

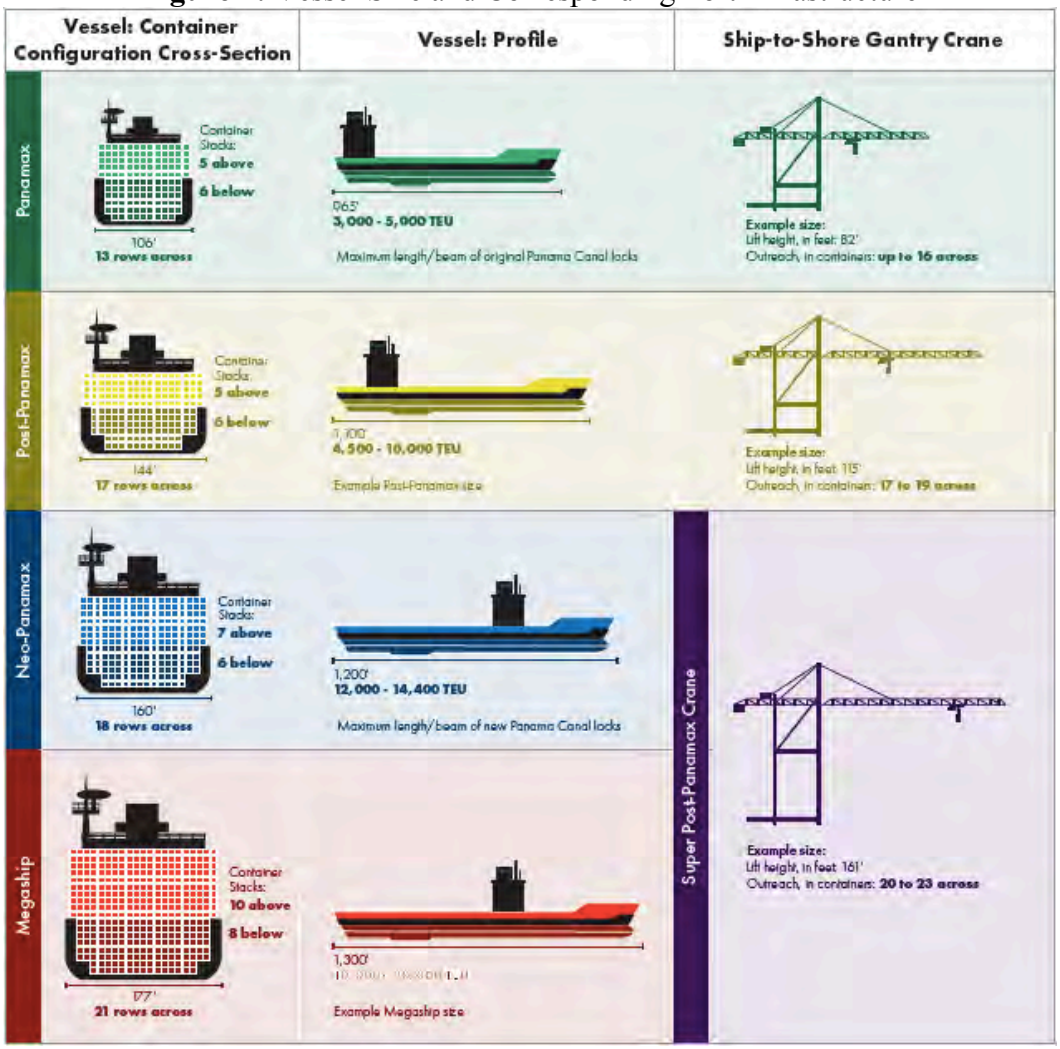
I. Introduction

Prior to its expansion in 2016, the Panama Canal was only able to accommodate the passage of Panamax vessels—ships with a length of 965 ft. (294.13 m), width of 106 ft. (32.31 m), and draught of 41.2 ft. (12.04 m). In terms of twenty-foot equivalent units (TEUs), the Panamax can carry up to 5,000 TEUs. The expansion of the canal now enables the passage of larger vessels that are approximately 25 percent longer, 52 percent wider, and 26 percent deeper than the Panamax ones. These new ships are called Neopanamax and can carry up to 14,000 TEUs. Figure 1 compares the different vessels by their size and port infrastructure needed. This increase in the capacity of ships going through the canal puts pressure on U.S. Atlantic and Gulf ports to be able to handle increasing volumes of incoming cargo efficiently (Webster 2015).

The Panama Canal Authority reports an increasing number of vessels of at least Neopanamax size passing through the canal since its expansion (Panama Canal Authority 2018). Table 1 shows that 59 of these ships (6.24 percent of the total number of vessels) used the canal in the first month after its expansion. One year later, the number of ships increased to 163 (16.03 percent), and to 233 (23.35 percent) the year after. The increasing share of these vessels implies that the total volume of containers that went through the canal is larger after the expansion.

The increase in the traffic of containers resulting from larger vessels passing through the canal poses challenges for ports in the U.S. and more so for ports in the Atlantic and Gulf coasts. To remain competitive, ports need to invest in their capacity to efficiently accommodate a higher number of Neopanamax vessels passing through the canal and avoid long queues (Lang and Veenstra 2010). For instance, Bonney (2016) reports that on the Atlantic Coast of the U.S., New York-New Jersey and Virginia ports have faced congestion due to being unable to efficiently accommodate the inbound traffic of Neopanamax ships. In this paper, we attempt to see if the greater number of larger vessels (Panamax and above) passing through the Panama Canal after its expansion pushes the traffic of small- and medium-sized vessels (below Panamax size) to ports in the Gulf and the Atlantic coasts that (1) cannot accommodate larger vessels, and (2) are either nearby or relatively far from ports that can. We hypothesize that, due to the increase in the number of larger vessels headed to relatively larger ports, smaller vessels will unload their containers at either smaller ports that are less congested and nearby, or smaller ports

Figure 1: Vessel Size and Corresponding Port Infrastructure



Source: Bureau of Transportation Statistics, 2017

Table 1: Monthly Canal Operations

	July 2014 (1)	July 2015 (2)	July 2016 (3)	July 2017 (4)	July 2018 (5)
Total number of vessels	950	1026	946	1017	998
Panamax* and smaller	950	1026	887	854	765
Neopanamax** and over	-	-	59	163	233
Neopanamax and over %	-	-	6.24	16.03	23.35
Neopanamax daily average	-	-	1.9	5.26	7.52

* vessel with a beam of 106 feet (32.3 meters), ** vessel with a beam of 107 feet (32.6). Sources: (Panama Canal Authority 2018)

that are farther away and closer to the final destination of the containers.

Our results show weak evidence supporting that the greater traffic of larger vessels increases the import volumes for relatively smaller ports in the Atlantic and Gulf compared to their counterparts in the Pacific. When we look specifically at "small ports" in the Atlantic and control for the presence of a "big port" in their state, we do not find meaningful results showing that they benefit more than their counterparts in the Pacific if there is not a "big port" in their state. Conducting the same analysis for ports in the Gulf yields significant results showing that "big ports" impose a negative externality (rather than a positive externality) on "small ports." This is important information for relatively smaller ports because it will allow them to increase their efficiency and remain competitive by preparing for possible changes in their incoming container volume. The aim of this paper is to offer insight on possible externalities that "big ports" may impose on "small ports" as a result of the increase in the transit of mega vessels—an indirect effect of the Panama Canal expansion.

The remainder of this paper is organized as follows. Sections 2 and 3 present a review of the current literature and discusses the data, respectively. Section 4 presents the model specification. Section 5 our empirical results regarding the effects of the canal's expansion on the Atlantic and Gulf ports. Section 6 concludes with a summary of the implications of expanding the Panama Canal on relatively smaller ports.

II. Literature Review

The Panama Canal is the only passage connecting the Pacific and Atlantic oceans. Since its construction in 1914, the canal has served approximately 5 percent of global trade (Rodrigue 2010). Data from the Panama Canal Authority shows that most of the vessels going through the canal are those on a U.S. East Coast-Asia route and South America West Coast-U.S. East Coast route. More precisely, data from 2017 show that the U.S. and China are the most frequent users of the Panama Canal (Panama Canal Authority 2018). The Maritime Administration Agency of the U.S. Department of Transportation (MARAD) reports three main routes for trade between Northeast Asia and the U.S.: Transpacific to the U.S. West Coast, transpacific to the U.S. East Coast via the Panama Canal, and Asia to the U.S. East Coast via the Suez Canal (U.S. Department of Transportation 2013). For waterborne trade directly to the U.S. Atlantic and Gulf coasts, vessels coming from Asia can also go around the Cape of Good Hope in South Africa or

through the Panama or Suez canals. In 2016, Bloomberg estimated that a ship traveling from Asia to the U.S. Gulf Coast takes 31 days through the Suez Canal, 34 days if it goes around the Cape of Good Hope, and a total of 20 days for ships traveling from Asia to the U.S. Atlantic Coast if they use the Panama Canal (Nussbaum and Malik 2016).

Despite being the cheapest route connecting Asia and the U.S. Atlantic and Gulf coasts markets, the Panama Canal's popularity decreased due to its inability to accommodate ships larger than the Panamax, together with often, long queues (Nussbaum and Malik 2016). Panama approved the expansion of the canal through a national referendum in 2006, with a construction period that lasted from 2009 to 2016. According to the Panama Canal Authority, the expansion of the canal was the largest investment on its infrastructure since its construction (Panama Canal Authority n.d.). The expansion project included deepening the Pacific and Atlantic Canal entrances, widening and deepening the Gatun Lake navigational channel, deepening of Culebra Cut, building new locks and water-reutilization basins on the Atlantic and the Pacific, raising the Gatun Lake maximum operational level, and excavating a new access channel (Pacific Access Channel). These changes enabled the Panama Canal to accommodate the passage of vessels up to Neopanamax size.

Previous studies have looked at the effects of the Panama Canal expansion. The U.S. Department of Transportation examines the expansion's effect on U.S. trade, costs, and shifts in cargo flows (U.S. Department of Transportation 2013). For ports specifically, the study reports a possible geographical rerouting of cargo—through the Panama Canal instead of through the U.S. West Coast. Prozi and Overmyer (2018) estimated potential effects of the Panama Canal expansion on Texas and other ports in the Gulf by comparing traffic data from 2015 to 2016. They found that the expansion of the canal had a greater impact on tankers than on container ships, indicating that the expansion had no immediate effect on the transit of these vessels. Boske and Harrison (2017) also predict that the expansion of the canal to have a positive effect on tankers. All of these studies, however, are limited due to not having much data after expansion was completed.

III. Data Sources and Description

We use port level data on yearly total import volume measured in TEUs from MARAD for our dependent variable. MARAD provides historical trade statistics on major U.S. ports, such

as U.S. waterborne foreign containerized trade by U.S. customs ports since 1997 (U.S. Department of Transportation 2017). Our data cover the period 2000-2017. MARAD classifies U.S. ports into the following six regions according to their location: Pacific, Atlantic, Gulf of Mexico, Alaska, Hawaii, and Puerto Rico. In this study, we focus only on ports in the Atlantic, Gulf, and Pacific coasts. A limitation of these data is that it does not provide the point of origin of the imported cargo.

These data allow us to rank ports by yearly traffic volume in TEU. We define small ports as those that rank lower than the top 20 by TEU, and large ports as those that rank in the top 15. Hereinafter, we will refer to these two groups as small and big ports, respectively. We limit our sample to the top 50 ports because the yearly total TEU for some ports ranking below 50 is not available. Most of the ports ranking 21-50 are not able to accommodate Panamax vessels, so the direct impact of the expansion of the canal should be negligible.

To observe possible effects that the expansion of the Panama Canal may have on the import volume for small ports, we use a dummy variable with a value of 1 after the expansion of the canal (years 2016 and 2017) and 0 otherwise. For additional determinants of import volume, we calculate the relative price of imports using the monthly U.S. import price index (excluding petroleum), and the monthly U.S. city average producer price index (PPI) for all final goods except food and energy. Data for these price indexes come from the Federal Reserve Bank of St. Louis (Bureau of Economic Analysis 2017). We also use real GDP to measure income at the national and state levels. Real GDP at the national level controls for global yearly import demand shocks. Real GDP for the states where the ports in our sample are located controls for local yearly demand shocks. Data for real GDP at the national and state levels come from the Bureau of Economic Analysis (BEA) agency of the U.S. Department of Commerce. Furthermore, we control for the effect that the financial crisis of 2008 may have had on import volumes by using a dummy variable that is equal to 1 after 2008 and 0 otherwise, the possibility that the expansion of the canal had a different impact on small ports contingent on their location, and the presence of a large port in the same state. Finally, we also use data on yearly imports from Europe measured in terms of monetary value from the Foreign Trade database managed by the U.S.

Census Bureau (U.S. Census Bureau 2018) as an attempt to control for waterborne imports coming from Europe[1].

IV. Model Specification

To analyze the impact of the expansion of the Panama Canal on the import volume for small ports, we start with a baseline specification of the form

$$\begin{aligned}\ln TEU_{it} = \beta_0 + \beta_1 DPanama_{t\geq 2016} + \delta_1 \ln GDP_t + \delta_2 \ln StateGDP_{it} \\ + \delta_3 \ln ImpPrice_t + \delta_4 DFinCrisis_{t>2008} \\ + \delta_5 \ln EuropeImp_t \times DNonPacific_i + \delta_6 Year + \varepsilon_{it}\end{aligned} \tag{1}$$

where TEU_{it} is the total import volume for port i in year t measured in TEUs, $DPanama_{t\geq 2016}$ is a dummy variable controlling for the expansion of the canal in 2016 (equal to 1 in and after 2016, 0 otherwise). Additionally, GDP_t is the real income at the national level, $StateGDP_{it}$ is the real income in the state of port i in year t, $ImpPrice_t$ is the relative price of imports in year t, $DFinCrisis_{t>2008}$ is a dummy variable controlling for the financial crisis of 2008 (equal to 1 after 2008 and 0 otherwise), $EuropeImp_t \times DNonPacific_i$ controls for the changes in import volume coming from Europe that presumably have an impact only in the Gulf and Atlantic coasts, and $Year$ is a year dummy. For simplicity, we will refer to these explanatory variables as "additional covariates" and denote them by using a column vector, X. After this change, our baseline model becomes

$$\ln TEU_{it} = \beta_0 + \beta_1 DPanama_{t\geq 2016} + X'\delta + \varepsilon_{it} \tag{2}$$

To see if the expansion of the canal had a different effect on the import volumes of small ports in the Atlantic and Gulf coasts combined (non-Pacific), we use a second specification of the form

$$\begin{aligned}\ln TEU_{it} = \beta_0 + \beta_1 DPanama_{t\geq 2016} + \beta_2 DPanama_{t\geq 2016} \times DNonPacific_i \\ + X'\delta + \varepsilon_{it}\end{aligned} \tag{3}$$

where $DPanama_{t\geq 2016} \times DNonPacific_i$ is an interaction term showing the effect of the canal expansion on the import volumes for small ports in the non-Pacific area when compared to small ports in the Pacific.

[1] The U.S. Army Engineer Institute for Water Resources offers waterborne import by country of origin, but these data do not include information for 2016, which is when the expansion of the Panama Canal was completed.

We believe that the impact of the expansion of the Panama Canal on the import volumes for small ports could be different if there are big ports able to accommodate vessels of Panamax size and above in their state. For example, a big port in *State X* will attract larger vessels and push cargo shipped on smaller vessels to small ports also in *State X*. To test this hypothesis, we use a dummy variable controlling for the absence of a top 15 port in the same state. We also want to see the difference in the effect of the canal expansion on small ports in the non-Pacific based on whether they have a big port in their state or not. To test this hypothesis, we add an interaction term and use a third specification of the form

$$\begin{aligned}\ln TEU_{it} = \beta_0 &+ \beta_1 DPanama_{t\geq 2016} + \beta_2 DPanama_{t\geq 2016} \times DNonPacific_i \\ &+ \beta_3 DTop15_i + \beta_4 DPanama_{t\geq 2016} \times DNonPacific_i \times DTop15_i \\ &+ X'\delta + \varepsilon_{it}\end{aligned} \tag{4}$$

where $Top15_i$ is a dummy variable that is equal to 1 if there is not a large port in the same state and 0 otherwise, and $DPanama_{t\geq 2016} \times DNonPacific_i \times DTop15_i$ is an interaction term showing the difference in the effect of the expansion of the canal on the import volumes between small ports in the non-Pacific that do not have a big port in the same state and those that do.

To pay closer attention to the differences in the effect of the canal expansion on small ports based on the coast in which they are located (instead of non-Pacific vs. Pacific), we repeat the analyses in our second and third specifications but include dummies specific to the location of each port. We use a fourth specification of the form

$$\begin{aligned}\ln TEU_{it} = \beta_0 &+ \beta_1 DPanama_{t\geq 2016} + \beta_2 DTop15_i + \beta_3 DPanama_{t\geq 2016} \times DGulf_i \\ &+ \beta_4 DPanama_{t\geq 2016} \times DAtlantic_i + X'\delta + \varepsilon_{it}\end{aligned} \tag{5}$$

which has interaction terms to test if the expansion of the canal had a different effect on import volumes specifically for small ports on the Gulf Coast or the Atlantic Coast when compared to the Pacific coast each ($DPanama_{t\geq 2016} \times DGulf_i$ and $DPanama_{t\geq 2016} \times DAtlantic_i$, respectively). Finally, our fifth specification is of the form

$$\begin{aligned}\ln TEU_{it} = \beta_0 &+ \beta_1 DPanama_{t\geq 2016} + \beta_2 DTop15_i + \beta_3 DPanama_{t\geq 2016} \times DGulf_i \\ &+ \beta_4 DPanama_{t\geq 2016} \times DAtlantic_i \\ &+ \beta_5 DPanama_{t\geq 2016} \times DGulf_i \times DTop15_i \\ &+ \beta_6 DPanama_{t\geq 2016} \times DAtlantic_i \times DTop15_i + X'\delta + \varepsilon_{it}\end{aligned} \tag{6}$$

where we include interactions measuring the difference in the effect of the canal expansion on the import volumes for small ports in the Gulf that do not have a big port in the same state and

those that do ($DPanama_{t\geq 2016} \times DGulf_i \times DTop15_i$). We use a similar control for ports in the Atlantic Coast ($DPanama_{t\geq 2016} \times DAtlantic_i \times DTop15_i$).

V. Results

Table 2 shows our results. We begin our analysis by estimating the effect of the Panama Canal expansion on the import volume for smaller ports after controlling for the set of additional covariates mentioned in the previous section. Specification 1 shows that the expansion of the canal does not have a significant impact on import volume among small ports in the U.S. However, this result changes depending on which side of the Panama Canal the port is located. Specification 2 shows that if we combine small ports in the Atlantic and the Gulf coasts (non-Pacific), the expansion of the canal has a statistically significant impact on the import volume for small ports in the non-Pacific when compared to small ports in the Pacific. Specifically, the expansion of the canal increases import volumes for small ports in the non-Pacific by approximately 91 percent more.

Controlling for the presence of a big port does not change our results. Specification 3 shows that the effect of the canal expansion on the import volumes for small ports in the non-Pacific compared to their counterparts in the Pacific remains at approximately 91 percent. These results also show that, overall, not having a big port in the same state has a significant impact on the import volumes for small ports. More specifically, import volumes for small ports that do not have a big port in their state increase by approximately 105 percent more than for ports that have a big port in their state. However, we do not find significant results specifically for non-Pacific ports that do not have a big port in their state.

Our results change if we separate ports in the Atlantic from those in the Gulf. In specification 4, we find that not having a big port in the same state still increases the import volumes for small ports (approximately 107 percent more than for small ports that have a big port in the same state), but the effect of the canal expansion is different for small ports in the Gulf Coast than in the Atlantic Coast. For small ports in the Gulf, we do not find significant results showing that the canal expansion has an effect on their import volumes compared to small ports in the Pacific Coast, but we do for small ports in the Atlantic Coast. For small ports in the Atlantic, the expansion of the canal increased their import volumes approximately 133 percent

Table 2: Determinants of Import Volume for Small Ports in the U.S.

Dependent Variable:	$\ln TEU$				
	(1)	(2)	(3)	(4)	(5)
$DPanama$	0.631	-0.077	-0.073	-0.047	-0.105
	[0.493]	[0.603]	[0.602]	[0.598]	[0.606]
$DPanama \times DNonPacific$		0.914*	0.906*		
		[0.499]	[0.522]		
$DTop15$			1.051***	1.070***	1.080***
			[0.170]	[0.176]	[0.185]
$DPanama \times DNonPacific \times DTop15$			0.026		
			[0.808]		
$DPanama \times DGulf$				0.532	0.414
				[0.520]	[0.534]
$DPanama \times DAtlantic$				1.334*	1.499*
				[0.726]	[0.842]
$DPanama \times DGulf \times DTop15$					0.831*
					[0.477]
$DPanama \times DAtlantic \times DTop15$					-0.81
					[1.498]
Additional Covariates	Yes	Yes	Yes	Yes	Yes
R-squared	0.111	0.114	0.119	0.122	0.124
Adjusted R	0.0746	0.0765	0.0771	0.0808	0.079
Number Ports	37	37	37	37	37
Observations	489	489	489	489	489

* indicates statistical significance using conventional standard errors at the 10 percent level, ** indicates statistical significance at the 5 percent level, and *** indicates statistical significance at the 1 percent level

Note: Regressions include constants. Robust standard errors are given in parenthesis.

more than for small ports in the Pacific.

Specification 5 continues to show that not having a big port in the same state increases the import volumes for small ports, but it also shows that the absence of a big port affects the import volumes for small ports differently depending on the coast in which they are located. For small ports in the Gulf Coast compared to their counterparts in the Pacific, we do not find significant results supporting that the expansion of the Panama Canal has an effect on their import volumes. However, when comparing small ports in the Gulf without a big port in their state to other ports in the Gulf with a big port in their state, we find that the expansion of the canal increases their import volumes by approximately 83 percent more. Moreover, the addition of the coefficients measuring the effect of the expansion of the canal on import volumes when comparing small ports in the Gulf and the Pacific, and small ports in the Gulf with and without a big port in their state is statistically significant. The addition of these two coefficients implies that the expansion of the canal causes a significant difference in the import volumes for small ports in the Gulf Coast compared to the Pacific Coast when neither of them have a big port present in their state. Furthermore, adding the coefficient measuring the effect of the canal expansion on import volumes for small ports in the U.S. to the two coefficients mentioned previously is not statistically significant. Hence, we do not find a meaningful result showing a change in the import volumes for small ports in the U.S. that do not have a big port in their state after the Panama Canal expansion. One possible explanation for this result would be not having enough observations after the expansion of the canal.[2]

For small ports in the Atlantic Coast, our results show different effects. The expansion of the Panama Canal has a statistically significant impact on their import volumes compared to small ports in the Pacific Coast—approximately 150 percent more. However, this result is not significant if these small ports in the Atlantic do not have a big port in their state. More specifically, we do not find meaningful evidence of the canal expansion having an effect on import volumes when comparing small ports in the Atlantic with and without a big port in their state. Moreover, adding these two coefficients is not statistically significant, implying that there is no significant difference in the effect of expansion of the canal on the import volumes for small ports in the Atlantic that do not have a big port in their state and their counterparts in the

[2] We have yearly data up to 2017. The expansion of the canal was completed in June 2016, but we take 2016 as the year in which the expansion was effective.

Pacific. Furthermore, adding the coefficient measuring the effect of the canal expansion on import volumes for small ports in the U.S. to the two previous coefficients is also not statistically significant. This implies that the expansion of the canal does not have a significant effect on the import volumes for small ports that do not have a big port in their state.

VI. Conclusion

We wanted to examine the possibility that small- and medium-sized vessels (below Panamax size) could be pushed to smaller ports (below top 20 by TEU) after the expansion of the Panama Canal due to greater traffic of larger vessels (Panamax size and above) that could be accommodated only by big ports (top 15 by TEU). Our results show that, (1) for small ports in the Atlantic Coast that have a big port in their state, import volumes increase more than their counterparts in the Pacific as a result of the canal expansion. On the contrary, (2) for small ports in the Gulf Coast that do not have a big port in their state, import volumes increased more than their counterparts in the Pacific. Additionally, (3) for small ports in the Gulf Coast that do not have a big port in their state, import volumes increased more than other small ports in the Gulf that have a big port in their state.

Although some of our results show an increase in the import volumes for small ports in the Gulf or Atlantic resulting from the expansion of the Panama Canal, this is only true when we compare them to ports in the Pacific.

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Corporate Inversions and the Cost of Equity: A Tale of Two Strategies

March 16, 2019

Abstract

Firms invert either through a pure inversion strategy or by merging with a foreign entity. I document that the impact of corporate inversions on the cost of equity is significantly different between the two strategies. I find that pure inversions increase the cost of equity by 10%, whereas inversions through mergers decrease it by 13%. Although both inversion strategies increase the inverting firm's shareholder value, inversions through mergers appear to create more value. However, before the tax reform of 2004, which eliminated the tax savings from pure inversions, most inversions were pure, whereas after the tax reform most were done through mergers. This finding suggests that the tax reform had an unintended consequence of reducing a managerial agency problem by eliminating the less beneficial inversion option.

Keywords: Corporate inversions; cost of equity; M&A; tax reform; agency problem.

1. Introduction

The exodus of U.S. corporations for tax-haven countries,[1] known as "corporate inversion," has led to a discussion among policy makers regarding possible tax and other regulatory reforms. In a corporate inversion, a U.S. multinational corporation (UMC) either (i) is acquired by its own foreign subsidiary (pure inversion strategy) or (ii) merges with or is acquired by a foreign operating company (M&A inversion strategy). The newly incorporated firm is governed and taxed by the foreign jurisdiction's corporate laws while still maintaining its listing in the U.S. stock markets.

The current literature on corporate inversions has focused on the benefits of inversions. Hines and Hubbard (1990), Atlshuler, Newlon, and Randolph (1995), and Desai, Foley, and Hines (2001) identify that the inverting firm avoids paying repatriation taxes by inverting to a country with a territorial tax regime.[2] An inverting firm will also allocate its expenses more effectively across borders and reap indirect tax savings after inversion.[3] Additionally, Talley (2015) argues that besides the tax incentives, the progressive "federalization" of corporate law and corporate governance encourages UMCs to reincorporate overseas.

Although the benefits of inversions have been extensively investigated in the literature, not much attention has been paid to the costs associated with inversions and the differences between inversion strategies. Specifically, issues requiring further inquiry include the impact of inversion on a firm's financing costs; whether pure and M&A inversion strategies are equally efficient at increasing existing shareholder value; whether there is evidence that the

[1]Tax-haven countries are those with special tax attributes designed to attract foreign investors. They typically have very low tax rates. In return, they will receive large foreign investments and enjoy fast economic growth. Currently, there are about 40 tax havens, including Bermuda, the Cayman Islands, and Ireland. (see Dharmapala and Hines, 2009).

[2]The tax-saving motive is also the most commonly cited reason for inverting firms' management to support their inversion decision. For instance, in its announcement of inverting to Canada, Burger King predicted that it could save $117 million annually. Similarly, Walgreens estimated that it could dodge up to $4 billion in U.S. taxes over five years by inverting to Switzerland.

[3]For example, the surviving tax-haven parent company can lend to the U.S. subsidiary, thereby generating interest deductions against U.S. taxable income while the interest income of the parent company is tax-free (Desai and Hines, 2002). This practice is referred to as "interest stripping." In contrast, this practice is not allowed for UMCs because the funds borrowed from subsidiaries are taxed as repatriated dividends.

choice of strategies may be driven by the managerial agency problem; and whether the 2004 tax reform aimed at curbing inversions has been effective.

This paper attempts to answer some of these questions. First, I believe this paper is the first to document changes in the cost of equity *caused* by a corporate inversion. I also find differential impacts of inversions on the cost of equity between the two inversion strategies: pure inversions *increase* the cost of equity by around 10% of pre-inversion levels, whereas M&A inversions *decrease* it by around 13%. Second, I document that an M&A inversion is more beneficial to existing shareholders than a pure inversion and on average delivers an additional amount of around $4.6 billion to existing shareholders over a 5 year window. Third, before the 2004 tax reform, most inversions were pure, whereas after the tax reform, they were done through M&A. Although this may have been an unintended consequence of the tax reform, my results suggest that the tax reform appears to have reduced a managerial agency problem by making the less efficient strategy unattractive and, thus, inducing managers to choose the more efficient inversion strategy.

The differential impacts of inversions on the cost of equity between the two strategies can be explained by the salient differences between them. The preferred pure inversion destinations are usually offshore tax-haven destinations such as Bermuda and the Cayman Islands, where corporate tax rates are usually zero. Moreover, there is usually no change in the location of the headquarters, the firm's management, and the daily operations of inverting firms under pure inversion.[4] There is a change, however, in the jurisdiction of the firm because it is now governed by the new home country's corporate laws, which are usually weaker.[5] Political and economic risks are larger in these destination jurisdictions as well.

In contrast, the headquarters location, firms' management, and their business operations are likely to change if there are efficiency gains to be achieved in an M&A inversion. Also, the destination jurisdictions of M&A inversions are in better developed countries such as Ireland

[4]In fact, the company is not required to conduct any meetings or even have an office in the newly incorporated country.

[5]For example, the U.S. corporate laws are more protective against hostile take overs than the corporate laws in most of the tax havens.

and the United Kingdom, and their corporate law systems and political risks are similar to those in the United States. Therefore, *ceteris paribus*, the cost of equity increase caused by the change in corporate law jurisdiction in an M&A inversion should be smaller than the increase following a pure inversion. Second, in an M&A inversion, a UMC merges with a foreign firm that is usually of similar size, economically profitable, and internationally well known. All else equal, merging with such firms mitigates equity investors' concerns about the impact of the change in corporate laws and therefore lowers the shareholders' required rate of return. Last, since the two companies in an M&A inversion are generally in the same industry, an M&A inversion decreases the global competition of this industry and expands the inverting UMC's business. Overall, the estimated positive effect of M&A inversions on the cost of equity indicates that the benefits created through an M&A inversion outweigh equity investors' concerns about losing the protection of U.S. corporate laws.

Though an M&A inversion strategy is more favorable than pure inversions in terms of reducing the cost of equity, the tax savings through an M&A inversion strategy are usually less than those through pure inversions because the corporate tax rates in the destination jurisdictions of M&A inversions are usually higher than those in the offshore tax-haven destination jurisdictions of pure inversions. This begs the question of which strategy is more beneficial to existing shareholders. I look at the impact of the 2004 tax reform, which restricts the tax benefits from pure inversions and induces inverting firms to invert through mergers. By estimating the changes in existing shareholder value after a firm inverts, either through a pure inversion strategy or by merging with a foreign entity, I am able to document that the M&A inversion strategy is more beneficial to existing shareholders in that it delivers an additional amount of around $4.6 billion to existing shareholders. This finding suggests that prior to the 2004 tax reform, managers do not appear to maximize shareholder value. Moreover, it appears that the tax policy change had an unintended consequence of reducing the managerial agency problem.

To test the hypothesis that UMCs invert in order to have access to the cash held in foreign

subsidiaries, I look at changes in the cash holdings of inverting firms and find a statistically significant decrease in the cash holdings of pure-inverting firms. I further show that the repatriated cash holdings are mainly used to invest in potentially profitable projects located in the United States instead of used to distribute more dividends: the capital expenditure of the pure-inverting firm significantly increases, whereas the dividend payment is unchanged after a pure inversion. However, the cash holdings and investment policies of the foreign acquirer affect the post-inversion cash holdings, dividend payments, and capital expenditure in an M&A inversion, which makes the changes insignificant.

In this paper, I investigate the impact of inversions on the cost of equity and shareholder value by causal inference. The difference-in-difference (diff-in-diff) method is used to eliminate factors that can simultaneously affect inverting and non-inverting firms, thus leaving inversion to be the only policy change between the inverting firm and its matched non-inverting control pair. Moreover, different from the traditional "two groups-two periods" linear diff-in-diff model, I use "two groups-multiple periods" individual-level linear and nonlinear diff-in-diff models to capture more unobserved firm and time heterogeneities and hence to increase explanatory power.

Since the incentive to invert comes from the less costly benefit of having profitable foreign operations and repatriating cash held in foreign subsidiaries, I choose the control sample from the pool of U.S. multinationals. To find the appropriate match for the inverting firm, I first define the "measurement quarter" as the last quarter of the calendar year prior to the announcement of inversion. Then within the same industry[6] and measurement quarter, I identify up to four control firms for each inverting one by matching on three observable firm characteristics using the Mahalanobis distance[7]: firm size (log of total assets), leverage

[6]Industry is an important factor to control because there is significant heterogeneity in the concentration of inversions (Babkin, Glover, and Levine, 2016).

[7]The Mahalanobis distance of two vectors $\mathbf{x_i}$ and $\mathbf{x_j}$ is defined as

$$d(i,j) = (\mathbf{x_i} - \mathbf{x_j})'\mathbf{\Sigma^{-1}}(\mathbf{x_i} - \mathbf{x_j}),$$

where $\mathbf{\Sigma}$ is the variance-covariance matrix of $\mathbf{x_i}$ and $\mathbf{x_j}$. For a fixed vector $\mathbf{x_i}$, the vector $\mathbf{x_j}^*$ that gives the shortest $d(i,j)$ is the best match for vector $\mathbf{x_i}$.

(leverage ratio), and profitability (return on assets). My matching results show that there is no statistical difference in the distribution of these matched variables between the treated and control sample. Since I find matches for each inverting firm, I essentially estimate the average treatment effect on the treated (ATT) of corporate inversions. Robustness checking results show that the analysis in this paper is robust to the size of the control sample.

The rest of the paper is organized as follows. Section 2 discusses the related literature. Section 3 briefly discusses the benefits of corporate inversions and the legislative actions taken that aim to curb (pure) inversions. Section 4 gives my empirical methodology. Section 5 describes the data and provides the summary statistics. Section 6 discusses the empirical testing results of the impact of inversions on the cost of equity. Sections 7 compares changes in existing shareholder value after a firm inverts either through a pure inversion strategy or by merging with a foreign entity. Section 8 concludes.

2. Literature Review

An important strand of literature on corporate inversions is investigating the causes of inversions. Hines and Hubbard (1990), Atlshuler et al. (1995), and Desai et al. (2001) identify two components of the tax benefits of inversion. First, by inverting to a country with a territorial tax regime, the firm can avoid paying repatriation taxes as well as circumvent taking costly actions to avoid such taxes had the firm not inverted. Second, an inverting company can save taxes by reallocating expenses, including the allocation of interest expense to foreign source income. Desai and Hines (2002) find that large firms, those with extensive foreign assets, and those with considerable debt are most likely to expatriate, which suggests that U.S. taxation of foreign income, including the interest expense allocation rules, significantly affects inversions. Seida and Wempe (2003a) further confirm that the reduction in taxes post-inversion is partly due to the reduction in U.S. taxable income by shifting more expenses to the United States after inversion. Talley (2015) argues that besides the tax

incentives, the progressive "federalization" of corporate law and corporate governance has encouraged UMCs to reincorporate overseas. Over the last 15 years, federal law has progressively encroached on firms' internal corporate governance, which is traditionally the domain of state law. These mandates have displaced state law as a primary source of governance regulations for U.S.-listed issuers, and this displacement has gradually unbundled domestic tax law from corporate governance, which erodes the U.S. market power in regulatory competition.

The second strand of literature on inversion, albeit small, analyzes the costs of inversion. Cortes, Gomes, and Gopalan (2015) find that inverting firms have higher bid-ask spreads and their investors put a lower value on the cash on their balance sheets. They also find that inverting firms have a more concentrated institutional share ownership structure, and they document the lower stock liquidity resulting from inversions. Different from their paper, my paper analyzes the cost change in a more direct way by analyzing the changes in the cost of equity. Babkin et al. (2016) develop a model to value the net benefits of inversion and show that while the benefits of inversion disproportionately accrue to the CEO, foreign shareholders, and short-term investors, many long-term investors suffer a net loss. The negative return of long-term investors results from the capital gains tax event triggered by inversion. They have to pay capital gains taxes immediately after inversion, thus losing the option to defer capital gains taxes on their shares. That loss outweighs the benefits generated from the reduced future corporate tax rate.

This paper is also related to the literature that analyzes the share price reaction around an inversion. Based on a sample of 19 pure-inverting firms, Desai and Hines (2002) find that share prices rise by an average of 1.7% in response to expatriation announcements. Among these 19 companies, 8 experienced positive abnormal returns over the one-day window, and 10 did so over a five-day window. But their paper does not indicate whether the increase is statistically significant. Cloyd, Mills, and Weaver (2003) and Seida and Wempe (2003b) find no evidence of a positive market reaction to board approval announcements. Since

these papers were published before the passing of Section 7874 of the 2004 American Jobs Creation Act, they all analyze pure-inverting firms with a small sample. The sample used in my paper also includes post-2004 inverting companies and M&A inverting companies. Thus, the sample size in this paper is much larger than their sample size (63 versus 19).

Finally, this paper is also related to the literature on cross-listing firms (Doidge, Karolyi, and Stulz, 2004; Doidge, Karolyi, and Stulz, 2007), which suggests that U.S. listing facilitates the firm to take growth opportunities by limiting the extent to which controlling shareholders can engage in expropriation. But there is a difference between the inverting companies and the cross-listing companies. Compared to the cross-listed companies discussed in this strand of literature whose significant operations are mainly outside of the United States, the inverting firms still operate mainly in the United States. This further enhances the SEC's ability to enforce its penalties on the inverting companies (Siegel, 2005; Shnitser, 2010; Licht, 2003; Cortes et al., 2015).

3. Incentives of Corporate Inversions and Section 7874 of the 2004 American Jobs Creation Act

3.1. Incentives of Corporate Inversions

The high U.S. "headline" tax rate has been regarded as an important reason that caused companies to invert. The dominant federal tax bracket for most moderate-sized (or larger) U.S. corporations is 35%.[8] Adding state corporate taxes, which range from 0% to 9%, to this figure, most UMCs are faced with a marginal headline tax rate around 40%.[9] As Figure 1 illustrates, the combined headline rate in the United States (the top thick line) far exceeds the rate in most of the competitive jurisdictions, and the gap has been widening in recent

[8]To be more specific, these are the companies whose taxable net earnings exceed approximately $18.3 million per year (Talley, 2015).

[9]See Corporate Tax Rates Table, KPMG, `http://www.kpmg.com/global/en/services/tax/tax-tools-and-resources/pages/corporate-tax-rates-table.aspx`.

years. In 2016, the U.S. corporate headline tax rate is 39%, much higher than that of Ireland (12.5%), the United Kingdom (20% and falling), Canada (26.5%), and the OECD average (25%). It is also significantly higher than the European Union average (22%) and the global average (24%). Although the effective tax rate in the United States may be well below the headline tax rates because of various kinds of accounting and financing methods, U.S. corporations are still faced with a large tax bill.

[**Insert Figure 1 near here**]

In addition, the worldwide approach of the U.S. tax regime combined with the high U.S. tax rates give UMCs the incentive to invert.[10] Different from the territorial tax regime in most OECD countries, which exempts the distributions from controlled foreign subsidiaries for tax purposes, the U.S. tax authorities levy taxes on UMCs' worldwide income, not just the proportion generated in the United States. To avoid double taxation, the U.S. tax code grants a credit for foreign taxes already paid to the foreign governments, and the foreign operations are liable only to the extent that tax liability under U.S. law would exceed that amount. Also, a UMC can defer U.S. recognition of earnings as long as it does not repatriate its foreign subsidiary's earnings to the parent. I use a hypothetical example to illustrate this point (see Panel A of Figure 2).

[**Insert Figure 2 near here**]

Suppose a U.S. incorporated multinational parent company has two separately incorporated subsidiaries,[11] a U.S. subsidiary and a foreign subsidiary, and each generates $100 in taxable earnings. Suppose the U.S. worldwide corporate tax rate is 40% and the foreign country's territorial corporate tax rate is 15%. Immediately when the earnings are generated, the U.S. subsidiary pays $40 to the U.S. tax authority and the foreign subsidiary pays $15

[10] Besides the United States, other OECD countries that take a worldwide approach are Chile, Greece, Ireland, Israel, South Korea, and Mexico.

[11] The profits of unincorporated foreign business branches are taxed immediately by the United States. Tax deferral is not allowed for foreign business branches.

to the foreign government. No further taxes are levied at the corporate level as long as the remaining $85 is kept in the foreign subsidiary. However, if the foreign subsidiary repatriates the profits to its U.S. parent, in theory it should pay $40 to the United States, but the U.S. law permits the company to claim $15 of foreign tax credits, which equals the amount of taxes already paid to the foreign government. So it needs to pay a $25 repatriation tax to the U.S. government before repatriating the remaining $60 to the U.S. parent. The overall after-tax earnings of the parent company is $120.

There is not much a U.S. parent company can do to avoid the U.S. tax liabilities on the foreign earnings. Though it could defer the $25 U.S. tax liability indefinitely as long as the after-tax foreign earnings are retained within the firm's foreign-incorporated subsidiaries, the parent company might want to utilize these earnings for profitable investment undertakings in the United States or for distributing more cash dividends. A common strategy for using unrepatriated earnings is through intra-company loans from the foreign company to the U.S. parent company. But such practices are usually restricted under Section 956 of the U.S. Internal Revenue Code by deeming such loans as dividends and thus taxable.[12]

After inverting to a tax-haven country, the multinational firm can avoid paying repatriation taxes and unlock its overseas earnings. Suppose the U.S. parent company shown in Panel A of Figure 2 is acquired by its foreign subsidiary and then the surviving company is reincorporated in the country where the subsidiary is located (Panel B of Figure 2). If that country's tax system is territorial, all $60 in after-tax earnings in the U.S. subsidiary can be repatriated to the foreign parent company without paying any repatriation taxes. The overall after-tax earnings of the parent company are now $145 compared to the $120 pre-inversion, thereby generating $25 in tax savings.

In addition, the surviving firm after an inversion can allocate its expenses more effectively across borders and further save taxes after inversion. For example, the surviving tax-haven-

[12]There are some limited exceptions under Section 956 of Internal Revenue Code, which gives criteria under which certain loans are nontaxable. But such loans are required to be short-term in nature and generally need to be repaid within the end of the subsidiary's fiscal quarter.

incorporated parent company can lend to the U.S. subsidiary, thereby generating interest deductions against U.S. taxable income while the interest income of the parent company is tax-free. In this way, overseas funds are made available to the U.S. subsidiary, and the firm also pays less taxes.

3.2. Section 7874 of the 2004 American Jobs Creation Act

The first wave of inversion came after 1994 when Helen of Troy, a publicly traded U.S. company in the personal care industry, pure-inverted to Bermuda. From 1994 to 2003, 28 companies were reincorporated abroad, among which 24 companies used pure inversions. Typically, the U.S. parent company is acquired by one of its foreign subsidiaries registered in a tax-haven country such as Bermuda in a pure inversion. After the transaction, the foreign subsidiary becomes the new parent company and the U.S. parent company becomes a subsidiary: therefore, the corporate structure is inverted. Existing shareholders of the former U.S. parent company typically still hold 100% of the shares in the new foreign-incorporated company. For instance, after Helen of Troy announced its inversion decision in December of 1993, it registered a subsidiary firm in Bermuda at first and then flipped it to become the new parent. Shareholders of the former U.S. parent firm received one share of the new firm for each share that they owned. The headquarters location, firms' management, and business operations all remained unchanged.

In response to this trend, Section 7874 of the 2004 American Jobs Creation Act was passed in 2004 and aimed at curbing pure inversions. In Section 7874, the "60% or 80% continuity threshold" (following Talley (2015)) is used to determine whether an inverting firm is qualified to reap tax benefits after an inversion.[13] First, the 60% threshold kicks in when the existing shareholders of the inverting firm hold less than 60% of the shares in

[13]Besides the "60% or 80% continuity threshold," two other criteria are set out in Section 7874: (i) the foreign buyer acquires substantially all of the U.S. corporation's properties; (ii) the surviving company does not have substantial business activities in the foreign acquiring company's country of incorporation. If an inversion fails any one of these three criteria, it can reap the benefits of tax savings. But criteria (i) and (ii) are usually satisfied for almost all pure inversions, which makes the "60% or 80% continuity threshold" a key consideration.

the surviving (combined) company. If so, the surviving company will be fully treated as a foreign corporation by the U.S. tax authorities. Second, if the existing shareholders of the inverting firm hold greater than 60% but less than 80% of the shares in the surviving company, the surviving company is partly recognized as a foreign entity. That is, the U.S. subsidiary's taxable income cannot be less than the gains that it received in this transaction in the following 10 years after inversion. Third, if the existing shareholders of the inverting firm hold more than 80% of the shares in the surviving company, the surviving company is still regarded as a U.S. incorporated company for tax purposes and thus reaps no tax benefits from this inversion.

Section 7874 effectively put a leash on pure inversions because the existing shareholders of a pure-inverting firm hold almost 100% of the shares in the surviving firm, and therefore the firm incurs no tax-saving benefits from the inversion. But the trend of corporate inversions was not stopped by Section 7874, and M&A inversions took the place of pure inversions, becoming the most favorable inversion strategy after 2004. Different from pure inversions, a UMC merges with or is acquired by a foreign company of similar size in an M&A inversion and changes its incorporation country to where the foreign acquirer is located. For example, in August of 2014 the then Delaware-incorporated fast food chain Burger King Worldwide, Inc., announced that it agreed to acquire Tim Hortons, Canada's largest quick service restaurant, for about $11 billion.[14] The new company is now governed by Canadian corporate laws while it still lists on the New York Stock Exchange.

An inverting company can easily bypass the 80% threshold by acquiring a foreign company of similar size, and frequently the existing shareholders' ownership of the surviving company can even be below 60% after M&A inversions. Following this change, more mature and better developed countries such as Canada, the United Kingdom and Ireland replaced

[14]In this transaction, Tim Hortons' investors received C$65.50 in cash and 0.8025 a share of the surviving company for each share they owned. The two brands still operate independently after the merger under the new combined company, Restaurant Brands International, which is incorporated in Canada. The shares of the combined company started trading on the Toronto Stock Exchange and New York Stock Exchange under the symbol QSR on December 15, 2014.

Bermuda and the Cayman Islands as the most popular countries to invert to. These new destinations have stronger economies, more stable economic policies, more favorable corporate law structures, and similar political risks than the pure inversions. Those advantages will possibly be reflected in the inverting firm's cost of equity and existing shareholder value change.

4. Empirical Methodology

4.1. Implied Cost of Capital

In this paper, I use the implied cost of capital (ICC), computed using earnings forecasts and market price, to measure the cost of equity. Fama and French (1997) conclude that the cost of equity estimates derived from the capital asset pricing model and three-factor models using realized rate of return are "unavoidably imprecise" because of three potential problems: difficulties in identifying the right asset pricing model, imprecision in the estimates of factor loadings, and the imprecision in the estimates of factor risk premia. Pastor, Sinha, and Swaminathan (2008) further show in simulations as well as empirically that ICC outperforms the realized rate of return in detecting a risk-return trade-off.

The empirical construction of the ICC in this paper closely follows Pastor et al. (2008). The firm-level quarterly ICC is the value of r_e that solves the empirically tractable finite-horizon model:

$$P_t = \sum_{k=1}^{T} \frac{FE_{t+k}(1 - b_{t+k})}{(1 + r_e)^k} + \frac{FE_{t+T+1}}{r_e(1 + r_e)^T}, \tag{1}$$

where P_t is the (average) stock price at quarter t, FE_{t+k} and b_{t+k} are the forecasts of the earnings per share (EPS) and the plowback ratio in k years after quarter t, and T is the forecasting horizon ($T = 15$). Notice that $FE_{t+k}(1 - b_{t+k})$ represents the free cash flow to equity in k years after quarter t. The first term in equation (1) captures the total present value of free cash flow to equity up to the terminal period T, and the second term captures

the total present value of all cash flows beyond the terminal period.

The EPS forecasts FE_{t+k} $(k = 1, 2, ..., T+1)$ are obtained based on the following steps. (i) The 1- and 2-year-ahead EPS forecasts are the median I/B/E/S 1- and 2-year-ahead analysts' EPS forecasts. (ii) The 3-year-ahead EPS forecast is computed as $FE_{t+3} = FE_{t+2}(1 + LTG)$, where LTG is the long-term earnings growth rate obtained from I/B/E/S. If LTG is missing in the I/B/E/S database, I extrapolate the growth rate in the first two years $(FE_{t+2}/FE_{t+1} - 1)$ for another year. Following Pastor et al. (2008), firms with growth rates above 100% (below 2%) are assigned with 100% (2%). (iii) By imposing an exponential rate of decline to mean-revert the 3-year-ahead growth rate to the steady-state growth rate, I compute the 4- to (T+1)-year-ahead EPS as follows:

$$g_{t+k} = g_{t+k-1} \times \exp[\log(g/g_{t+3})/(T-1)], \tag{2}$$

$$FE_{t+k} = FE_{t+k-1} \times (1 + g_{t+k}), \tag{3}$$

where g_{t+k} is the k-year ahead earnings growth rate, and g is the steady-state growth rate starting in $T + 2$ periods after t. I use the 10-year rolling average of the annual nominal GDP growth rate as a proxy for g. (iv) I assume that the dividend paid to the shareholders in year $t + k$ is zero if the forecasted earnings in that year are negative.

The last thing needed to compute the ICC is the forecasted plowback rate b_{t+k}, which is computed in two stages: (i) I explicitly forecast the plowback ratio in the nearest two years, b_{t+1} and b_{t+2}, as one minus the firm's most recent payout ratio (i.e., total dividend paid divided by net income)[15]; (ii) I mean-revert the plowback ratios between $t+2$ and $t+T+1$ linearly to the steady-state plowback ratio based on the following equation:

$$b_{t+k} = b_{t+k-1} - \frac{b_{t+2} - b}{T-1} \tag{4}$$

[15]Following Gerbardt, Lee, and Swaminathan (2001), for firms with negative earnings, I divide dividends by long-term earnings. The long-term earnings are estimated to be 6% of total assets since the long-run return on assets in the United States is 6%.

where b is the steady-state plowback ratio. The variable b is computed from the sustainable growth rate formula, $g = ROI \times b$, where ROI is the steady-state return on investment. Following Gerbardt et al. (2001) I use the 10-year rolling average of the firm's return on investment as the steady-state ROI. Finally, with the forecasted EPS and plowback ratio readily available, ICC can be computed from equation (1).

4.2. Matching

I test the change in the cost of equity by comparing the inverting firms to a matched sample of UMCs and computing the diff-in-diff estimate of the effect of inversion on the cost of equity. I select the control sample from the pool of UMCs instead of the entire group of U.S. incorporated companies for two reasons. First, as illustrated in Section 3, only multinational firms can benefit from inversions, and the incentive to invert comes from the less costly benefit of having profitable foreign operations and repatriating the cash held within foreign subsidiaries. So companies with 100% business in the United States will not construct a good control sample, and therefore these firms should be excluded from our consideration. Second, because firms in my treated sample are all incorporated in the United States and are publicly traded in U.S. markets before they invert, to make a good comparison, I select the control sample only from the firms that have remained incorporated and publicly traded in the United States since their inception. So, different from Cortes et al. (2015), I do not consider the foreign private issuer (FPI) and American foreign corporations (AFC) in this paper.[16]

To find the appropriate control sample by matching, I first define the measurement quarter to be the last quarter of the calendar year prior to the announcement of inversion. Then

[16]FPIs are foreign incorporated and have business mainly outside of the United States. Though they are cross-listed in the United States and are governed under the federal securities law, they are usually faced with less stringent disclosure and corporate governance rules (Siegel, 2005; Shnitser, 2010; Licht, 2003). AFCs include household names such as Michael Kors Holdings Ltd and Carnival Corporation, which have substantial business in the United States but were incorporate outside of the United States from the time they were built. Since they started out as a foreign company, there is no need to invert out of the United States for them.

for each inverting firm, I match on three observable firm characteristics while controlling the measurement quarter and industry: firm size (*log(total assets)*), leverage (*leverage ratio*), and profitability (*return on assets*, or *ROA*). These matching variables are chosen because the literature (e.g., Desai and Hines (2002) and Cortes et al. (2015)) has shown that large, profitable multinational firms with high leverage have a higher probability of inverting. Industry is another important factor to control because some industries, such as the pharmaceutical products industry, tend to have more inversions compared to other industries.

Specifically, for each inverting firm in the treated sample, I identify the best match in the same industry and the same measurement quarter in terms of those three observable firm characteristics using the Mahalanobis distance. It might be instructive to look at an example to understand the matching used here. If firm A announces that it will invert to Bermuda in March of 2010, I define the measurement quarter to be the fourth quarter of 2009. I then compute the Mahalanobis distance for all the UMCs in the measurement quarter based on *log(total assets)*, *leverage ratio*, and *return on assets*, and double-sort the firms by distance and industry. Lastly, I use the firm with the smallest distance in the same industry as firm A to be the control firm. To ensure that the control firm is the closest match, I match with replacement and drop the duplicates. In addition, the first four closest matches are used for a robustness check.

This matching method guarantees the three matching variables to be exogenous to the treatment (inversion) because they are measured in the quarter before the inversion announcement. In the commonly used matching method, a match is found for each firm-quarter observation before and after the treatment, so that these matching firm characteristics will be changed by an inversion, especially an M&A inversion, therefore weakening the analysis. In this sense, my matching method is more advantageous than the commonly used matching method and differs from that of Cortes et al. (2015).

4.3. Linear Difference-in-Difference Analysis

Having identified the treated and control groups, I test the effects of inversion on the cost of equity by estimating the following linear model:

$$RP_{it} = \tau D_{it} + \mathbf{x_{it}}\gamma + c_i + \lambda_t + u_{it}, \quad t = 1, 2, ..., T, \tag{5}$$

where RP_{it} is the risk premium (the cost of equity minus the risk-free rate) of company i at time t, and D_{it} is the incorporation status dummy variable of company i at time t. If company i is incorporated in the United States at time t, D_{it} equals 0. Otherwise, if it is incorporated in a foreign country at time t, D_{it} equals 1. Notably, D_{it} equals 0 for all control firms. For treated firms, D_{it} equals 0 before they invert, and 1 afterward. Since no companies in my sample reincorporate back to the United States after they invert, $D_{it} = 1$ whenever $D_{is} = 1$ for all $s < t$. *Log(total assets)*, *leverage ratio*, and *ROA* are used as controls and included in $\mathbf{x_{it}}$. The term c_i denotes a full set of unobserved heterogeneity effects, which will absorb the impact of any time-invariant firm characteristics, and λ_t denote a full set of time-fixed effects. The error term u_{it} includes all other time-varying unobservable shocks to the cost of equity.

We assume that the incorporation indicator D_{it} is strictly exogenous: after controlling for *log(total assets)*, *leverage ratio*, *ROA*, unobserved firm-specific heterogeneity, and time-fixed effects, u_{it} is conditionally independent of incorporation status, D_{it}. This assumption is plausible because companies invert mainly because of tax savings and expense reallocation, and there is no evidence indicating that shocks to the cost of capital affect a firm's inverting decision.

Following Imbens and Wooldridge (2007), equation (5) is essentially an individual-level diff-in-diff model, and τ is the diff-in-diff estimator. Compared to traditional linear diff-in-diff regressions with only two periods around the treatment, the individual-level diff-in-diff regression controls more unobservable time-fixed effects by using the entire time series path

of the firms, and thus increases the explanatory power of the regression. It can be estimated using the standard fixed effects (FE) estimation, and the strict exogeneity assumption ensures the FE estimator to be consistent. The standard errors are robust to the heteroskedasticity and are clustered at the firm level. Since all the matching variables are included in $\mathbf{x_{it}}$, equation (5) helps us to find the bias-corrected ATT (Abadie and Imbens (2011)).

Another issue to notice is that no systematic factors are included in equation (5). There is little doubt that systematic factors such as the market risk premium, size, and book-to-market effects significantly affect the cost of equity (Pastor et al., 2008). They are omitted from equation (5) because they tend to affect both treated and control observations, and their net contribution to the diff-in-diff estimate is zero.

4.4. Nonlinear Analysis: Fractional Response Models

To make the estimation of the effects of inversion more precise, I use a fractional response model to capture the property that the cost of equity is generally between 0 and 1:

$$R_{it} = G(\tau D_{it} + \mathbf{x_{it}}\gamma + c_i + \lambda_t) + u_{it}, \quad t = 1, 2, ..., T, \tag{6}$$

where R_{it} is the cost of equity. Assuming $E(u_{it} \mid D_{it}, \mathbf{x_{it}}, c_i, \lambda_t) = 0$, we have

$$E(R_{it} \mid D_{it}, \mathbf{x_{it}}, c_i, \lambda_t) = G(\tau D_{it} + \mathbf{x_{it}}\gamma + c_i + \lambda_t). \tag{7}$$

To ensure $E(R_{it} \mid D_{it}, \mathbf{x_{it}}, c_i, \lambda_t)$ lies between 0 and 1, I choose three functional forms of $G(\cdot)$:

(i) $G(z) = exp(z)/(1 + exp(z))$; (fractional logit)

(ii) $G(z) = \Phi(z)$, where $\Phi(z)$ is the cumulative function of the standard normal distribution, or $\Phi(z) = \int_{-\infty}^{z} \frac{1}{\sqrt{2\pi}} exp(-\frac{x^2}{2})dx$; (fractional probit)

(iii) $G(z) = 1 - exp(-exp(z))$; (fractional complementary log-log).

All of these models are estimated using quasi-maximum likelihood estimation, and the standard errors are fully robust to firm-level heteroskedasticity and serial correlation. The average treatment effect on the treated (ATT) estimated in the fractional response models is the diff-in-diff estimate of the inversion's impact on the cost of equity.

5. Data and Summary Statistics

5.1. Data

I obtain price data from CRSP, accounting data from COMPUSTAT (U.S., quarterly), analyst forecast data from I/B/E/S, and the one-month T-bill rate of return from Kenneth French's website. Additionally, nominal GDP growth rates are available from the Bureau of Economic Analysis. To compute the ICC, we need to merge COMPUSTAT with I/B/E/S first. However, we cannot merge them directly because COMPUSTAT uses GVKEY as the permanent identifier to track each company, while I/B/E/S uses I/B/E/S TICKER. So I start with merging I/B/E/S and CRSP by CUSIP, CUSIP dates, and company names to build a one-to-one match between I/B/E/S TICKER and CRSP PERMNO,[17] and then merge the resulting file with CRSP/COMPUSTAT-Merged dataset by PERMNO and date. In this way, we obtain the COMPUSTAT/IBES-Merged dataset.

The list of corporate inversions is obtained mainly from three sources: the existing literature (Desai and Hines, 2002; Seida and Wempe, 2003b; Talley, 2015), the Bloomberg Corporate Expatriates list, and the SEC. Appendix A lists 88 companies that announced plans to invert from 1994 to 2015, including 8 companies that failed to pass the board's approval. To be consistent with the existing literature's treatment of inversions, I further screen these companies by comparing each firm with its SEC Edgar filings based on the following criteria: (i) the inversion passed the board's approval; (ii) the inverting company

[17]The matched pairs whose exchange tickers match but the company names and CUSIPs do not match are omitted.

was a publicly traded U.S. company before inversion; (iii) stocks of the surviving company are still publicly traded in the United States;[18] (iv) the transaction was closed/completed by December 31, 2015. We are left with 63 inversions for empirical testing purposes (Appendix B).

5.2. Summary Statistics

Figure 3 plots the total number of inversions and the number of inversions through each strategy from 1993 to 2014. Before 2004, 28 companies inverted overseas, among which the majority (24) inverted purely. Nevertheless, after the passing of Section 7874 in 2004, inverting by merging with a foreign entity replaces pure inversion as the most common inversion strategy. Moreover, it has become the dominant strategy especially after 2010. For instance, while there have been only 4 pure inversion announcements since 2010, there were 13 M&A inversions in 2014 alone. Spin-off inversion is more frequent after 2004 than before, but the number of this type is negligible.

[Insert Figure 3 near here]

Table 1 displays the number of inversions announced in each industry. Generally, inversions occur in a wide range of industries: they exist in 26 out of 48 Fama-French industries. That being said, inversions cluster mainly in three industries: pharmaceutical products (14), petroleum and natural gas (13), and insurance (8). A firm in the petroleum and natural gas industry inverts mainly through a pure inversion strategy, whereas a firm in the pharmaceutical products industry commonly inverts through mergers.

[Insert Table 1 near here]

We also display 17 destination countries in Table 2, and 6 of them are tax havens (Hines and Rice, 1994; Dharmapala and Hines, 2009). The second column in Table 2 gives the

[18] Hence, firms whose stocks are traded on the OTC market after inversion are not included in the treated sample in this paper.

total number of inversions for each destination; Bermuda is the most popular destination (26 inversions out of 88). The other popular destination jurisdictions are Ireland (13), the Cayman Islands (10), the United Kingdom (9), Canada (8), and the Netherlands (7). Importantly, inverting firms' destinations have been shifting from less developed offshore tax-haven jurisdictions such as Bermuda and the Cayman Islands to more developed countries such as Ireland, the Netherlands, and the United Kingdom (see column (3) of Table 2). Moreover, this shifting has become more apparent after 2010. There have been 12 inversions to Ireland, 8 to the United Kingdom and five to the Netherlands, but only four to Bermuda since 2010 (see column (5) of Table 2).

[**Insert Table 2 near here**]

Inverting firms prefer more developed economies after 2004 because it is easier for them to find a foreign acquirer in these countries to bypass the "60% or 80% continuity threshold" imposed by Section 7874 of the 2004 American Jobs Creation Act. Interestingly, even for the firms inverting to Bermuda after 2004, M&A is also a common strategy to take. These firms were often acquired by a Bermuda-incorporated firm that pure-inverted to Bermuda before 2004. For example, the insurance company Argonaut Group inverted to Bermuda in 2007 by merging with the Bermuda-incorporated PXRE Group in 2007, and the PXRE Group pure-inverted to Bermuda earlier in 1999.

Table 3 displays the summary statistics for the main variables used in this analysis. Panel A and Panel B report the statistics for the group of inversions and the group of 13,152 UMCs separately. All the UMCs reported in Panel B have been incorporated in the United States since their inception. We observe that inverting companies tend to have a lower average cost of equity than UMCs. They are also larger in size, have higher leverage ratios, and are more profitable on average, which is consistent with the findings in the literature. Panel C and Panel D give the summary statistics for firms taking pure and M&A inversion strategies. Slightly different from pure-inverting firms, M&A-inverting firms typically have

a lower leverage than UMCs. But they are both larger in size and more profitable when compared to an average UMC.

[Insert Table 3 near here]

6. Results

6.1. Linear Regression

I start by checking whether we have a comparable control sample to the treated sample in terms of the three matching variables, *log(total assets)*, *leverage ratio*, and *ROA*. I use the inverting firms as the treated sample and the closest match as the control sample (CS1). Table 4 reports the 25th percentiles, 50th percentiles, and 75th percentiles of the three matching variables, and I find that the distributions are very close between the treated and control samples.[19] The p-values of the mean and distribution comparisons reported in the last two columns of Table 4 further confirm that the treated and control groups have similar distributions.

[Insert Table 4 near here]

Table 5 provides the results of the benchmark linear regressions (equation (5)) using CS1 as the control sample. Columns (1)-(3) of Table 5 report the regression results by including all 63 inversions as treated sample, and I find no economically and statistically significant impact of inversions on the cost of equity. The magnitude of foreign reincorporation dummy D_{it} is roughly the same with and without the control variables, which indicates that the impacts of the control variables on the cost of equity have been largely captured by the reincorporation dummy.

[19]The only noticeable difference is that the 25th percentile of treatment sample *ROA* is negative, whereas that of the CS1 is positive. But considering that their magnitudes are very small, this difference is economically insignificant.

[Insert Table 5 near here]

Next I look at the effects of inversion on the cost of equity by conditioning on inversion strategies (see columns (4)-(9) in Table 5). Results of pure-inverting firms are reported in columns (4)-(6). As a benchmark regression, I do not include any controls in $\mathbf{x_{it}}$ in the first specification, and I find that a pure inversion increases the cost of equity by 23 basis points (bps) (column (4)), which is marginally significant at the 5% significance level after controlling for firm-level heteroskedasticity and serial correlation. Since the mean risk premium of pure-inverting firms is 0.0116 before inverting, pure inversion increases the risk premium of these firms by 19.8% on average. In the second specification (column (5)), I include *log(total assets)*, *leverage ratio*, and *ROA* as control variables and find no significant changes in the coefficient of the reincorporation dummy. Lastly, as a robustness check, I control for industry fixed effects in the third specification (column (6)) and find no significant changes either.

The increase in the cost of equity after a pure inversion reveals that the shareholders of pure-inverting firms raise their required rate of return, which could be caused by the following reasons. First, after a pure inversion, the firm is governed under the corporate laws of the destination jurisdiction, thus losing the protection of U.S. corporate laws. Compared to the corporate laws in Bermuda and the Cayman Islands, the Delaware legal framework and accompanying institutions add net economic value to public companies, better serve shareholders' interests (Daines, 2001), and provide more protection to the shareholders against hostile take-overs (Talley, 2015). Second, political risks and economic policy uncertainty are greater in pure inversion destinations such as Bermuda than they are in the United States. Third, pure-inverting firms' stock trading activities will change after an inversion. For example, Cortes et al. (2015) show that inverting firms tend to have higher bid-ask spreads, less liquid stocks, and less institutional ownership. Investors put a lower value on the cash on their balance sheets after inversions as well.

Columns (7)-(9) of Table 5 report the impact of M&A inversions on the cost of equity.

An M&A-inverting firm's cost of equity typically *decreases* by 33bps (29bps) on average after inversion, which is significant at the 1% significance level, with (without) controlling matching variables (columns (7) and (8)). Since the mean risk premium of M&A-inverting firms is 0.018 prior to the inversion, M&A inversion decreases these firms' risk premium by 18.3% on average. Additionally, there is no significant change in the estimates after controlling for industry fixed effects.

The decrease in the cost of equity after an M&A inversion is a result of several mixed effects. First, the new destination jurisdictions of M&A inversions are better developed than destinations of pure inversions and have similar political and economic risks as in the United States. Therefore, U.S. investors would be better protected under the corporate laws of M&A inversion destinations and are more confident about their economic developments compared to pure inversions.

Second, different from pure inversions in which the only material change is the change in the registration jurisdictions, inverting by merging with a foreign entity is bundled with the change in jurisdiction and changes in the firm's management, business operations, and ownership compositions. An M&A-inverting firm commonly merges with a foreign firm which is usually economically profitable and internationally well known, thus mitigating equity investors' concerns, or even boosting their confidence, about the new combined firm's future economic prospectus. This process therefore lowers the shareholders' required rate of return.

Last, since the two companies in an M&A inversion are generally household names in the same industry, an M&A transaction decreases the global competition of that industry and expands the inverting UMC's business to foreign markets. Consequently, the decrease in the cost of equity is a result of the synergy created from less intra-industry competition and geographical business diversification. Overall, the estimated negative effect of M&A inversions on the cost of equity indicates that the positive synergy created from an M&A inversion outweighs equity investors' worries about the political and economic risks in the

new destination jurisdiction.

6.2. Fractional Response Model

Fractional response models are suitable for capturing the property that the cost of equity typically lies between zero and one, which makes the diff-in-diff estimate more precise. I use the cost of equity as the dependent variable in three estimation equations following equation (5): *fractional logit*, *fractional probit*, and *fractional complementary-log-log*.[20] All models are fully saturated in that firm- and time-fixed effects are all controlled. Standard errors are fully robust and are clustered at the firm level.

[Insert Table 6 near here]

Panel A of Table 6 gives the results of regressions using all inverting firms as the treated group. As shown, the impact of inversion on the cost of equity is economically and statistically insignificant across all three fractional response models, which is consistent with the linear regression findings in Table 5.

Panel B reports the regression results of pure-inverting firms. I find that a pure inversion increases the cost of equity by up to 103bps after controlling for firm- and time-fixed effects (see columns (2), (5) and (8)).[21] Moreover, the estimates are marginally significant at the 5% significance level. Since the mean level of a pure-inverting firm's cost of equity is around 0.106 before inversion, pure inversion increases the cost of equity by up to 10%, and it almost doubles the risk premium of inverting firms (from 116bps to 219bps). Additionally, the similarity of the estimates across three models precludes the concern that the estimation over relies on the functional form of $G(\cdot)$ in equation (6). Additionally, there are no noticeable changes in the estimates after controlling industry fixed effects (see columns (3), (6), and (9)).

[20] In particular, the complementary-log-log model allows for the existence of extreme values.

[21] The estimates in regressions with controls (see columns (2), (5), and (8)) are larger than those without any control variables (columns (1), (4), and (7)).

Panel C reports the results of M&A-inverting firms. I find that an M&A inversion decreases the cost of equity by up to 139bps on average, which is statistically significant at the 1% significance level. Since the average cost of equity and the risk premium before an M&A inversion are 11% and 1.8% respectively, an M&A inversion decreases the cost of equity by up to 12.6% and the risk premium by up to 77%, which indicates that an M&A inversion tends to greatly lower stock investors' required rate of return on the inverting firm's stock.

In sum, the nonlinear diff-in-diff estimates of fractional response regressions are larger than the estimates of linear regressions because fractional response models incorporate the $[0, 1]$ data structure of the cost of equity and therefore make the estimation more precise. That being said, fractional response regression results are consistent with linear regression results in terms of the statistical significance and the direction of the change in the cost of equity.

6.3. Robustness Checking

6.3.1. One-for-Four Matching

In this section, I check whether our results are being driven by the choice of control sample size in my earlier regressions. Using the one-for-one match as the control sample might restrict the generalization of the findings. Following Abadie, Drukker, Herr, and Imbens (2004), as a robustness check, I use the first four closest matches of each inverting firm as the control sample. Summary statistics for the comparison between the inverting/treated group and its one-for-four matching group (CS4) are reported in Table 7. The 25th, 50th, and 75th percentiles of the matching variables are close between the treated and control samples. The p-values for the mean and distribution comparisons further confirm that the treated and control groups are statistically equivalent.

[Insert Table 7 near here]

I repeat the linear and fractional response regressions using CS4 as the control group. The results are reported in Table 8 (linear) and Table 9 (fractional response). The linear diff-in-diff estimates are still small in magnitude and statistically insignificant if we pool all inverting firms in the treated sample (Panel A of Table 8), which is consistent with our findings in Table 5. The regression results for pure-inverting firms (Panel B of Table 8) and M&A-inverting firms (Panel C of Table 8) are also consistent with our earlier findings. On average, a pure inversion increases the cost of equity, whereas an M&A inversion decreases it. The diff-in-diff estimates are statistically significant and close in magnitude to the findings using CS1 as the control group.

[Insert Table 8 near here]

[Insert Table 9 near here]

The fractional response regression results using CS4 as the control group are also consistent with the results obtained using CS1. The estimate of the impact of inversion on the cost of equity using all inverting firms as the treated sample (Panel A of Table 9) is still insignificant. Panel B and Panel C show that the impact on the cost of equity is positive (up to +82bps) for pure inversions and negative (up to -88bps) for M&A inversions. Moreover, the diff-in-diff estimates in Table 9 are slightly smaller than the estimates obtained using CS1 because CS4 increases the control sample size by including less perfectly matched observations. In summary, my regression results are robust to the choice of control sample observations.

6.3.2. Augmented Linear Regression

In our prior regressions, we treat the reincorporation dummy as an exogenous variable, and we assumed that besides a firm's size, leverage, and profitability, no other factors affecting a firm's cost of equity are correlated with its inversion decision. In this section, I address the concern that other variables might be simultaneously driving a firm's inversion

decision and its cost of equity by looking at an augmented linear model and using CS1 as the control sample. I identify four variables that might be missing in our earlier regressions: *Cash Holdings*, *Capital Expenditure*, *R&D Expenditure*, and *Tax Rate*. Cortes et al. (2015) have demonstrated that these variables are all relevant to a firm's inversion.

Cash holdings will affect a firm's financing costs for two possible reasons. First, cash held inside the firm could be regarded as a high-quality collateral, which tends to lower the cost of equity. On the other hand, holding too much cash may imply that the firm lacks good investment opportunities, which tends to increase the cost of equity (or equivalently, the required rate of return by stock investors). Whichever the direction is, both reasons demonstrate that cash held inside the firm is correlated with the cost of equity. Section 3 has discussed that a firm with more cash held in a foreign subsidiary has more incentive to invert to repatriate the cash in a less costly manner. Therefore, the cash holdings of a firm might correlated with both the cost of equity and the inversion decision.

High expenditures in capital and R&D in a firm have two implications. A firm with high expenditures in capital and R&D will have a high demand for equity to finance such activities, and this tends to increase the cost of equity. It might also signal to the equity investors that the firm has good investment opportunities, and this tends to lower the cost of equity. Both implications demonstrate that the capital expenditure and R&D expenditure are correlated with the cost of equity. They also appear to be correlated with inversion decisions in that a multinational firm with high capital and R&D expenditures has a higher demand for repatriating its overseas cash to spend on such activities.

Additionally, the Modigliani and Miller theorem demonstrates that a firm's cost of equity is positively correlated the corporate taxes. Since avoiding high U.S. corporate taxes is the main incentive of inversions, as shown in Section 3, I also include the firm's average tax rate in the augmented regression model.

Technically, besides *Reincorporation Dummy*, *log(total assets)*, *Leverage*, and *ROA*, I include *Cash Holdings*, *Capital Expenditure*, *R&D Expenditure*, and *Tax Rate* in $\mathbf{x_{it}}$ of equation

(5) to eliminate the potential missing variable issue in Table 5, and I report the results in Table 10. I find that generally there are no significant differences in the diff-in-diff estimates with and without these extra control variables: a pure inversion still increases the inverting firm's cost of equity, and an M&A inversion still decreases it. The results reported are statistically significant, which implies that our earlier results are robust to the potential missing variable issue.

[**Insert Table 10 near here**]

6.4. Cash Holdings, Dividend Payments, and Capital Expenditures

As illustrated in Section 3, firms have an incentive to invert because of the less costly benefit of repatriating the cash held in foreign subsidiaries either to invest in projects in the United States or to pay more dividends to U.S. shareholders. Therefore, the cash holdings in a pure-inverting firm will decrease after an inversion. However, different from pure inversions, the surviving firm's cash holdings after an M&A inversion are also affected by the cash holdings of the foreign acquirer. Therefore, it is unclear how the cash holdings will change after an M&A inversion. I empirically test the cash holdings change for pure and M&A inversions separately in Table 11.

[**Insert Table 11 near here**]

Regression results reported in Table 11 are consistent with our hypothesis proposed above. On the one hand, the ratio of cash to total assets decreases by about 18 percentage points and is statistically significant after a pure inversion (column (2)), which indicates that a pure inversion enables the U.S. subsidiary to utilize the cash held overseas, and subsequently the total cash holdings in the firm decrease. Additionally, for a firm with better profitability (higher *ROA*), the cash holdings tend to be higher. On the other hand, though the impact of an M&A inversion on cash holdings is negative, it is statistically insignificant (column

(3)), which is consistent with the hypothesis that the change in cash holdings after an M&A inversion is also affected by the cash holdings policy of the acquirer.

To investigate whether the repatriated cash is used to pay dividends to U.S. shareholders or to invest in potentially profitable investment projects in the United States after a pure inversion, I regress dividend payments on *Reincorporation Dummy* and other relevant factors. As reported in column (2) of Table 12, dividend payments do not change significantly after a pure inversion, which indicates that the purpose of pure inversion is not to repatriate cash in foreign subsidiaries to pay the firm's existing shareholders more dividends. Again, lacking information on the foreign acquirer's dividend payment policy, we could not see the impact of inversion on dividend payments in the M&A case.

[**Insert Table 12 near here**]

The effects of corporate inversions on capital expenditures are reported in Table 13. A pure-inverting firm's capital expenditure increases after it inverts to countries such as Bermuda or the Cayman Islands. Considering that the cash holdings of the pure-inverting firm decrease while their dividend payments do not change significantly, this indicates that pure-inverting firms repatriate their cash held in foreign subsidiaries to invest in potentially profitable projects in the United States. However, similar to Table 11 and Table 12, the change in capital expenditures after an M&A inversion is statistically insignificant because the investment policy of the foreign acquirer also affects the change in capital expenditures after an M&A inversion.

[**Insert Table 13 near here**]

7. Corporate Inversion Strategies and Existing Shareholder Value

7.1. The Advantage of M&A Inversions over Pure Inversions

In the former section, I have demonstrated that inverting by merging with a foreign entity is more favorable than inverting through a pure inversion strategy in terms of reducing financing costs. However, the tax savings through an M&A inversion strategy are usually less than those through through a pure inversion strategy because the corporate tax rates in the destination jurisdictions of M&A inversions are usually higher than the tax rates in pure inversion destinations. Specifically, corporate tax rates in offshore tax-haven jurisdictions where pure inversions commonly reincorporate are usually zero, whereas the corporate tax rates in M&A inversion destination jurisdictions are usually higher than zero. For example, for the three commonly used M&A inversion destinations, Ireland, the United Kingdom, and Canada, their marginal corporate tax rates are 12.5%, 20%, and 26.5%, respectively, in 2016. Therefore, compared to the pure inversion strategy, taking an M&A inversion strategy lowers tax savings by around 20% depending on where the foreign acquirer is located. This begs the question, which strategy is more beneficial overall to existing shareholders? In this section, I look at the impact of the 2004 tax reform, which restricts the tax benefits in a pure inversion and induces firms, perhaps unintentionally, to use an M&A inversion strategy. Technically, I compare the existing shareholder value increase after a pure inversion to the increase after an M&A inversion using the following diff-in-diff model:

$$MKV_{it} = \beta_0 + \beta_1 After_{it} + \beta_2 MA_{it} + \beta_3 After_{it} \times MA_{it} + u_{it}, \quad t = 1, 2, ..., T, \qquad (8)$$

where MKV_{it} is the market value of firm i's existing shareholder value at time t (in billions of dollars). $After_{it}$ equals 1 in the post-inversion stage and 0 in the pre-inversion stage. MA_{it} equals 1 for M&A-inverting firms and 0 for pure-inverting firms. The error term u_{it}

includes all the other time-varying unobservable shocks to existing shareholder value. It is easy to show that

$$\begin{aligned}\beta_3 = (&E[MKV_{it}|After_{it} = 1, MA_{it} = 1] - E[MKV_{it}|After_{it} = 0, MA_{it} = 1]) \\ -(&E[MKV_{it}|After_{it} = 1, MA_{it} = 0] - E[MKV_{it}|After_{it} = 0, MA_{it} = 0]),\end{aligned} \tag{9}$$

which means that the coefficient of the interaction term, β_3, measures the difference between the existing shareholder value increase in M&A inversions and the increase in pure inversions.

The data used to estimate equation (8) are obtained from CRSP. Before inversion, the pre-inversion shareholders' equity value equals the product of the stock price and the number of outstanding shares. After inversion, the existing shareholder value is calculated as follows:

$$MKVPOST_{it} = Fraction_i \times Price_{it} \times Shares_{it}, \quad t = 1, 2, ..., T, \tag{10}$$

where $MKVPOST_{it}$ is the pre-inversion shareholders' value after an inversion. $Price_{it}$ denotes the stock price and $Shares_{it}$ denotes the number of shares outstanding. $Fraction_i$ denotes the U.S. inverting firm i's ownership percentage of the surviving company. For pure-inverting firms, $Fraction_i$ equals 100% because the pre-inversion shareholders still hold 100% of the firm after a pure inversion. In contrast, $Fraction_i$ is less than 100% for M&A inversions because when a U.S. multinational firm merges with a foreign company, only the surviving/combined firm is traded on the NYSE or NASDAQ. The actual U.S. inverting firms' ownership percentage of the surviving company is obtained from Talley (2015), Appendix B, and from SEC filings (forms S-4, 14D9, 14D6, and 8-K).[22]

The regression results are reported in Panel A of Table 14. Because the dependent variable is highly serially correlated, I report the Newey-West standard errors in parentheses.

[22]If the firms have stocks that are still separately traded in the United States and foreign markets after M&A transactions, equation (10) will underestimate the pre-inversion shareholders' equity value. I assume $Fraction_i$ equals 100% in this case. Six companies fall into this category: C&J Energy Services, Mondelez International Inc., Restaurant Brands International, Tower Group, Valeant Pharmaceuticals International, and Wright Medical Group.

In column (1), I use the monthly data after 1978 for estimation.[23] The estimate of β_3 (in boldface) is positive and statistically significant at the 1% significance level. That means, all else equal, an M&A inversion delivers around $2.07 billion additional to existing shareholders than a pure inversion on average.

[Insert Table 14 near here]

Because other corporate structural changes during a firm's lifetime might affect the existing shareholder value, I rerun the regression with shorter windows. In the second specification, I use a 10-year window (the data within 120 months before the announcement month and the data within 120 months after the completion month of inversions) for the regression. The regression results reported in column (2)of Table 14 are close to the results in column (1). Similarly, I run regressions with a 5-year window and a 3-year window. With these shorter windows, the estimate of β_3 is still positive and statistically significant, but the magnitude is larger.

Potentially, the inverting firms' stock prices could react before the announcement of inverting decisions. This reaction could be caused by information leakage and insider trading. As a robustness check, I delete the data within the 12 months before the inversion announcement and redo the regressions in columns (2), (3), and (4), and I report the results with these "censored" windows in columns (5), (6), and (7). I find no significant difference with and without censoring.

Additionally it can be shown that

$$\beta_1 = E[MKV_{it}|After_{it} = 1, MA_{it} = 0] - E[MKV_{it}|After_{it} = 0, MA_{it} = 0], \qquad (11)$$

which means that β_1 measures the increase in existing shareholder value if the firm inverts through a pure inversion strategy. The results in columns (1) to (7) in Table 14 reveal that

[23]Since the first inverting firm in our inversion sample, Helen of Troy, announced its plans to invert in 1993, I choose 1978 as the starting year to make sure there is a 15-year window prior to its announcement.

although a pure inversion increases the cost of equity, it still increases the inverting firms' shareholder value, and the increase is statistically significant.

Including firms that pure-inverted after the 2004 tax reform in the sample tends to lower the average existing shareholder value increase in pure inversions, and therefore overestimates the advantage of an M&A inversion strategy over a pure inversion strategy. That is because pure-inverting firms that do not pass the "60% or 80% continuity threshold" test in Section 7874 will not be able to save as much in repatriation taxes. As a robustness check, in Panel B of Table 14, I drop all the firms that pure-inverted after 2004 and redo the regression reported in Panel A.[24] All the estimates of β_3 reported in Panel B are positive and statistically significant at the 1% level and are very close in magnitude to the results reported in Panel A, which is consistent with our earlier results that the existing shareholder value tends to increase more if the firm inverts by merging with a foreign entity.

7.2. A Moral Hazard Implication

In Section 6 and Section 7.1, I have established that compared to the pure inversion strategy, inverting through a merger not only lowers the inverting firms' cost of equity but also adds more value to existing shareholders. Therefore, theoretically, to maximize existing shareholder value, firm managers should choose an M&A inversion as the main inversion strategy. However, in reality, a pure inversion strategy was more preferable prior to the passing of Section 7874 of the 2004 American Jobs Creation Act, which effectively restricts the tax savings from pure inversions. We observe 28 pure inversions from 1990 to 2004 but only three M&A inversions in the same period.

The disagreement between theory and reality discussed above has two implications. First, before 2004, inverting firms' managers appear not to maximize existing shareholders' interest. Since the main objective of inversion is to save repatriation taxes by changing the incorporation country, reincorporating overseas without changing the headquarters location

[24]Seven firms are dropped in this panel: Lazard, Freescale Semiconductor, Western Goldfields, Tim Hortons, ENSCO International, Styron, and Delphi Automotive.

and management team composition would be the easiest method for inverting firms' managers. Additionally, by taking a pure inversion strategy, managers still have the same level of control in the company. In short, inverting firms' managers tend to incur lower costs by taking a pure inversion strategy, though it adds less to existing shareholder value.

Second, while the main objective of passing Section 7874 is to curb corporate pure inversions and maintain the tax revenue paid to the U.S. government, the tax reform has two unintended consequences. First, managers are induced to take an M&A inversion strategy after the tax reform, which might not be expected by the policy makers. The trend of inverting to foreign countries has not been stopped by the 2004 reform, and there are even more M&A inversions from 2004 to 2014 than pure inversions from 1990 to 2004 (38 versus 28). Therefore, the tax reform appears to have failed in stopping lost tax revenue and switches corporate inversions from one mode to another, echoing the current mainstream view that another tax reform is needed. Second, and more important, the tax reform has an unintended consequence of reducing the managerial agency problem because managers are induced to take an M&A inversion strategy, which adds more value to existing shareholders. Contrary to the common belief that economic interventions generally are detrimental to social welfare, the tax reform tends to increase shareholder wealth in the inversion case. Therefore, the 2004 tax reform appears to be successful. If the government policy aims at increasing shareholder wealth instead of maximizing tax revenue, no additional tax reform is needed.

8. Conclusion

The past two decades have witnessed more than 80 U.S. multinational companies leaving to reincorporate overseas. The exodus of U.S. corporations for tax-haven countries has led to heated discussions among policy makers regarding possible tax and other regulatory reforms. For example, in his weekly presidential address on July 26, 2014, President Obama said,

> *Even as corporate profits are as high as ever, a small but growing group of big corporations are fleeing the country to get out of paying taxes. They are keeping most of their business inside the United States, but they're basically renouncing their citizenship and declaring that they're based somewhere else, just to avoid paying their fair share.*[25]

In this paper, I analyzed the changes in the cost of equity caused by a corporate inversion contingent on two major inversion strategies: pure inversions and M&A inversions. The linear and nonlinear regression results indicate that the impacts of inversions on the cost of equity between these two inversion strategies are different. On average, a pure inversion increases the cost of equity by around 10%, whereas an M&A inversion decreases the cost of equity by around 13%. The difference arises from two sources: the differential political and economic risks associated with the new jurisdictions and the synergy created through the merger. My findings are robust to the control sample size and the missing variable issue.

Moreover, I documented that while pure inversions do increase existing shareholder value, these shareholders benefit more from M&A inversions, and the results are economically and statistically significant and robust to various testing windows. My findings imply that the managers appear not to maximize existing shareholder value. By looking at the impact of the 2004 tax reform that restricted tax savings under pure inversions, I am able to document that whereas before 2004 most inversions were pure, the ones after 2004 were done mostly through mergers. This finding suggests that the reform had an unintended consequence of reducing the managerial agency problem by making their more preferred mode unattractive and increasing existing shareholder value.

There are two potential directions that future research on inversions could follow. One direction is to disentangle the M&A inversion's "pure" impact on the cost of equity from the synergy created in an M&A transaction. This research would help us to better understand

[25]Barack Obama, President, United States of America, Weekly Presidential Address: Closing Corporate Tax Loopholes (July 26, 2014) (the transcript is available at: `https://obamawhitehouse.archives.gov/the-press-office/2014/07/26/weekly-address-closing-corporate-tax-loopholes`).

the pure effect of inversions on an inverting firm's equity financing costs and quantify the synergy created by merging with a foreign entity. The other direction is to investigate the consequences of the higher (lower) post-inversion cost of equity on corporate financing and investment behavior. This paper has provided some evidence on the changes in cash holdings and capital expenditures after an inversion, but a more detailed analysis should be a valuable path to take in the future.

Appendix A. List of Corporate Inversions Announced between 1993 and 2015

This appendix lists 88 firms that announced plans to reincorporate overseas between 1993 and 2015. The first column lists the company name at the time of the inversion announcement (some firms changed their names after the inversion was completed). The second column lists the industry in which the firm is operating. Industry classification follows the 48-industry classification system in Fama and French (1997). The third column lists the foreign acquirer's name. "N/A" in this column means that the firm announced plans to pure-invert abroad. The fourth column lists the inversion strategy: pure inversion, M&A inversion, or spin-off inversion. The fifth column lists the destination jurisdiction. Columns (6) and (7) report the time when the company's management announced their inversion decision and the time when the transaction was completed. "Y" in column (8) indicates this company was/is listed in the S&P 500 portfolio.

U.S. Target Name	Industry	Foreign Acquirer Name	Inversion Strategy	Destination	Announcement	Completion	S&P
Helen of Troy	Consumer Goods	N/A	Pure	Bermuda	1993-12	1994	
Core Laboratories	Petroleum and Natural Gas	N/A	Pure	Netherlands	1993-12	1994	
Loral	Communication	N/A	Pure	Bermuda	1996-01	1996	
Triton Energy	Petroleum and Natural Gas	N/A	Pure	Cayman Islands	1996-02	1996	
Chicago Bridge & Iron	Construction	N/A	Pure	Netherlands	1997-03	1997	
Tyco International	Electronic Equipment	ADT	M&A	Bermuda	1997-03	1997	Y
Flirty Girl International	Business Services	N/A	Pure	Antigua	1998-05	1998	
Xoma	Pharmaceutical Products	N/A	Pure	Bermuda	1998-11	1999	
Gold Reserve	Precious Metals	N/A	Pure	Canada	1999-02	1999	
Fruit of the Loom	Textiles	N/A	Pure	Cayman Islands	1999-03	1999	
Transocean Offshore	Petroleum and Natural Gas	N/A	Pure	Cayman Islands	1999-05	1999	Y
Everest Reinsurance Holdings	Insurance	N/A	Pure	Bermuda	1999-09	2000	
PXRE	Insurance	N/A	Pure	Bermuda	1999-10	1999	
White Mountains Insurance Group	Insurance	N/A	Pure	Bermuda	1999-10	1999	
Trenwick Group	Insurance	LaSalle Re Holdings	M&A	Bermuda	1999-12	1999	
Tycom	Electronic Equipment	N/A	Spin-off	Bermuda	2000-01	2000	

Applied Power	Machinery	N/A	Pure	Bermuda	2000-07	2000	
Seagate Technology	Computers	N/A	Pure	Cayman Islands	2000-08	2000	Y
Arch Capital Group	Insurance	N/A	Pure	Bermuda	2000-09	2000	
Foster Wheeler	Construction	N/A	Pure	Bermuda	2000-12	2001	
Cooper Industries	Electrical Equipment	N/A	Pure	Bermuda	2001-06	2002	Y
Global Marine	Petroleum and Natural Gas	Santa Fe Int'l	M&A	Cayman Islands	2001-09	2001	
Ingersoll-Rand	Machinery	N/A	Pure	Bermuda	2001-10	2001	Y
Noble Drilling	Petroleum and Natural Gas	N/A	Pure	Cayman Islands	2002-01	2002	Y
Stanley Works	Construction Materials	N/A	Pure	Bermuda	2002-2	Failed	Y
Herbalife	Wholesale	N/A	Pure	Cayman Islands	2002-02	2002	
Nabors Industries	Petroleum and Natural Gas	N/A	Pure	Bermuda	2002-06	2002	
Weatherford Int'l	Petroleum and Natural Gas	N/A	Pure	Bermuda	2002-06	2002	
Luna Gold	Precious Metals	N/A	Pure	Canada	2005-10	2005	
Lazard	Finance Trading	N/A	Pure	Bermuda	2005-12	2005	
Covidien	Medical Equipment	N/A	Spin-off	Ireland	2006-01	2007	Y
TE Connectivity	Electronic Equipment	N/A	Spin-off	Switzerland	2006-01	2007	Y
Freescale Semiconductor	Electronic Equipment	N/A	Pure	Bermuda	2006-09	2006	
Patch International	Petroleum and Natural Gas	Damascus Energy	M&A	Canada	2006-12	2006	
Argonaut Group	Insurance	PXRE Group	M&A	Bermuda	2007-03	2007	
Star Maritime Acq.	Transportation	Star Bulk Carriers	M&A	Marshall Islands	2007-03	2007	
Western Goldfields	Precious Metals	N/A	Pure	Canada	2007-05	2007	
Ascend Acquisition	Business Services	e.Pak Res. (S) Pte.	M&A	Bermuda	2007-07	2007	
Vantage Energy Services	Petroleum and Natural Gas	Offshore Group Inv.	M&A	Cayman Islands	2007-08	2007	
Lincoln Gold	Non-metallic and Industrial Metal Mining	N/A	Pure	Canada	2007-09	2007	
Energy Infrastructure Acquisition	Transportation	N/A	Pure	Marshall Is.	2008-06	Failed	
InterAmerican Acquisition	Finance Trading	N/A	Pure	BVI	2008-07	2008	
Arcade Acquisition	Transportation	Conbulk	M&A	Marshall Is.	2008-09	2008	
Hungarian Tel & Cable	Communication	Invitel Holdings	M&A	Austria	2008-11	2007	
Alpha Security	Finance Trading	Soya China Pte.	M&A	Bermuda	2008-12	Failed	
Invitel Holdings A/S	Communication	N/A	Pure	Denmark	2009-02	2009	
Ideation Acquisition	Finance Trading	SearchMedia Int'l	M&A	Cayman Islands	2009-04	2009	
2020 ChinaCap Acquirco	Consumer Goods	Windrace Int'l	M&A	British Virgin Islands	2009-05	2009	
Altisource Portfolio Solutions	Business Services	N/A	Spin-off	Luxembourg	2009-07	2009	
Tim Hortons	restaurants, hotels, motels	N/A	Pure	Canada	2009-09	2009	
Delphi Automotive	Automobile and Trucks	N/A	Pure	Jersey	2009-10	2011	Y
ENSCO Int'l	Petroleum and Natural Gas	N/A	Pure	UK	2009-11	2009	Y
Plastinum Polymer Technologies	Rubber and Plastic Products	N/A	Pure	Netherlands	2010-06	Failed	
Styron	Chemicals	N/A	Pure	Luxembourg	2010-06	2010	
Valeant Pharmaceuticals Int'l	Pharmaceutical Products	Biovail	M&A	Canada	2010-06	2010	
Alkermes	Pharmaceutical Products	Elan	M&A	Ireland	2011-05	2011	

Jazz Pharmaceuticals	Pharmaceutical Products	Azur Pharma	M&A	Ireland	2011-09	2011	
Tronox	Chemicals	Exxaro Res.	M&A	Australia	2011-09	2011	
AON	Insurance	N/A	Pure	UK	2012-01	2012	Y
Rowan Companies	Petroleum and Natural Gas	N/A	Pure	UK	2012-02	2012	Y
Pentair	Machinery	Tyco International	M&A	Switzerland	2012-03	2012	Y
Stratasys	Computers	Objet	M&A	Israel	2012-04	2012	
Tower Group	Insurance	Canopius Holdings Bermuda	M&A	Bermuda	2012-04	2012	
Eaton	Electrical Equipment	Cooper Industries	M&A	Ireland	2012-05	2012	
Axalta Coating Systems	Chemicals	The Carlyle Group	M&A	Bermuda	2013-02	2013	
Liberty Global	Communication	Virgin Media	M&A	UK	2013-02	2013	
Actavis	Pharmaceutical Products	Warner Chilcott	M&A	Ireland	2013-05	2013	Y
Omnicom Group	Business Services	Publicis Groupe UK	M&A	UK	2013-07	Failed	Y
Perrigo	Pharmaceutical Products	Elan, Blisfont	M&A	Ireland	2013-07	2013	Y
Applied Materials	Electronic Equipment	Tokyo Electron	Pure	Netherlands	2013-09	Failed	Y
Allegion	Construction Materials	N/A	Spin-off	Ireland	2013-11	2013	Y
Endo Health Solutions	Pharmaceutical Products	Paladin Labs	M&A	Ireland	2013-11	2013	Y
Multi Packaging Solutions Int'l	Shipping Containers	AGI-Shorewood Group	M&A	Bermuda	2013-11	2014	
Horizon Pharma	Pharmaceutical Products	Vidara Therapeutics Int'l	M&A	Ireland	2014-03	2014	
Chiquita Brands Int'l	Agriculture	Fyffes Plc	M&A	Ireland	2014-04	2014	
Pfizer	Pharmaceutical Products	Astrozenica	M&A	UK	2014-04	Failed	Y
Questcor Pharmaceuticals	Pharmaceutical Products	Mallinckrodt	M&A	Ireland	2014-04	2014	
Theravance	Pharmaceutical Products	N/A	Pure	Cayman Islands	2014-04	2014	
Mondelez International	Food Products	D.E. Master Blenders	M&A	Netherlands	2014-05	2014	
C&J Energy Services	Petroleum and Natural Gas	Nabors Industries	M&A	Bermuda	2014-06	2014	
Medtronic	Medical Equipment	Covidien	M&A	Ireland	2014-06	2014	Y
AbbVie	Pharmaceutical Products	Shire	M&A	UK	2014-07	Failed	Y
Mylan	Pharmaceutical Products	Abbott Laboratories Non-US Assets	M&A	Netherlands	2014-07	2014	Y
Burger King Worldwide	restaurants, hotels, motels	Tim Hortons	M&A	Canada	2014-08	2014	
Auxilium Pharmaceuticals	Pharmaceutical Products	Endo International	M&A	Ireland	2014-10	2014	
Steris	Medical Equipment	Synergy Health	M&A	UK	2014-10	2014	
Wright Medical Group	Medical Equipment	Tornier	M&A	Netherlands	2014-10	2014	
Paragon Offshore	Petroleum and Natural Gas	N/A	spin-off	UK	2014-11	2015	

Appendix B. Corporate Inversions Used for Empirical Analysis

This appendix lists the inverting firms used for empirical analysis in this paper. The firms listed in Appendix A are further screened by comparing each firm with their SEC Edgar filings based on the following criteria and using the ones that qualify: (i) the inversion passed the board's approval; (ii) the inverting company was a publicly traded U.S. company before inversion; (iii) stocks of the surviving company are still publicly traded in the United States; (iv) the transaction was closed/completed by December 31, 2015. We are left with 63 inversions after screening.

U.S. Target Name	Industry	Foreign Acquirer Name	Inversion Strategy	Destination	Announcement	Completion	S&P
Helen of Troy	Consumer Goods	N/A	Pure	Bermuda	1993-12	1994	
Loral	Communication	N/A	Pure	Bermuda	1996-01	1996	
Triton Energy	Petroleum and Natural Gas	N/A	Pure	Cayman Islands	1996-02	1996	
Chicago Bridge & Iron	Construction	N/A	Pure	Netherlands	1997-03	1997	
Tyco International	Electronic Equipment	ADT	M&A	Bermuda	1997-03	1997	Y
Xoma	Pharmaceutical Products	N/A	Pure	Bermuda	1998-11	1999	
Gold Reserve	Precious Metals	N/A	Pure	Canada	1999-02	1999	
Fruit of the Loom	Textiles	N/A	Pure	Cayman Islands	1999-03	1999	
Transocean Offshore	Petroleum and Natural Gas	N/A	Pure	Cayman Islands	1999-05	1999	Y
PXRE	Insurance	N/A	Pure	Bermuda	1999-10	1999	
White Mountains Insurance Group	Insurance	N/A	Pure	Bermuda	1999-10	1999	
Trenwick Group	Insurance	LaSalle Re Holdings	M&A	Bermuda	1999-12	1999	
Everest Reinsurance Holdings	Insurance	N/A	Pure	Bermuda	1999-09	2000	
Tycom	Electronic Equipment	N/A	Spin-off	Bermuda	2000-01	2000	
Applied Power	Machinery	N/A	Pure	Bermuda	2000-07	2000	
Seagate Technology	Computers	N/A	Pure	Cayman Islands	2000-08	2000	Y
Arch Capital Group	Insurance	N/A	Pure	Bermuda	2000-09	2000	
Foster Wheeler	Construction	N/A	Pure	Bermuda	2000-12	2001	
Global Marine	Petroleum and Natural Gas	Santa Fe Int'l	M&A	Cayman Islands	2001-09	2001	
Ingersoll-Rand	Machinery	N/A	Pure	Bermuda	2001-10	2001	Y
Noble Drilling	Petroleum and Natural Gas	N/A	Pure	Cayman Islands	2002-01	2002	Y
Herbalife	Wholesale	N/A	Pure	Cayman Islands	2002-02	2002	
Nabors Industries	Petroleum and Natural Gas	N/A	Pure	Bermuda	2002-06	2002	
Weatherford Int'l	Petroleum and Natural Gas	N/A	Pure	Bermuda	2002-06	2002	
Lazard	Finance Trading	N/A	Pure	Bermuda	2005-12	2005	

Freescale Semiconductor	Electronic Equipment	N/A	Pure	Bermuda	2006-09	2006	
Covidien	Medical Equipment	N/A	Spin-off	Ireland	2006-01	2007	Y
TE Connectivity	Electronic Equipment	N/A	Spin-off	Switzerland	2006-01	2007	Y
Argonaut Group	Insurance	PXRE Group	M&A	Bermuda	2007-03	2007	
Star Maritime Acq.	Transportation	Star Bulk Carriers	M&A	Marshall Islands	2007-03	2007	
Western Goldfields	Precious Metals	N/A	Pure	Canada	2007-05	2007	
Altisource Portfolio Solutions	Business Services	N/A	Spin-off	Luxembourg	2009-07	2009	
Tim Hortons	restaurants, hotels, motels	N/A	Pure	Canada	2009-09	2009	
ENSCO Int'l	Petroleum and Natural Gas	N/A	Pure	UK	2009-11	2009	Y
Styron	Chemicals	N/A	Pure	Luxembourg	2010-06	2010	
Valeant Pharmaceuticals Int'l	Pharmaceutical Products	Biovail	M&A	Canada	2010-06	2010	
Delphi Automotive	Automobile and Trucks	N/A	Pure	Jersey	2009-10	2011	Y
Alkermes	Pharmaceutical Products	Elan	M&A	Ireland	2011-05	2011	
Jazz Pharmaceuticals	Pharmaceutical Products	Azur Pharma	M&A	Ireland	2011-09	2011	
Tronox	Chemicals	Exxaro Res.	M&A	Australia	2011-09	2011	
AON	Insurance	N/A	Pure	UK	2012-01	2012	Y
Rowan Companies	Petroleum and Natural Gas	N/A	Pure	UK	2012-02	2012	Y
Pentair	Machinery	Tyco International	M&A	Switzerland	2012-03	2012	Y
Stratasys	Computers	Objet	M&A	Israel	2012-04	2012	
Tower Group	Insurance	Canopius Holdings Bermuda	M&A	Bermuda	2012-04	2012	
Eaton	Electrical Equipment	Cooper Industries	M&A	Ireland	2012-05	2012	
Axalta Coating Systems	Chemicals	The Carlyle Group	M&A	Bermuda	2013-02	2013	
Liberty Global	Communication	Virgin Media	M&A	UK	2013-02	2013	
Actavis	Pharmaceutical Products	Warner Chilcott	M&A	Ireland	2013-05	2013	Y
Perrigo	Pharmaceutical Products	Elan, Blisfont	M&A	Ireland	2013-07	2013	Y
Allegion	Construction Materials	N/A	Spin-off	Ireland	2013-11	2013	Y
Endo Health Solutions	Pharmaceutical Products	Paladin Labs	M&A	Ireland	2013-11	2013	Y
Horizon Pharma	Pharmaceutical Products	Vidara Therapeutics Int'l	M&A	Ireland	2014-03	2014	
Questcor Pharmaceuticals	Pharmaceutical Products	Mallinckrodt	M&A	Ireland	2014-04	2014	
Theravance	Pharmaceutical Products	N/A	Pure	Cayman Islands	2014-04	2014	
Mondelez International	Food Products	D.E. Master Blenders	M&A	Netherlands	2014-05	2014	
C&J Energy Services	Petroleum and Natural Gas	Nabors Industries	M&A	Bermuda	2014-06	2014	
Medtronic	Medical Equipment	Covidien	M&A	Ireland	2014-06	2014	Y
Mylan	Pharmaceutical Products	Abbott Laboratories Non-US Assets	M&A	Netherlands	2014-07	2014	Y
Burger King Worldwide	restaurants, hotels, motels	Tim Hortons	M&A	Canada	2014-08	2014	
Steris	Medical Equipment	Synergy Health	M&A	UK	2014-10	2014	
Wright Medical Group	Medical Equipment	Tornier	M&A	Netherlands	2014-10	2014	
Paragon Offshore	Petroleum and Natural Gas	N/A	spin-off	UK	2014-11	2015	

Appendix C. Variable Definitions

- *Cash Holdings*: The ratio of cash and short-term investments to the book value of total assets.
- *Capital Expenditure*: The ratio of capital expenditures to the book value of total assets.
- D_{it}: A dummy variable that identifies the incorporation status of company i at time t. If company i is incorporated in the United States at time t, D_{it} equals 0. If the company reincorporates overseas and thus becomes foreign-incorporated at time t, D_{it} equals 1.
- *Dividend*: The ratio of total dividends paid to the book value of total assets.
- *Leverage*: Leverage ratio, defined to be the ratio of the book value of total debt to the book value of total assets.
- *R&D Expenditure*: The ratio of R&D expenditures to the book value of total assets.
- *ROA*: Return on assets, defined to be the ratio of earnings to the book value of total assets.
- *SG&A*: The ratio of selling, general, and administrative expenses to the book value of total assets.
- *Tax Rate*: The ratio of cash tax paid to pre-tax income before special items. Extreme values are truncated at zero and one.
- *Total Assets*: The book value of total assets (in millions of dollars).

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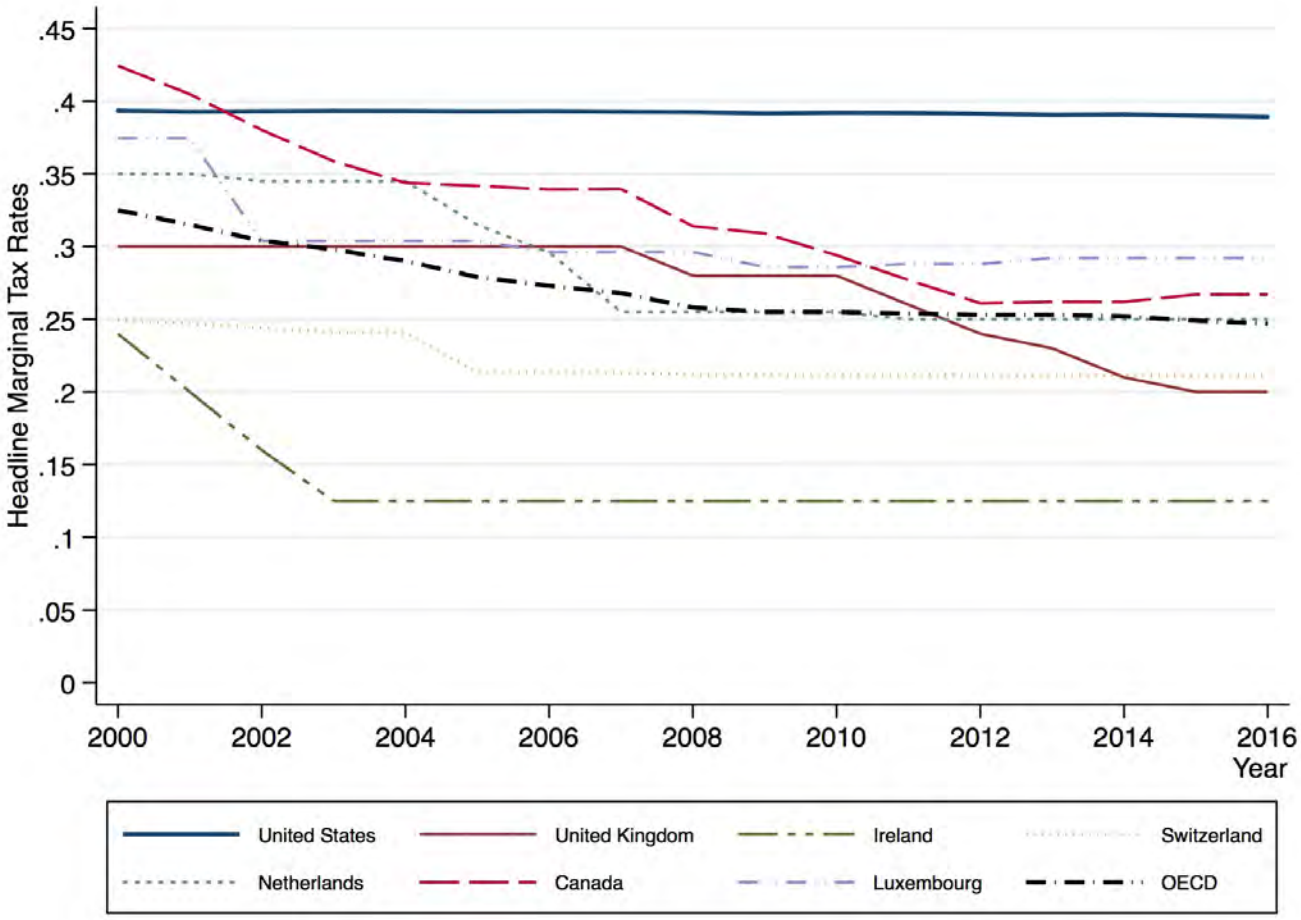

Figure 1. Headline Marginal Corporate Tax Rates (Selected Countries). This figure depicts the headline (country plus state) marginal tax rates of several selected OECD countries. The headline marginal tax rate in the United States (the thick line at the top) far exceeds the rate in most of the competitive jurisdictions, and the gap has been widening in recent years. In 2016, the U.S. corporate headline tax rate is 39%, much higher than that of Ireland (12.5%), the United Kingdom (20% and falling), Canada (26.5%), and the OECD average (25%).

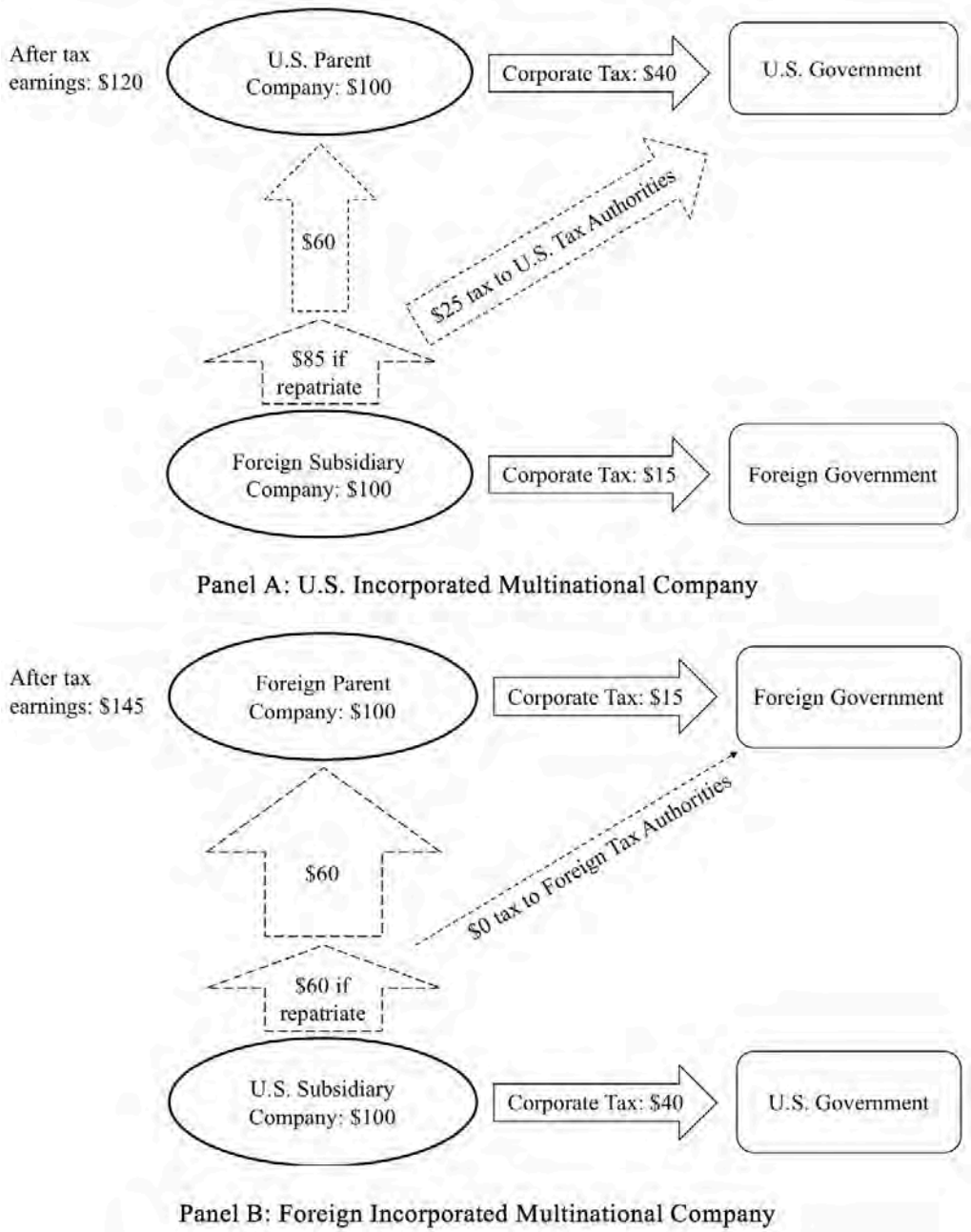

Figure 2. After-Tax Earnings Before and After Inversion.

In this figure I use a hypothetical example to show where the tax savings originate after a corporate inversion. The corporate tax rate in the United States and the foreign country is assumed to be 40% and 15%, respectively. Panel A represents the case in which the multinational corporation is U.S.-incorporated. Because the U.S. tax regime takes a worldwide approach, the firm needs to pay a $25 repatriation taxes to the U.S. government if it wants to repatriate the $85 in foreign after-tax earnings. By flipping the corporate structure and reincorporating in a foreign country where taxes are levied only on the earnings generated domestically (territorial regime), as indicated in Panel B, the multinational firm could save $25 in repatriation taxes and hence increase its overall after-tax earnings by $25.

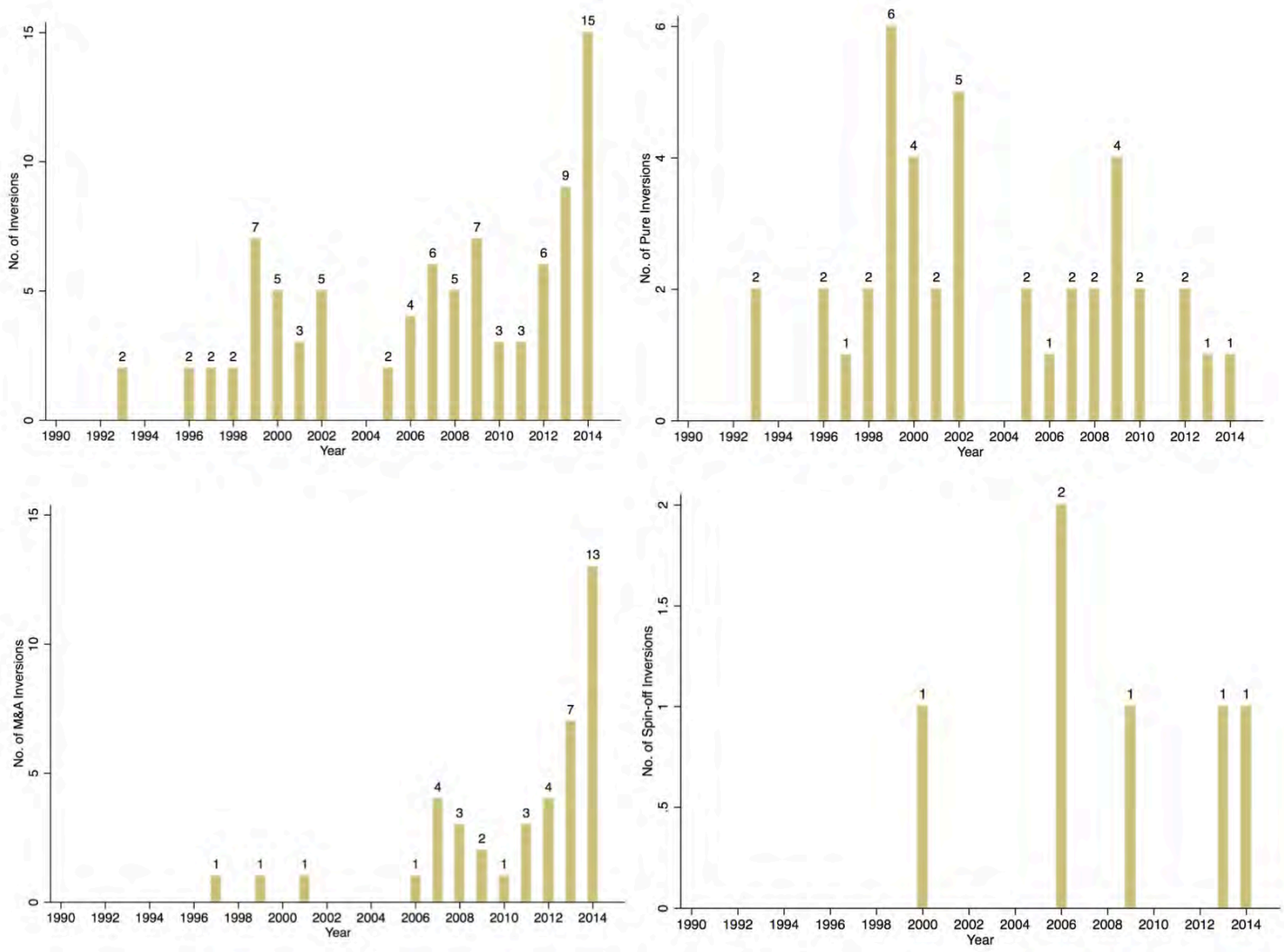

Figure 3. Inversion Volume.

The figure displays the number of inversion announcements from 1993 to 2014. Panel A displays the overall announcements. The other three panels display the number of inversions for all three kinds of inversions: pure inversion (Panel B), M&A inversion (Panel C), and spin-off inversion (Panel D). The integers above the bars indicate the number of inversions announced in that year.

Table 1: **Inversion Announcements Across Industries.**
The industry classification follows Fama-French (1997). Inversions exist in 26 out of 48 Fama-French industries and cluster mainly in three industries: pharmaceutical products (14), petroleum and natural gas (13), and insurance (8).

Industries	**All**	**Pure**	**M&A**	**Spin-off**
Agriculture	1	0	1	0
Automobiles and Trucks	1	1	0	0
Business Services	4	1	2	1
Chemicals	3	1	2	0
Communication	4	2	2	0
Computers	2	1	1	0
Construction	2	2	0	0
Construction Materials	2	1	0	1
Consumer Goods	2	1	1	0
Electrical Equipment	2	1	1	0
Electronic Equipment	5	2	1	2
Finance Trading	4	2	2	0
Food Products	1	0	1	0
Insurance	8	5	3	0
Machinery	3	2	1	0
Medical Equipment	4	0	3	1
Non-metallic and Industrial Metal Mining	1	1	0	0
Petroleum and Natural Gas	13	8	4	1
Pharmaceutical Products	14	2	12	0
Precious Metals	3	3	0	0
Rubber and Plastic Products	1	1	0	0
Shipping Containers	1	0	1	0
Textiles	1	1	0	0
Transportation	3	1	2	0
Wholesale	1	1	0	0
Restaurants, Hotels, Motels	2	1	1	0
Total	**88**	**41**	**41**	**6**

Table 2: **Inversion Destinations.**
This table displays the inversion destination jurisdictions. Overall, Bermuda, Canada, the Cayman Islands, Ireland, the Netherlands, and the United Kingdom are the most popular inversion destinations. Before the passing of Section 7874 of the 2004 American Jobs Creation Act, firms were mainly inverting to Bermuda (17) and the Cayman Islands (7). After 2004, firms were inverting to more developed countries such as Canada (7), Ireland (13), the Netherlands (5) and the United Kingdom (9). Bermuda appears to lose its charm to inverting firms after 2004. The "Y" in the last column indicates that the country is a tax-haven country, following the definition in Hines and Rice (1994).

Destination	**All**	**Before 2004**	**After 2004**	**After 2010**	**Tax Haven**
Antigua	1	1	0	0	
Australia	1	0	1	1	
Austria	1	0	1	0	
Bermuda	26	17	9	4	Y
British Virgin Islands	1	0	1	0	Y
Canada	8	1	7	2	
Cayman Islands	10	7	3	0	Y
Denmark	1	0	1	0	
Ireland	13	0	13	12	Y
Israel	1	0	1	1	
Jersey	1	0	1	0	
Luxembourg	2	0	2	1	
Marshall Islands	3	0	3	0	Y
Netherlands	7	2	5	5	
Switzerland	2	0	2	1	Y
United Kingdom	9	0	9	8	
Total	**88**	**28**	**60**	**36**	**6**

Table 3: **Summary Statistics for the Main Variables Used in This Analysis.**

Panel A: Treated Group (Firms that Reincorporated from the United States to Overseas)

Number of Firms:	63				
Variable	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Cost of Equity	4,529	0.108	0.018	0.002	0.149
Risk Premium	4,529	0.017	0.009	-0.025	0.035
Total Assets (in Million Dollars)	4,458	7,211.73	13,052.23	12.74	135,840.70
Total Assets (in Log Points)	4,458	7.598	1.787	2.545	11.819
Leverage Ratio (Total Liability/Total Assets)	4,452	0.572	0.261	0	2.508
Return on Assets (Net Income/Total Assets)	4,447	0.005	0.059	-1.296	0.444

Panel B: U.S. Multinational Group

Number of Firms:	13,152				
Variable	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Cost of Equity	341,244	0.11	0.017	0.00008	0.291
Risk Premium	341,244	0.018	0.008	-0.021	0.066
Total Assets (in Million Dollars)	337,447	5,361.56	47,309.95	0.076	3,281,222
Total Assets (in Log Points)	337,447	6.228	2.006	-2.577	15.004
Leverage Ratio (Total Liability/Total Assets)	337,145	0.546	0.425	-0.004	95.163
Return on Assets (Net Income/Total Assets)	336,997	-0.007	0.151	-28.427	10.053

Panel C: Treated Group (Pure Inversion)

Number of Firms:	31				
Variable	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Cost of Equity	2,555	0.106	0.02	0.002	0.147
Risk Premium	2,555	0.016	0.009	-0.025	0.035
Total Assets (in Million Dollars)	2,543	6,756.00	10,391.15	24.691	115,505.40
Total Assets (in Log Points)	2,543	7.647	1.758	3.206	11.657
Leverage Ratio (Total Liability/Total Assets)	2,543	0.612	0.281	0	2.508
Return on Assets (Net Income/Total Assets)	2,536	0.002	0.061	-1.296	0.398

Panel D: Treated Group (M&A Inversion)

Number of Firms:	26				
Variable	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Cost of Equity	1,582	0.11	0.016	0.018	0.149
Risk Premium	1,582	0.019	0.008	-0.02	0.035
Total Assets (in Million Dollars)	1,552	6,350.10	13,200.93	12.738	135,840.70
Total Assets (in Log Points)	1,552	7.406	1.778	2.545	11.819
Leverage Ratio (Total Liability/Total Assets)	1,546	0.499	0.23	0.014	1.84
Return on Assets (Net Income/Total Assets)	1,548	0.008	0.06	-0.759	0.444

Table 4: **Comparison of Treated and Control Groups: One-to-One Matching.**
This table compares the distributions of the matching variables, *log(total assets)*, *leverage ratio*, and *ROA*, in the treated sample to its one-for-one matched control sample (CS1). This table reveals that the CS1 is very similar to the treated sample. The 25th percentiles, 50th percentiles, and 75th percentiles of the three matching variables are very close. The p-values of the mean and distribution comparisons reported in the last two columns further confirm that these three matching variables have the same distribution between the treated and control samples.

Variables	**25th Percentile**		**50th Percentile**		**75th Percentile**		**P-Values for Mean**	**P-Values for Dist.**
	Treated	Control	Treated	Control	Treated	Control		
Log of Total Assets	6.60	6.30	7.86	7.72	8.70	8.57	0.86	0.93
Leverage Ratio	0.39	0.40	0.55	0.52	0.75	0.65	0.65	0.34
Return on Assets	-0.01	0.00	0.01	0.01	0.02	0.03	0.32	0.90

Table 5: **Effect of Inversion on the Cost of Equity: Benchmark Linear Regression.**
This table reports the benchmark results of linear regressions investigating the impact of inversions on the cost of equity. The control samples used in this table are the closest matches for each inverting company based on industry, measurement quarter, *log(total assets)*, *leverage ratio*, and *ROA* (CS1). I run regressions separately using all inversions, pure inversions, and M&A inversions as treated samples, respectively. In columns (1), (4), and (7), we estimate the regression: $RP_{it} = \tau D_{it} + c_i + \lambda_t + u_{it}, t = 1, 2, ..., T$, and in the other columns, I estimate the regression: $RP_{it} = \tau D_{it} + \mathbf{x_{it}}\gamma + c_i + \lambda_t + \eta_j + u_{it}, t = 1, 2, ..., T$, where RP_{it} is the risk premium of company i at time t. D_{it} is the incorporation status dummy variable of company i at time t. If company i is incorporated in the United States at time t, D_{it} equals 0. If the company reincorporates overseas and thus becomes foreign-incorporated at time t, D_{it} equals 1. The variable c_i denotes the unobserved firm fixed effects, λ_t denotes the time fixed effects, and η_j denotes the industry fixed effects. Columns (2), (5), and (8) (columns (3), (6), and (9)) report the result without (with) industry fixed effects. The error term u_{it} includes all other time-varying unobservable shocks to the cost of equity. *Log(Total assets)*, *leverage ratio*, and *ROA* are used as controls and included in $\mathbf{x_{it}}$. Standard errors are robust to heteroskedasticity and serial correlation and are reported in parentheses. Note that I use "$***$," "$**$," and "$*$" to indicate that the estimates are significant at 1%, 5%, and 10% significance levels, respectively.

Variables	**All**			**Pure Inversion**			**M&A Inversion**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
D (Reincorp. Dummy)	-0.0001	-0.0001	-0.0001	0.0021	0.0023	0.0023	-0.0029	-0.0033	-0.0033
	(0.0008)	(0.0008)	(0.0008)	(0.0010)**	(0.0011)**	(0.0011)**	(0.0009)***	(0.0011)***	(0.0012)***
Log(total assets)		-0.0005	-0.0005		-0.0005	-0.0005		-0.00002	-0.00002
		(0.0002)**	(0.0002)**		(0.0011)**	(0.0004)		(0.0004)	(0.0004)
Leverage		-0.0005	-0.0005		-0.0009	-0.0009		-0.0019	-0.0019
		(0.0008)	(0.0008)		(0.0011)**	(0.0012)		(0.0010)*	(0.0010)*
ROA		0.0002	0.0002		-0.0031	-0.0031		-0.00007	-0.0001
		(0.0010)	(0.0011)		(0.0030)	(0.0030)		(0.0011)	(0.0011)
Constant	0.0058	0.0103	0.0118	0.0059	0.0116	0.0101	0.0060	0.0070	0.0100
	(0.0010)***	(0.0022)***	(0.0016)***	(0.0018)***	(0.0038)***	(0.0022)***	(0.0004)***	(0.0024)***	(0.0013)***
Adj. R-squared	0.82	0.81	0.88	0.74	0.73	0.84	0.87	0.87	0.90
Firms in sample	105	105	105	52	52	52	52	45	45
Observations	5272	5192	5192	2410	2395	2395	2395	2410	2410
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	No	No	Yes	No	No	Yes

Table 6: **Effect of Inversion on the Cost of Equity: Benchmark Fractional Response Models.**
This table reports the results of regressions investigating the impact of inversions on the cost of equity. The control samples used in this table are the closest matches for each inverting company based on industry, measurement quarter, *log(total asset)*, *leverage ratio*, and *ROA* (CS1). Panel A uses all the inversions in the treated sample, and Panels B and C use pure inversions and M&A inversions as treated samples, respectively. Within each panel, I estimate three fractional response models: fractional logit, fractional probit, and complementary-log-log. In columns (1), (4), and (7) of each panel, I estimate the regression $R_{it} = G(\tau D_{it} + c_i + \lambda_t) + u_{it}, t = 1, 2, ..., T$. In columns (2), (5), and (8), I estimate the regression $R_{it} = G(\tau D_{it} + \mathbf{x_{it}}\gamma + c_i + \lambda_t) + u_{it}, t = 1, 2, ..., T$, where R_{it} is the cost of equity of firm i at time t, and $G(\cdot)$ represents the three functional forms. D_{it} is the incorporation status dummy variable of company i at time t. If company i is incorporated in the United States at time t, D_{it} equals 0. If the company reincorporates overseas and thus becomes foreign-incorporated at time t, D_{it} equals 1. The variable c_i denotes a full set of firm fixed effects, and λ_i denotes a full set of time fixed effects. The error term u_{it} includes all other time-varying unobservable shocks to the cost of equity. *Log(total assets)*, *leverage ratio*, and *ROA* are used as controls and included in $\mathbf{x_{it}}$. In columns (3), (6), and (9), I include the industry fixed effects η_j and estimate the regression $R_{it} = G(\tau D_{it} + \mathbf{x_{it}}\gamma + c_i + \lambda_t + \eta_j) + u_{it}, t = 1, 2, ..., T$. Fully robust standard errors are reported in parentheses. Note: "$***$," "$**$," and "$*$" indicate that the estimates are significant at 1%, 5%, and 10% significance levels, respectively.

Table 6: **Effect of Inversion on the Cost of Equity: Benchmark Fractional Response Models. (Continued)**

Model	**Fractional Logit**			**Fractional Probit**			**Fractional C-Log-Log**		
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Across all inverting firms									
D (Reincorp.Dummy)	-0.0061	-0.0073	-0.0072	-0.0023	-0.0029	-0.0028	-0.0062	-0.0073	-0.0073
	(0.0333)	(0.0338)	(0.0348)	(0.0177)	(0.0179)	(0.0185)	(0.0312)	(0.0317)	(0.0326)
Log(total assets)		-0.0203	-0.0208		-0.0108	-0.0111		-0.0190	-0.0194
		(0.0091)**	(0.0097)**		(0.0048)**	(0.0051)**		(0.0086)**	(0.0091)**
Leverage		-0.0212	-0.2188		-0.0110	-0.0115		-0.0200	-0.0206
		(0.0348)	(0.0355)		(0.0184)	(0.0188)		(0.0326)	(0.0333)
ROA		0.0084	0.0094		0.0037	0.0044		0.0083	0.0092
		(0.0444)	(0.0446)		(0.0237)	(0.0238)		(0.0415)	(0.0416)
Constant	-2.5212	-2.3174	-2.2610	-1.4453	-1.3367	-1.3070	-2.5593	-2.3684	-2.3155
	(0.0612)***	(0.1038)***	(0.0767)***	(0.0301)***	(0.0538)***	(0.0393)***	(0.0589)***	(0.0981)***	(0.0728)***
Impact on Cost of Equity	**-0.0006**	**-0.0007**	**-0.0007**	**-0.0004**	**-0.0005**	**-0.0005**	**-0.0006**	**-0.0008**	**-0.0007**
	(0.0032)	**(0.0033)**	**(0.0033)**	**(0.0033)**	**(0.0033)**	**(0.0034)**	**(0.0032)**	**(0.0032)**	**(0.0033)**
Observations	5272	5192	5192	5272	5192	5192	5272	5192	5192
Panel B: Pure Inversion									
D (Reincorp.Dummy)	0.0928	0.1026	0.1026	0.0497	0.0550	0.0550	0.0867	0.0959	0.0959
	(0.0506)**	(0.0530)**	(0.0530)**	(0 .0268)**	(0.0280)**	(0.0280)**	(0.0475)**	(0.0498)**	(0.0498)**
Log(total assets)		-0.0236	-0.0236		-0.0126	-0.0126		0.0221	0.0221
		(0.0158)	(0.0158)		(0.0083)	(0.0083)		(0.0149)	(0.0149)
Leverage		-0.0408	-0.0408		-0.0212	-0.0219		-0.0382	-0.0382
		(0.0534)	(0.0534)		(0.0282)	(0.0282)		(0.0501)	(0.0501)
ROA		-0.1537	-0.1537		-0.0219	-0.0815		-0.1442	-0.1442
		(0.1279)	(0.1279)		(0.0683)	(0.0683)		(0.1197)	(0.1197)
Constant	-2.5323	-2.2679	-2.3429	-1.4491	-1.3078	-1.3487	-2.5710	-2.3236	-2.3933
	(0.1109)***	(0.1849)***	(0.1247)***	(0.0538)***	(0.0950)***	(0.0617)***	(0.1070)***	(0.1753)***	(0.1197)***
Impact on Cost of Equity	**0.0090**	**0.0100**	**0.0100**	**0.0093**	**0.0103**	**0.0103**	**0.0090**	**0.0100**	**0.0100**
	(0.0050)**	**(0.0053)****	**(0.0053)****	**(0.0051)****	**(0.0053)****	**(0.0053)****	**(0.0050)****	**(0.0053)****	**(0.0053)****
Observations	2410	2395	2395	2410	2395	2395	2410	2395	2395
Panel C: M&A Inversion									
D (Reincorp.Dummy)	-0.1247	-0.1454	-0.1454	-0.0658	-0.0767	-0.0767	-0.1171	-0.1365	-0.1365
	(0.0412)***	(0.0501)***	(0.0501)***	(0.0216)***	(0.0263)***	(0.0263)***	(0.0388)***	(0.0472)***	(0.0472)***
Log(total assets)		-0.0009	-0.0009		-0.0006	-0.0006		-0.0008	-0.0008
		(0.0161)	(0.0161)		(0.0085)	(0.0085)		(0.0151)	(0.0151)
Leverage		-0.0821	-0.0821		-0.0430	-0.0430		-0.0772	-0.0772
		(0.0425)*	(0.0425)*		(0.0224)*	(0.0224)*		(0.0399)*	(0.0399)*
ROA		-0.0026	-0.0026		-0.0014	-0.0014		-0.0025	-0.0025
		(0.0445)	(0.0445)		(0.0235)	(0.0235)		(0.0418)	(0.0418)
Constant	-2.4893	-2.4492	-2.3181	-1.4306	-1.4092	-1.3403	-2.5279	-2.4905	-2.3673
	(0.0235)***	(0.1001)***	(0.0547)***	(0.0116)***	(0.0532)***	(0.0290)***	(0.0225)***	(0.0937)***	(0.0512)***
Impact on Cost of Equity	**-0.0118**	**-0.0136**	**-0.0136**	**-0.012**	**-0.0139**	**-0.0139**	**-0.0117**	**-0.0135**	**-0.0135**
	(0.0037)***	**(0.0045)*****	**(0.0045)*****	**(0.0038)*****	**(0.0046)*****	**(0.0046)*****	**(0.0037)*****	**(0.0044)*****	**(0.0044)*****
Observations	2446	2410	2410	2446	2410	2410	2446	2410	2410
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	No	No	Yes	No	No	Yes

Table 7: **Comparison of Treated and Control Groups: One-to-Four Matching.**
This table compares the distributions of the matching variables, *log(total assets)*, *leverage ratio*, and *ROA*, in the treated sample to its one-for-four matched control sample (CS4). This table reveals that the CS4 is very similar to the treated sample. The 25th percentiles, 50th percentiles, and 75th percentiles of the three matching variables are very close. The p-values of the mean and distribution comparisons reported in the last two columns further confirm that these three matching variables have the same distribution between the treated and control samples.

Variables	**25th Percentile**		**50th Percentile**		**75th Percentile**		**P-Values for Mean**	**P-Values for Dist.**
	Treated	Control	Treated	Control	Treated	Control		
Log of Total Assets	6.60	6.30	7.86	7.49	8.70	8.28	0.23	0.11
Leverage Ratio	0.39	0.43	0.55	0.53	0.75	0.67	0.85	0.59
Return on Assets	-0.01	-0.01	0.01	0.01	0.02	0.02	0.81	0.39

Table 8: **Robustness Check for Control Sample Size: Linear Regression.**
This table reports the results of regressions investigating the robustness of control sample size in linear regressions. The control samples used in this table are the first four closest matches for each inverting company based on industry, measurement quarter, *log(total assets)*, *leverage ratio*, and *ROA* (CS4). I run regressions separately using all inversions, pure inversions, and M&A inversions as treatment samples, respectively. In columns (1), (3), and (5), I estimate the regression: $RP_{it} = \tau D_{it} + c_i + \lambda_t + u_{it}, t = 1, 2, ..., T$, and in columns (2), (4), and (6), I estimate the regression: $RP_{it} = \tau D_{it} + \mathbf{x_{it}}\gamma + c_i + \lambda_t + u_{it}, t = 1, 2, ..., T$, where RP_{it} is the risk premium of company i at time t. D_{it} is the incorporation status dummy variable of company i at time t. If company i is incorporated in the United States at time t, D_{it} equals 0. If the company reincorporates overseas and thus becomes foreign-incorporated at time t, D_{it} equals 1. The variable c_i denotes a full set of firm fixed effects, and the variable λ_t denotes a full set of time fixed effects. The error term u_{it} includes all other time-varying unobservable shocks to the cost of equity. *Log(Total assets)*, *leverage ratio*, and *ROA* are used as controls and included in $\mathbf{x_{it}}$ in columns (2). Standard errors are robust to heteroskedasticity and serial correlation and are reported in parentheses. Note that I use "$***$," "$**$," and "$*$" to indicate that the estimates are significant at 1%, 5%, and 10% significance levels, respectively.

Variables	**All**		**Pure Inversion**		**M&A Inversion**	
	(1)	(2)	(3)	(4)	(5)	(6)
D (Reincorporation Dummy)	-0.0001	-0.0002	0.0017	0.0018	-0.0021	-0.0020
	(0.0006)	(0.0006)	(0.0009)**	(0.0010)**	(0.0009)***	(0.0009)**
Log of Total Assets		-0.0003		-0.0003		-0.0004
		(0.0002)**		(0.0002)		(0.0002)
Leverage Ratio		-0.0003		-0.0006		-0.0008
		(0.0004)		(0.0009)		(0.0006)
Return on Assets		0.0011		-0.0003		0.0011
		(0.0008)		(0.0018)		(0.0012)
Constant	0.0074	0.0090	0.0069	0.0086	0.0074	0.0091
	(0.0010)***	(0.0012)***	(0.0017)***	(0.0021)***	(0.0004)***	(0.0010)***
Adj.R-squared	0.79	0.79	0.72	0.72	0.85	0.85
Firms in sample	247	247	127	127	106	106
Observations	10436	10356	4622	4607	5213	5177
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Table 9: **Robustness Check for Control Sample Size: Fractional Response Models.** This table reports the results of regressions investigating the robustness of control sample size in fractional response regressions. The control firms used in this table are the first four closest matches for each inverting company based on Fama-French industry, measurement quarter, *log(total asset)*, *leverage ratio*, and *ROA* (CS4). Panel A uses all the inversions in the treated sample, and Panels B and C use pure inversions and M&A inversions as treated samples, respectively. Within each panel, I estimate three fractional response models: fractional logit, fractional probit, and complementary-log-log. In columns (1), (3), and (4) of each panel, I estimate the regression:$R_{it} = G(\tau D_{it} + c_i + \lambda_t) + u_{it}, t = 1, 2, ..., T$, and in columns (2), (4), and (6) of each panel, I estimate the regression $R_{it} = G(\tau D_{it} + \mathbf{x_{it}}\gamma + c_i + \lambda_t) + u_{it}, t = 1, 2, ..., T$, where R_{it} is the cost of equity of firm i at time t, and $G(\cdot)$ represents the three functional forms. D_{it} is the incorporation status dummy variable of company i at time t. If company i is incorporated in the United States at time t, D_{it} equals 0. If the company reincorporates overseas and thus becomes foreign-incorporated at time t, D_{it} equals 1. The variable c_i denotes a full set of firm fixed effects, and the variable λ_i denotes a full set of time fixed effects. The error term u_{it} includes all other time-varying unobservable shocks to the cost of equity. *Log(Total assets)*, *leverage ratio*, and *ROA* are used as controls and included in $\mathbf{x_{it}}$. Fully robust standard errors are reported in parentheses. Note: "$***$," "$**$," and "$*$" indicate that the estimates are significant at 1%, 5%, and 10% significance levels, respectively.

Table 9: **Robustness Check for Control Sample Size: Fractional Response Models. (Continued)**

Model	**Fractional Logit**		**Fractional Probit**		**Fractional C-Log-Log**	
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Across all inverting firms						
D (Reincorp.Dummy)	-0.0062	-0.0069	-0.0024	-0.0028	-0.0062	-0.0069
	(0.0278)	(0.0285)	(0.0149)	(0 .0153)	(0.0260)	(0.0267)
Log(total assets)		-0.0144		-0.0076		-0.0136
		(0.0070)**		(0.0037)**		(0.0066)**
Leverage		-0.0151		-0.0081		-0.0141
		(0.0182)		(0.0097)		(0.0170)
ROA		0.0474		0.0251		0.0444
		(0.0356)		(0.0191)		(0.0332)
Constant	-2.6723	-2.5833	-1.5225	-1.4755	-2.7029	-2.7029
	(0.0598)***	(0.0732)***	(0.0294)***	(0.0370)***	(0.0575)***	(0.0574)***
Impact on Cost of Equity	**-0.0006**	**-0.0007**	**-0.0004**	**-0.0005**	**-0.0006**	**-0.0007**
	(0.0027)	**(0.0027)**	**(0.0028)**	**(0.0028)**	**(0.0027)**	**(0.0027)**
Observations	10436	10356	10436	10356	10436	10356
Panel B: Pure Inversion						
D (Reincorp.Dummy)	0.0773	0.0805	0.0418	0.0435	0.0721	0.0750
	(0.0427)**	(0.0442)**	(0.0227)**	(0.0235)**	(0.0399)**	(0.0414)**
Log(total assets)		-0.0119		-0.0063		-0.0112
		(0.0110)		(0.0057)		(0.0103)
Leverage		-0.0275		-0.0149		-0.0256
		(0.0401)		(0.0209)		(0.0377)
ROA		-0.0126		-0.0078		-0.0112
		(0.0777)		(0.0416)		(0.0725)
Constant	-2.6784	-2.5922	-1.5243	-2.5922	-2.7095	-2.6288
	(0.1080)***	(0.1250)***	(0.0523)***	(0.1250)***	(0.1042)***	(0.1198)***
Impact on Cost of Equity	**0.0075**	**0.0078**	**0.0078**	**0.0082**	**0.0074**	**0.0078**
	(0.0042)**	**(0.0044)****	**(0.0043)****	**(0.0045)****	**(0.0042)***	**(0.0044)***
Observations	4622	4607	4622	4607	4622	4607
Panel C: M&A Inversion						
D (Reincorp.Dummy)	-0.0898	-0.0834	-0.0477	-0.0444	-0.0842	-0.0781
	(0.0365)***	(0.0391)**	(0.0193)***	(0.0206)**	(0.0343)***	(0 .0366)**
Log(total assets)		-0.0158		-0.0083		-0.0149
		(0.0105)		(0.0056)		(0.0098)
Leverage		-0.0356		-0.0191		-0.0332
		(0.0231)		(0.0123)		(0.0217)
ROA		0.0449		0 .0241		0.0419
		(0.0489)		(0.0262)		(0.0456)
Constant	-2.4835	-2.3621	-1.4275	-1.3634	-2.5225	-2.4086
	(0.0222)***	(0.0744)***	(0.0109)***	(0.0399)***	(0.0213)***	(0.0695)***
Impact on Cost of Equity	**-0.0086**	**-0.008**	**-0.0088**	**-0.0082**	**-0.0085**	**-0.0079**
	(0.0033)***	**(0.0036)****	**(0.0034)*****	**(0.0037)****	**(0 .0033)*****	**(0.0035)****
Observations	5213	5177	5213	5177	5213	5177
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Table 10: **Augmented Linear Regression.**
This table reports the augmented linear regression results by adding extra controls in $\mathbf{x_{it}}$ of equation (5): $RP_{it} = \tau D_{it} + \mathbf{x_{it}}\gamma + c_i + \lambda_t + u_{it}, t = 1, 2, ..., T$. The control sample used in this table is CS1. I run regressions separately using all inversions (column (1)), pure inversions (column (2)), and M&A inversions (column (3)) as treated samples. *Reincorporation Dummy*, *log(total assets)*, *Leverage*, *ROA*, *Cash Holdings*, *Capital Expenditure*, *R&D Expenditure*, and *Tax Rate* are included in $\mathbf{x_{it}}$ as control variables. Firm and time fixed effects are both controlled. Standard errors are robust to heteroskedasticity and serial correlation, and are reported in parentheses. Note that I use "$***$," "$**$," and "$*$" to indicate that the estimates are significant at 1%, 5%, and 10% significance levels, respectively.

Variables	**All**	**Pure Inversion**	**M&A Inversion**
	(1)	(2)	(3)
D (Reincorp. Dummy)	-0.0005	0.0012	-0.0024
	(0.0007)	(0.0005)***	(0.0010)***
Log(total assets)	-0.0001	0.0005	0.0000
	(0.0004)	(0.0003)	(0.0005)
Leverage	-0.0002	-0.0001	-0.0013
	(0.0007)	(0.0009)	(0.0015)
ROA	0.0006	0.0004	0.0001
	(0.0012)	(0.0022)	(0.0015)
Cash	-0.0004	-0.0030	0.0002
	(0.0011)	(0.0011)***	(0.0011)
Capital Expenditure	-0.0028	-0.0162	0.0016
	(0.0034)	(0.0059)***	(0.0031)
R&D Expenditure	-0.0004	0.0062	-0.0004
	(0.0021)	(0.0048)	(0.0025)
Tax Rate	-0.0006	0.0002	-0.0009
	(0.0004)	(0.0012)	(0.0004)**
Constant	0.0106	0.0080	0.0054
	(0.0017)***	(0.0017)***	(0.0017)***
Adj. R-squared	0.85	0.91	0.87
Observations	1502	357	1081
Firm fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes

Table 11: **Effect of Inversion on Cash Holdings.**
This table reports the changes in cash holdings following an inversion. The control sample used in this table is CS1. I run regressions separately using all inversions (column (1)), pure inversions (column (2)), and M&A inversions (column (3)) as treated samples. The dependent variable, *Cash Holdings*, is defined to be the ratio of cash held within the firm to total assets. The explanatory variables include *Reincorporation Dummy*, *log(total assets)*, *Leverage*, *ROA*, *Capital Expenditure*, *R&D Expenditure*, and *Tax Rate*. Firm and time fixed effects are both controlled. Standard errors are robust to heteroskedasticity and serial correlation, and are reported in parentheses. Note that I use "***," "**," and "*" to indicate that the estimates are significant at 1%, 5%, and 10% significance levels, respectively.

Variables	**All**	**Pure Inversion**	**M&A Inversion**
	(1)	(2)	(3)
D (Reincorp. Dummy)	-0.0488	-0.1798	-0.1593
	(0.0514)	(0.0753)***	(0.1003)
Log(total assets)	-0.0299	-0.0550	-0.0071
	(0.0160)**	(0.0512)	(0.0202)
Leverage	-0.1629	-0.0928	-0.1778
	(0.0577)***	(0.0842)	(0.0527)***
ROA	0.0080	0.8527	-0.1180
	(0.0771)	(0.0941)***	(0.0649)**
Capital Expenditure	-0.4239	-0.0434	-0.7438
	(0.1649)**	(0.3683)	(0.1728)***
R&D Expenditure	-0.3946	-0.8872	-0.3740
	(0.1068)***	(0.3657)	(0.0883)***
Tax Rate	-0.0434	0.0866	0.0522
	(0.0282)	(0.0757)	(0.0312)*
Constant	0.3944	0.5230	0.2373
	(0.0757)***	(0.3213)	(0.0659)***
Adj. R-squared	0.15	0.46	0.17
Observations	1502	357	1081
Firms in sample	58	24	29
Firm fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes

Table 12: **Effect of Inversion on Dividend Payments.**
This table reports the changes in dividend payments following an inversion. The control sample used in this table is CS1. I run regressions separately using all inversions (column (1)), pure inversions (column (2)), and M&A inversions (column (3)) as treated samples. The dependent variable, *Dividend*, is defined to be the ratio of dividends paid to total assets. The explanatory variables include *Reincorporation Dummy*, *log(total assets)*, *Leverage*, *ROA*, *Cash Holdings*$_{t-1}$, *Capital Expenditure*, *R&D Expenditure*, *Tax Rate*, and *SG&A*. Firm and time fixed effects are both controlled. Standard errors are robust to heteroskedasticity and serial correlation, and are reported in parentheses. Note that I use "$***$," "$**$," and "$*$" to indicate that the estimates are significant at 1%, 5%, and 10% significance levels, respectively.

Variables	**All**	**Pure Inversion**	**M&A Inversion**
	(1)	(2)	(3)
D (Reincorp. Dummy)	-0.0015	-0.0018	-0.0058
	(0.0025)	(0.0074)	(0.0045)
Log(total assets)	-0.0005	0.0015	-0.0007
	(0.0017)	(0.0043)	(0.0023)
Leverage	-0.0066	0.0102	-0.0089
	(0.0035)*	(0.0130)	(0.0038)**
ROA	0.0309	-0.0369	0.0346
	(0.0160)*	(0.0688)	(0.0168)**
Cash Holdings$_{t-1}$	0.0001	0.0015	0.0024
	(0.0060)	(0.0155)	(0.0089)
Capital Expenditure	0.0472	0.1301	0.0339
	(0.0279)	(0.0962)	(0.0369)
R&D Expenditure	0.0976	0.0401	0.0809
	(0.0548)	(0.1003)	(0.0670)
Tax Rate	-0.0028	-0.0014	-0.0041
	(0.0015)	(0.0052)	(0.0017)**
SG&A	-0.0002	0.0126	-0.0003
	(0.0005)	(0.0291)	(0.0006)
Constant	0.0071	-0.0163	0.0003
	(0.0094)	(0.0310)	(0.0097)
Adj. R-squared	0.02	0.16	0.02
Observations	1502	357	1081
Firms in sample	58	24	29
Firm fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes

Table 13: **Effect of Inversion on Capital Expenditures.**
This table reports the changes in capital expenditures following an inversion. The control firms used in this table are CS1. We run regressions separately using all inversions (column (1)), pure inversions (column (2)), and M&A inversions (column (3)) as treated samples. The dependent variable, *Capital Expenditures*, is defined to be the ratio of capital expenditures to book value of total assets. The explanatory variables include *Reincorporation Dummy*, *log(total assets)*, *Leverage*, *ROA*, *R&D Expenditure*, and *Tax Rate*. Firm and time fixed effects are both controlled. Standard errors are robust to heteroskedasticity and serial correlation, and are reported in parentheses. Note that I use "$***$," "$**$," and "$*$" to indicate that the estimates are significant at 1%, 5%, and 10% significance levels, respectively.

Variables	**All**	**Pure Inversion**	**M&A Inversion**
	(1)	(2)	(3)
D (Reincorp. Dummy)	0.0135	0.0258	0.0011
	(0.0079)*	(0.0113)**	(0.0053)
Log(total assets)	0.0024	0.0042	0.0035
	(0.0021)	(0.0100)	(0.0025)
Leverage	0.0165	-0.0060	0.0204
	(0.0067)**	(0.0090)	(0.0084)**
ROA	0.0241	0.0521	0.0155
	(0.0111)**	(0.0527)	(0.0106)
R&D Expenditure	0.1433	0.3476	0.1117
	(0.0374)***	(0.0700)***	(0.0528)**
Tax Rate	-0.0012	0.0199	-0.0046
	(0.0053)	(0.0113)	(0.0060)
Constant	0.0167	-0.0122	0.0005
	(0.0070)**	(0.0576)	(0.0070)
Adj. R-squared	0.18	0.16	0.20
Observations	1502	357	1081
Firms in sample	58	24	29
Firm fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes

Table 14: **Existing Shareholder Value Change.**
This table reports the regression results of existing shareholder value change based on the following diff-in-diff model: $MKV_{it} = \beta_0 + \beta_1 After_{it} + \beta_2 MA_{it} + \beta_3 After_{it} \times MA_{it} + u_{it}$, where MKV_{it} is existing shareholder value of firm i at time t (in billions of dollars). $After_{it}$ equals 1 in the post-inversion stage and 0 in the pre-inversion stage. MA_{it} equals 1 for M&A-inverting firms and 0 for pure-inverting firms. The error term u_{it} includes all other time-varying unobservable shocks to existing shareholder value. I use all the pure-inverting and M&A-inverting firms in Panel A, and I drop the firms that pure-inverted after 2004 in Panel B. In column (1) of each panel, I use all the available monthly data from 1978 to 2016. Then I separately estimate the regression in a 10-year, 5-year, and 3-year window, and report the results in columns (2), (3), and (4). Moreover, as a robustness check, to control for the potential price reaction to inversion before the announcement due to information leakage and insider trading, I drop the year prior to the inversion announcement month and redo the regressions in columns (2) to (4). Results for these censored tests are reported in columns (5) to (7). Newey-West standard errors are reported in parentheses. Note that I use "$***$," "$**$," and "$*$" to indicate that the estimates are significant at 1%, 5%, and 10% significance levels, respectively.

Table 14: **Existing Shareholder Value Change. (Continued)**

Variables	All	10-Year Window	5-Year Window	3-Year Window	Censored 10-Year	Censored 5-Year	Censored 3-Year
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: All pure-inverting and M&A-inverting firms							
After	4.10	3.55	2.46	1.27	3.72	2.63	1.42
	(0.23)***	(0.26)***	(0.31)***	(0.35)***	(0.26)***	(0.31)***	(0.36)***
MA	5.29	5.06	4.57	4.73	5.01	4.32	4.34
	(0.39)***	(0.47)***	(0.59)***	(0.77)***	(0.49)***	(0.65)***	(0.93)***
After×MA	**2.07**	**2.88**	**4.60**	**4.78**	**2.93**	**4.86**	**5.16**
	(0.87)* **	**(0.99)*** **	**(1.16)*** **	**(1.34)*** **	**(1.01)*** **	**(1.20)*** **	**(1.44)*** **
Constant	2.44	2.91	3.40	3.75	2.74	3.23	3.61
	(0.08)***	(0.10)***	(0.14)***	(0.18)***	(0.10)***	(0.15)***	(0.20)***
Adjusted R-Squared	0.08	0.09	0.10	0.09	0.09	0.10	0.10
Observations	9143	7127	4506	2956	6584	3963	2413
Firms in Sample	53	53	53	53	53	53	53
Panel B: Dropping the firms that pure-inverted after 2004							
After	4.08	3.47	1.97	0.98	3.66	2.15	1.10
	(0.24)***	(0.28)***	(0.32)***	(0.37)***	(0.28)***	(0.32)***	(0.38)***
MA	5.61	5.40	4.81	4.98	5.37	4.58	4.63
	(0.39)***	(0.47)***	(0.60)***	(0.77)***	(0.50)***	(0.66)***	(0.93)***
After×MA	**2.08**	**2.97**	**5.09**	**5.14**	**3.00**	**5.33**	**5.48**
	(0.58)* **	**(0.99)*** **	**(1.16)*** **	**(1.35)*** **	**(1.01)*** **	**(1.20)*** **	**(1.45)*** **
Constant	2.13	2.56	3.16	3.50	2.37	2.98	3.32
	(0.09)***	(0.11)***	(0.15)***	(0.19)***	(0.11)***	(0.16)***	(0.21)***
Adjusted R-Squared	0.09	0.09	0.10	0.10	0.09	0.11	0.10
Observations	8638	6641	4189	2749	6139	3687	2247
Firms in Sample	46	46	46	46	46	46	46

ELEVATED AVERAGE DURATION OF UNEMPLOYMENT SIGNALS IMPROVED LABOR MARKET

December 17, 2018

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ELEVATED AVERAGE DURATION OF UNEMPLOYMENT SIGNALS IMPROVED LABOR MARKET

Abstract

Long-term unemployment was one of the biggest problems during the Great Recession. Nearly half of all unemployed persons were out of work for six months or more (BLS, 2018, 2).[1] This stood in sharp contrast to the experience in previous recessions, when unemployment stints beyond a half year were much less common. Since the Great Recession, the average duration of unemployment has gradually diminished along with the unemployment rate, but it has nevertheless remained relatively long. In fact, the average duration is still longer than every prior post-WWII recession. In the past, a long average duration of unemployment indicated structural impediments in the labor market, such as skills mismatches (Wiczer, 2015). Therefore, the current long duration is naturally seen as a sign of continued weakness (St. Louis Fed, 18, inter alia). In contrast, this paper posits that the elevated duration of unemployment actually indicates that the labor market is functioning unusually well. The long duration of unemployment is the result of very short job searches for newly unemployed workers, and is actually unrelated to long-term unemployment. Consequently, policies designed to solve this "problem" may be unnecessary and misguided.

Keywords: unemployment duration, structural unemployment, job mismatches

Section 1: Developments since the Great Recession

The sharp rise in the duration of unemployment during the Great Recession was a major focus of policy during the recession and the subsequent slow recovery. Former Fed Chair Ben Bernanke (2012) argued that the predominant force driving average duration of unemployment higher was cyclical, and therefore accommodative policies should alleviate the problem. Later, former Fed Chair, Janet Yellen (2014) highlighted alternative sources of labor market slack, including the "large share of the unemployed who have been out of work for six months or more." She said, "These workers find it exceptionally hard to find steady, regular work, and they appear to be at a severe competitive disadvantage when trying to find a job." Yellen leveraged these alternative

[1] Haver Analytics provided all the economic data in this study.

sources of slack to justify continued extraordinary monetary policy stimulus, even as the unemployment rate declined.

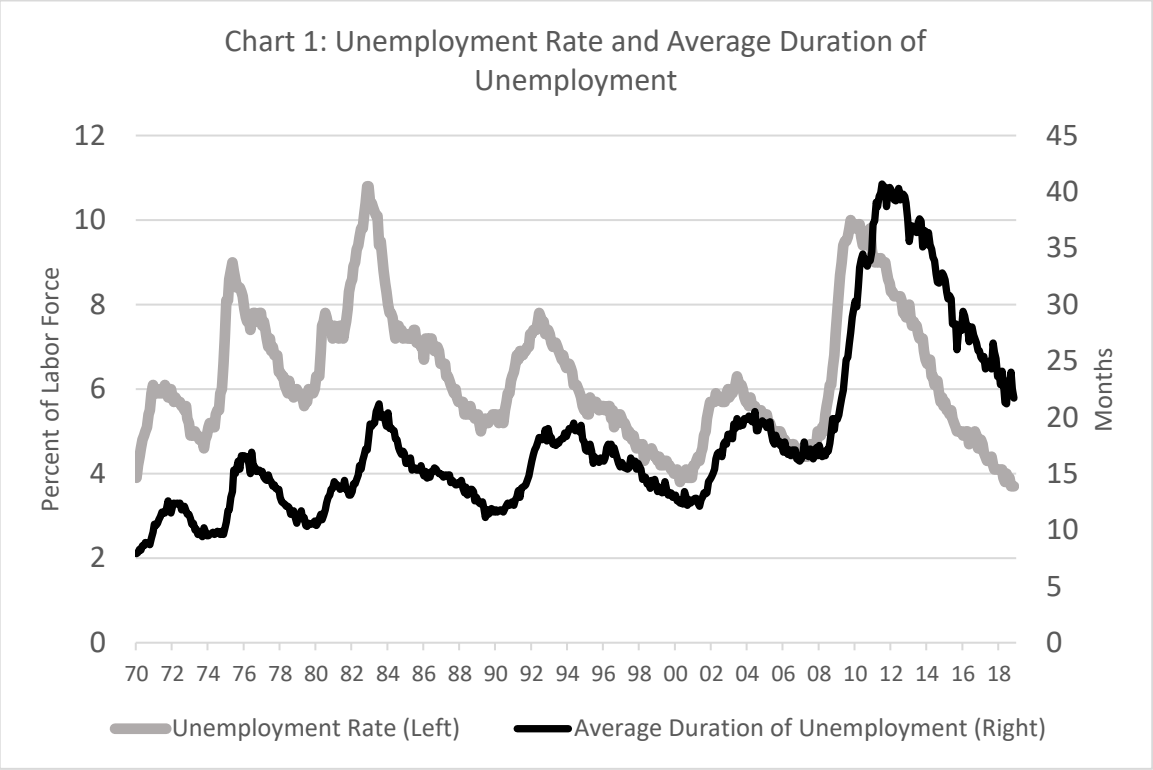
A Congressional Budget Office study (Carrington, 2014) attributed the long duration of unemployment to four forces: weak demand, generous unemployment insurance benefits, mismatches between worker skills and job requirements, and the loss of job skills during periods of unemployment. The first force (weak demand) is cyclical, and the last three forces are structural.

Two of these forces have been eliminated in recent years – weak demand and extended unemployment insurance. Weak demand generated cyclical unemployment. However, now that the unemployment rate has fallen well below Federal Reserve policymakers' assessment of the natural rate of unemployment, or the long-term unemployment rate (FOMC Statement, 2018 and BLS, 2018, 3), there is no cyclical reason for the elevated duration of unemployment. Also, unemployment insurance was scaled back to more normal levels by the end of 2013 (ATRA, 2012).

As a result, most analysts have concluded that the continued long average duration is evidence that the other two structural forces (skill mismatches and job skill losses) must be hampering the labor market. For instance, a Century Foundation study (McCormack, 2017) says the "hidden story is the unprecedented levels of long-term unemployment." He claims that "long-term unemployment has remained stubbornly high" and attributes it to a "hangover from the Great Recession and a demonstration of how hard it continues to be to find work." The elevated average duration has kept this idea in the public eye. For example, Jericho (2018) says that "long-term unemployment has become an increasing concern."

Even economists at the St. Louis Federal Reserve Bank have indicated that the elevated duration of unemployment signals labor market weakness (St. Louis Fed, 2018). It is a very powerful statement when the Fed gives its imprimatur to an idea like this. In a recent blog post entitled "The Unusual Duration of Unemployment: The Scars of the Great Recession," St. Louis Fed economists contrast an improving unemployment rate with a stubbornly high average duration of unemployment (see Chart 1). The St. Louis Fed researchers state that:

> The share of long-term unemployment is significantly higher than in any other post-WWII period. Indeed, those unemployed for more than six months still represent 20 percent of the unemployed, after a peak of over 45 percent in 2011. The share increases after recessions, but the most recent recession was deeper and much longer than the others. It's also well-known that the long-term unemployed have a much harder time finding a job […] And thus their numbers still persist at a high level (St. Louis Fed, 2018).



Source: Bureau of Labor Statistics.

The St. Louis Fed economists and other analysts are essentially attributing the current long average duration of unemployment to a combination of the Great Recession legacy and the difficulty that the long-term unemployed generally experience landing jobs. By implication, if the labor market is still hobbled in this way, there may be reason to continue policies designed to alleviate the pain associated with long-term unemployment, such as accommodative monetary and fiscal policies, job training and search assistance, tax credits, and reduced payroll taxes (CBO, 2014).

However, neither of these factors – the Great Recession legacy nor the difficulties long-term unemployed have finding jobs – actually explains the current long average duration of unemployment. The elevated average duration figure no longer reflects an abundance of long-term unemployed, as was the case during the Great Recession and the immediate aftermath. Instead, the elevated duration can be attributed to how few short-term unemployed there are in the labor market now.

Section 2: Benchmarking the long-term unemployment pool

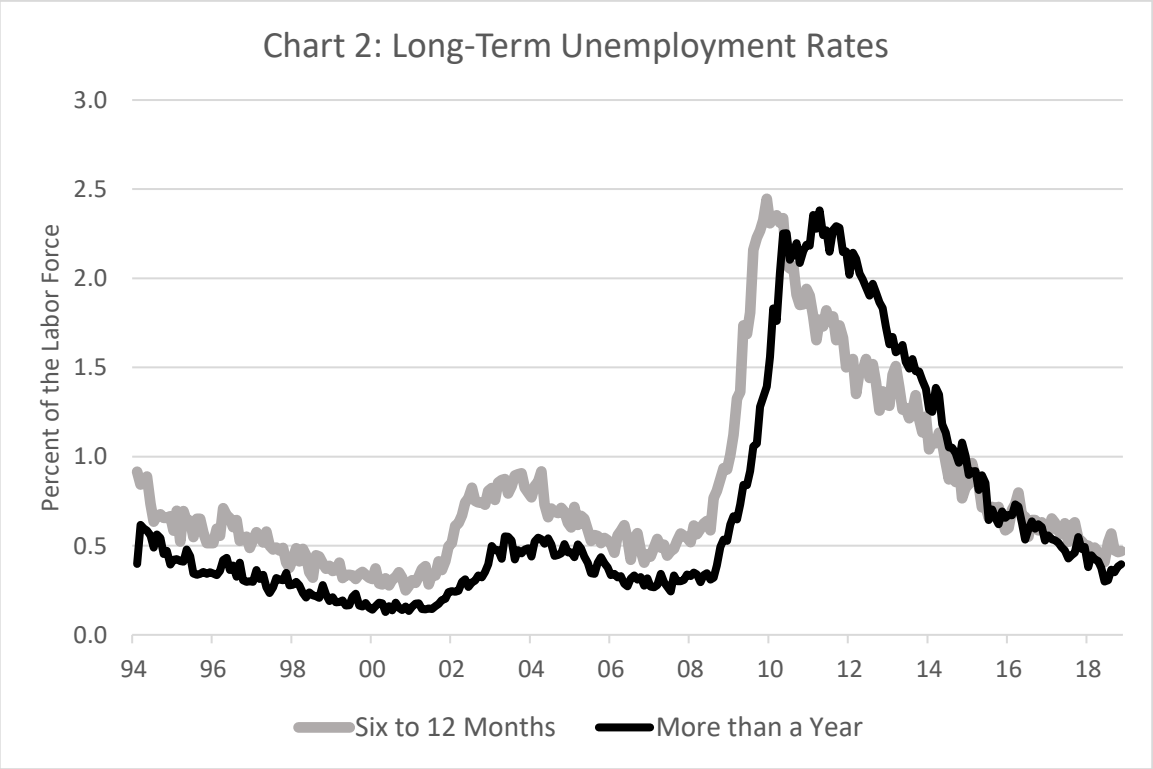
The St. Louis Fed researchers are absolutely correct that the share of people out of work for six months or more remains nearly as high as at the height of the worst previous post-WWII recessions (St. Louis Fed, 2018). Currently, 23 percent of unemployed workers are out of work for a half year or more, and 10 percent have been out of work for a year or more (BLS, 2018, 3). In 1982 when the economy was near the trough of a harsh recession, about 25 percent of unemployed workers were out of work for a half year or more. The difference is that the current high duration of unemployment follows an economic expansion of over nine years and the unemployment rate is unusually low. As the St. Louis Fed blog title – The Scars of the Great Recession – suggests, this elevated share of long-term unemployed is seen as a sign of hidden distress in the labor market.

Unemployment shares can be misleading, however. Duration of unemployment data are published as levels and shares of unemployment (BLS, 2018, 2) and, as the previous examples show, it has become customary to look at them by shares. But the raw numbers of unemployed workers by duration tell a vastly different story than the shares.

The raw numbers of unemployed people out of work for more than a half year or a full year are actually quite low, both in absolute terms and relative to the size of the labor force. There are currently just 1.4 million people unemployed for more than a half year and 645,000 for more than a year. In contrast, these figures reached 7.0 million and 3.6 million respectively in the last recession. The current levels of long-term unemployment are on par with the lowest readings of the previous expansion (BLS, 2018, 2). Meanwhile, the labor force has grown significantly in the past eleven years since the last expansion, suggesting that the current long-term unemployment figure may be even less worrisome when benchmarked against the entire labor force.

The published shares of unemployment by duration are stated as a percent of the total number of unemployed workers. For instance, the data take the long-term unemployed as a share of the total number of unemployed. This choice of benchmark, however, can make it difficult to assess the health of the labor force. The total number of unemployed changes dramatically through the business cycle. It is far different to say that 45 percent of the unemployed are out of work for a half year or more when the unemployment rate is 10 percent than when the unemployment rate is 3.7 percent. How can we get a benchmark that indicates the overall prevalence of long-term unemployment in the labor market?

Taking the ratio of long-term unemployed to the overall labor force, essentially deriving a long-term unemployment rate, can give a better sense of the prevalence of long-term unemployment. Chart 2 shows that this long-term unemployment rate is currently near the lowest level on record (for both six- and twelve-month spans). In other words, given the size of the labor market, there actually are relatively few people experiencing bouts of long-term unemployment. There does not appear to be an added layer of stress in the labor market that is being picked up by the high average duration of unemployment. Consequently, the high average duration should not be used to advocate for extraordinary policies to mitigate any implied lurking weakness.



Source: Bureau of Labor Statistics.

Section 3: Few newly unemployed, short searches

So how can two statistics – the elevated share of long-term unemployed and the high average duration of unemployment – suggest continued troubles in the labor market, while at the same time this long-term unemployment rate statistic signals an extremely healthy labor market? The answer lies in what has happened to short-term unemployment during this expansion and over the past three decades.

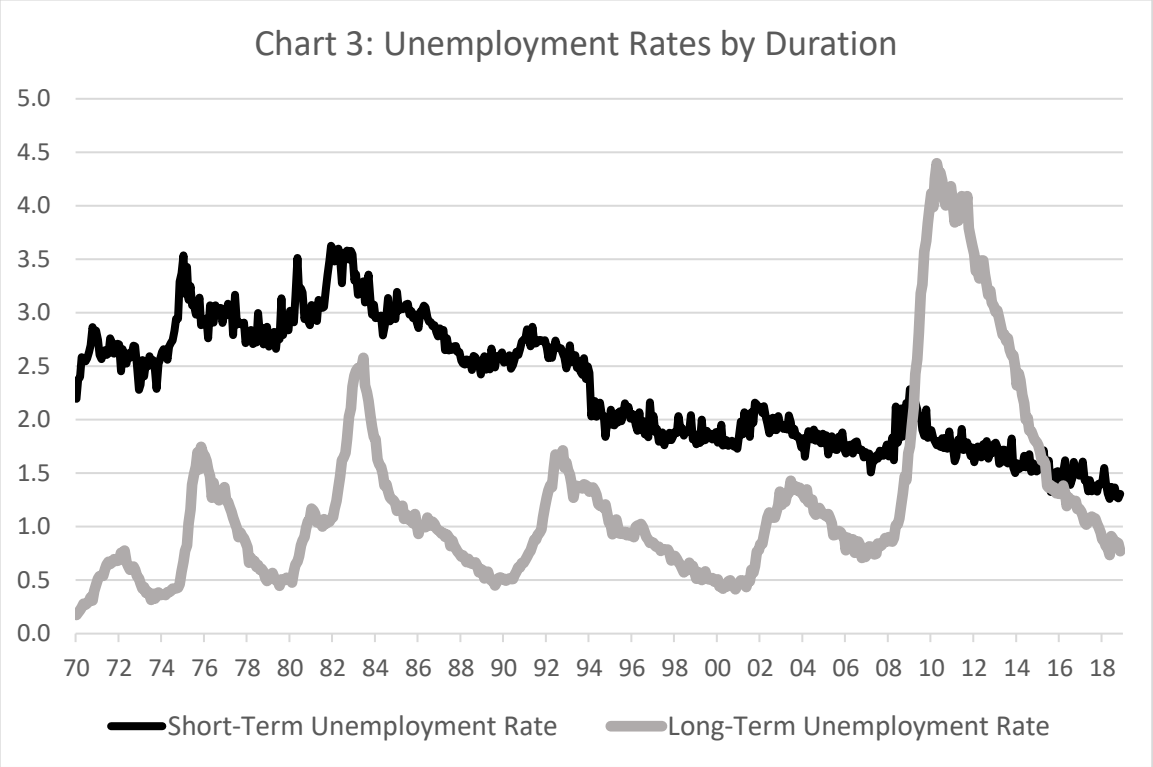
The average duration of unemployment is calculated as a weighted average of the number of weeks unemployed times the number of people at each level of weeks. The equation is written

$$\text{Average Duration} = \sum N_i \,.\, W_i \,/\, \sum N_i$$

where N_i is the number of unemployed people and W_i is the number of weeks they have been unemployed (Corak and Heisz, 1996).

The average can be high for several reasons. The natural thought is a high average duration of unemployment would be caused by an elevated number of people who are unemployed for long periods. However, the average can also be high because there is a low number unemployed for short periods.

The number of short-term unemployed people – the newly unemployed – is extremely low by historical standards. The proportion of the labor force that is out of work for a month or less – the short-term unemployment rate – is currently at just 1.3 percent. That is the lowest proportion of the labor force since the BLS started collecting the data in 1948 (BLS, 2018, 2). In fact, there has been a steady decline in short-term unemployment since the 1980s (see Chart 3).



Source: Bureau of Labor Statistics.

Meanwhile, long-term unemployment has shown a clear cyclical pattern, with the latest recession experiencing a massive spike. However, Chart 3 also shows that the calculated long-term unemployment rate has been remarkably consistent, as expansions have reached full employment. Currently, the unemployment rate for people out of work six months or more is 0.8 percent, which is within a half point of each of the previous five cycle lows. So, controlling for the state of the business cycle (i.e., looking only at the periods when the economy was at full employment), the real shift in the pattern of employment duration has been entirely in short-duration unemployment.

Moreover, newly unemployed people generally find jobs very quickly. In fact, most job searches last less than two months. Using BLS unpublished labor force flows data (BLS, 2018, 3), the probability of a newly unemployed person remaining unemployed after five weeks can be calculated in a manner similar to the "continuation rates" of Corak and Heisz (1996). Currently, there is a 38 percent probability that a person will remain unemployed. In other words, there is over a 60 percent chance that a newly unemployed person will either find employment or leave the workforce within two months (40 percent chance of finding a new job and 22 percent chance

of leaving the workforce).[2] Even during the worst of the Great Recession, the probability of remaining unemployed for more than a month hovered near 50 percent.

Given the relatively low number of newly unemployed people and the relative speed with which the short-term unemployed find jobs, it is no wonder that unemployment is skewed toward a longer average duration. In fact, the number of short-term unemployed is so low that it has boosted the average duration up even though there is a low number of long-term unemployed.

Section 4: Sign of strength

While it may seem counterintuitive, the elevated average duration of unemployment really is a sign that the labor market is doing very well. This can be seen by imagining that the calculated short-term unemployment rate did not decline over the past few decades. Let's say that the number of short-term unemployed represented about 2.3 percent of the labor force (on par with the lowest points of the previous two expansions). All else equal, the economy would not be as well off as it is today with only 1.3 percent of the labor force unemployed for a short duration.

How would the statistics change if this were the case? The overall unemployment rate would obviously be higher. Leaving the number of people unemployed constant for all longer tranches of duration, while raising the number of short-term unemployed, would have to raise the overall unemployment rate. It turns out that the increase in short-term unemployment rate from 1.3 percent to 2.3 percent would raise the overall by unemployment rate by a point as well – from 3.7 percent to 4.7 percent.[3]

What would happen to the average duration of unemployment if the short-term unemployment rate were a point higher? There would be more weight on the shorter end of the duration spectrum, pulling the average down. The increase in the unemployment rate would at the same

[2] The labor force status flows data can give probabilities of finding a new job or leaving the workforce. The probability of remaining unemployed is based on the ratio of the number of people unemployed for less than five weeks who remained unemployed to the total number unemployed less than five weeks the month before. The probabilities in this report follow the work in D'Antonio (2014).

[3] The sum of the unemployment rates by duration equals the overall unemployment rate. So, increasing any one of the duration tranche unemployment rates will cause the total to rise by the same amount. In this case, the 1 percentage point increase in the short-term unemployment rate boosts the total by 1 percentage point, to 4.7 percent.

time cause the average duration of unemployment to *decline* by 4 full months to 17.7 months.[4] An average duration of unemployment in that range would not be considered problematic, as it would be near the lows of the previous expansion (see Chart 1). In other words, a slightly higher number of people unemployed for short periods, relative to the size of the labor force, would signal a less robust labor market, but would be consistent with a sharply lower average duration of unemployment.

Section 5: Conclusion

This analysis shows that the elevated level of the duration of unemployment is not a sign of hidden slack in the labor market. The extremely low unemployment rate, along with the low incidence of long-term unemployment, implies that the labor market is currently operating at a point beyond full employment, notwithstanding the high average duration reading. In fact, the duration figure appears to be a statistical artifact of the extreme strength evident in the short-term unemployment rate. As a result, it would be misguided to conduct policy to address the long-term unemployment "problem" when the labor market is actually functioning extremely well.

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Abstract

Examining the Evolution of Investors' Views of Sustainability and Corporate Social Responsibility (CSR) Leadership

Currently, money managers and investors appear to be placing increasingly more importance on sustainability and corporate social responsibility (CSR) than the last two decades (e.g., Nelson, 2017; Bernow, et al., 2017; Choi, 2017). Studies on the impact of sustainability practices and CSR on a firm's performance indicate mixed results (e.g., Byus et al., 2010; Lopez et al., 2007; Robinson et al., 2011; Oberndorfer et al., 2011). Robinson et al. (2011) reported a significant positive impact for firms when added to the Dow Jones Sustainability Indices (DJSI), while Oberndorfer et al. (2011) and Lopez et al. (2007) found a negative impact on firms' performance associated with inclusion in the DJSI. Researchers have largely attributed these conflicting results to either the market (U.S. vs Europe) or the times that the studies were conducted.

This study builds upon the prior research by examining the impact of additions and deletions of firms to the DJSI over a longer period of time. In addition, the research investigates any changes to the financial value of the firm being designated the leader of sustainability and CSR by inclusion in the DJSI. The changes in the firm's performance is examined by being included/deleted not only from the World DJSI index but also from the regional DJSI indices (North American, Europe, Asia Pacific, & Emerging Markets).

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FORECASTING DEFINED CONTRIBUTION AND DEFINED BENEFIT RETIREMENT ACCOUNTS

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ABSTRACT

The focus of this paper is to forecast the value of a typical defined contribution retirement account using a binomial tree projection method based on S&P stock performance. For comparison, a simple bootstrapping simulation model is also considered. Defined benefit pension plans in recent years typically have a formula structure similar to defined contribution plans, but the growth in these plans is more stable. This paper contains a modern view of many types of employer funded retirement accounts, and forecasting methods that are valuable in understanding the future value and volatility of these account types.

Keywords: binomial tree, contribution forecasting, retirement accounts, pension

INTRODUCTION\BACKGROUND

A defined contribution (DC) retirement plan is the most common retirement benefit offered by employers in the United States. This type of plan, also known as a 401(k) plan, is an account balance comprised of employer and/or employee contributions. Generally, 401(k) contributions are a percentage of the employee's monthly pay, with the funds earning interest based on an array of plan-defined options including mutual funds and bonds. Employees manage their own accounts by directing their contributions amongst the plan-defined investment options.

Alternatively, defined benefit (DB) retirement plans are established with the intent of offering a lifetime of monthly annuity payments to the employee upon retirement. However, modern DB plans are designed as account balances, only converting the balance to a life annuity at the time of retirement. This concept of a growing balance is in contrast to the traditional percentage of pay formula computed as a one-time calculation as of retirement date. These plans are often called "hybrid" plans since they have the features of both DC and traditional DB plans. Hybrid plans have a variety of names such as: "cash balance", "pension equity", and "stable value" [4]. These hybrid plans are typically employer funded, but unlike defined contribution plans, hybrid plan contributions earn stable growth defined by the plan.

The general industry trend as reported by the Bureau Labor Statistics is summarized in Table 1. It is clear that defined contribution plans have continued to grow in popularity as compared to defined benefit plans.

Table 1

Year	Single Employer Combined	Single Employer DB	Single Employer DC	Multi-Employer Combined	Multi-Employer DB	Multi-Employer DC
1975	308,651	101,214	207,437	2,443	2,132	311
1980	486,142	145,764	340,378	2,759	2,332	427
1985	629,069	167,911	461,158	3,066	2,261	805
1990	709,404	111,251	598,153	2,904	1,812	1,092
1995	690,265	67,682	622,584	3,139	1,810	1,328
2000	732,654	47,015	685,639	2,997	1,758	1,239
2005	676,151	46,090	630,061	2,945	1,524	1,420
2010	698,186	45,072	653,114	2,826	1,471	1,355
2015	691,278	44,259	647,019	2,647	1,413	1,234
2016	699,904	44,888	655,017	2,636	1,412	1,224

*Does not include single participant plans
**SOURCE: Form 5500 filings with the U.S. Department of Labor

Defined contribution accrual rates of employer paid plans with a matching component (meaning the employee has to contribute a percentage of pay in addition to that contributed by the employer) had a median of 4.0% matching deferrals in 2017, up from 3.5% in 2013 (Vanguard pg. 20). For employers with both a matching and non-matching deferral, the median total rate was 8.0% in 2017, up from 7.5% in 2013. However, only about 40% of plans had both deferral components (constituting 50% of all participants).

Defined benefit plans have a wide variety of benefit structures. Retirement consulting companies such as Willis Towers Watson collect data on the major type's employer funded retirement benefit plans. Table 2 contains a summary of plan types resulting from the 2018 retirement benefit survey [8]. Note that in many cases, contribution rates among cash balance plans vary based on age and service criteria. In most cases, higher service and older employees have higher plan contribution rates. An example of a typical contribution grading schedule is 3%/year up to age 40, 5%/year between ages 40 and 50, and 7%/year over age 50. Alternatively, the graded schedule may be based on service (e.g. 10, 20, 30 years of service).

Cash Balance plans make up a large majority of DB plans with an account balance structure. The primary difference between cash balance plans and "stable value" or "pension equity" plans is that the cash balance grows in real time. The "other" types of DB balance plans have account balance structures that define a lump sum payment amount, payable at normal retirement date (typically age 65). This means that a plan participant with an account balance in a stable value plan of $100,000 as of age 40 does not have a right to that money until age 65, and the $100,000 is really just a promise to pay that amount as of age 65. If the participant elects to take their money prior to age 65 then the amount would be actuarially reduced due to the early payment date.

Table 2 – Defined Benefit Plan Survey Summary

Pension Plan Type	Number of Plans	Average Minimum Contribution Rate	Average Maximum Contribution Rate
Cash Balance Plan/Other Account Balance Plan	93	4.26%	6.93%

Pension Plan Type	Number of Plans	Minimum Accrual Rate Multplier	Maximum Accrual Rate Multplier
Traditional Annuity Plan	49	0.50%	2.00%

SIMULATION

Consider a typical employee eligible for DC plan contributions beginning at age 25. Contributions are assumed to be earned at the end of each year and the S&P will be used to model investment return. Account balance projections to age 65 are simulated using two different methods; we can then compare these projections to one using a fixed average S&P rate of return assumption.

Participant data assumptions for each model:

- wage increase 4.24% (average NAW increase 1976 – 2016; ssa.gov website)
- starting annual salary of $50,000 as of age 25, 35, 45
- retire at age 55, 65, 75

SIMULATION MODEL – DEFINED CONTRIBUTION

Fixed rate projected contribution formulas were performed in Excel. Bootstrapping was done using an Excel Visual Basic macro with 1,000 simulated projections. Bootstrapping was also performed in R programming language as a check. Finally, the binomial bootstrapping method was performed in R with 1,000 simulations per assumption set.

<u>Plan contribution Assumption:</u>

- DC contributions made end of year: general rates range from 4% - 8% of pay depending on matching or matching plus non-matching employer contributions
  [2% - 12% is the approximate maximum range]

Simulated contributions at three rates:

- 4%
- 8%
- Graded rates increasing every 10 years 4%, 5%, 6%, 7%

Plan investment return assumption: the following projection methods are modeled to compare DC account balance growth based on the S&P yield rates over a 68-year period:

- **Fixed Interest rate at 7.34%:** geometric average market yield rate from 1950 – 2018 (dividends included, 0.42% deduction for investment fees)
- **Bootstrapping:** annual S&P yield rates (1950 – 2018)
- **Binomial model**:

Two nodes are created each year:

"up" steps of $u = 1 + r_1 + \sigma_1$, and

"down" steps of $d = 1 + r_2 - \sigma_2$; where

r_i = discrete random selection of a historical yield rate (1950 – 2018)

σ_i = volatility for the year used to determine r_i.

The probability of an "up" step is then defined as:

$$p = (1 + (r_1 + r_2)/2 - d)/(u - d) \quad (1)$$

The expected return for a given year is determined using the expected value of the nodes:

$$r^* = p \times u + (1-p) \times d \quad (2)$$

Finally, the projected contribution balance (S) is determined by:

$$S = \sum_0^{n-1} c_k \times \prod_0^{n-1-k}(1 + r_j^*) \quad \text{; where} \quad (3)$$

n = number of projected years from current age to age 65

c_k = contribution in year k

r_j^* = simulated binomial return in year j

RESULTS – DEFINED CONTRIBUTION

Table 3a displays a summary of projected DC balances based on fixed yield at various contribution rates and ages. As commonly known, the longer savings period creates great growth in projected savings. A 40-year savings period earns six to seven times the amount saved over 20 years.

It is also important to note that a typical graded contribution schedule does not produce as great a final balance as one might expect. For a 40-year career, the graded schedule only gains 28% of the value between a 4% and 8% fixed rate projected balance. For a 20-year career, the value of a graded schedule only gains approximately 10% of value over the 4% projected balance. However, the results for the 20-year career would be higher if the grading schedule was based on age rather than the service schedule simulated here.

Table 3a

DC Plan - Fixed Return - LS amounts payable at age 65			
	Service Start Age ($50,000 Initial Salary)		
Contribution %	**25**	**35**	**45**
4.0%	$ 757,151	$ 315,919	$ 117,979
graded*	$ 973,377	$ 379,685	$ 130,581
8.0%	$ 1,514,303	$ 631,837	$ 235,958
*graded rates 4% for the first 10 years, 5%, 6%, 7% for each 10-year period thereafter			

Tables 3b & 3c summarize contribution projections based on simulation techniques. Table 3b demonstrates that the high variability of S&P returns can create very large projected balances. The standard deviation of results are quite large of course, and so there can be significant risk.

Table 3c shows that binomial step projections create balances that are close to those using traditional bootstrapping methodology. Although the “up” and “down” nodes include annual variability to the already highly variable S&P rates, the results do not show extreme projected balance due to the controlling impact of the averaging of the two nodes.

Table 3b

DC Plan - Bootstrap - LS amounts payable at age 65			
	Service Start Age ($50,000 Initial Salary)		
Contribution %	**25**	**35**	**45**
4.0%	$ 1,117,367	$ 404,360	$ 139,951
graded*	$ 1,407,924	$ 489,547	$ 155,211
8.0%	$ 2,234,735	$ 808,719	$ 279,901
*graded rates 4% for the first 10 years, 5%, 6%, 7% for each 10-year period thereafter			

Table 3c

DC Plan - Binomial - LS amounts payable at age 65			
	Service Start Age ($50,000 Initial Salary)		
Contribution %	**25**	**35**	**45**
4.0%	$ 1,005,403	$ 403,985	$ 136,555
graded*	$ 1,258,488	$ 454,048	$ 149,781
8.0%	$ 2,010,806	$ 807,970	$ 273,111
*graded rates 4% for the first 10 years, 5%, 6%, 7% for each 10-year period thereafter			

SIMULATION MODEL: DEFINED BENEFIT - CASH BALANCE

The fixed rate projected balances for the defined benefit cash balance were performed in Excel using standard account growth formulas. The bootstrapping projections were also performed in Excel with the use of Visual Basic programming to run 1,000 simulations for each assumption set. The binomial model was not used for cash balance projections because the return rates are much more stable (30-year treasury rates) than those used for the DC projections.

Plan Assumptions:

- DB cash balance plan contributions made end of year – 4%, 5%, 6%, 7% of pay [CB - based on average survey pension data range 4.26% - 6.93%]

The following models compare DB account balance growth based on interest growth over a 20 – 40 year period:

- **Fixed Interest rate at 6.59%:** median of average annual 30-year US Treasury rates over the past 40 years (1979 – 2018)
- **Bootstrapping:** average annual 30-year US Treasury rates (1979 – 2018)

RESULTS – DEFINED BENEFIT – CASH BALANCE

Tables 4a & 4b are remarkably similar. The Treasury rates used in the DB plans are much more stable that the S&P returns used in the DC plans. DC plans have generally higher projected balances than the DC cash balance plans.

In the case of a DB graded contribution schedule, the graded schedule performs slightly better than for the DC projection. For a 40-year career, the graded schedule gains approximately 30% of the value between a 4% and 8% fixed rate projected balance. For a 20-year career, the value of a graded schedule gains approximately 11% of value over the 4% projected balance. As in the DC simulation, the results for the 20-year career would be higher if the grading schedule was based on age rather than the service schedule simulated here.

Table 4a

DB Plan - Fixed Return - LS amounts payable at age 65			
	Service Start Age ($50,000 Initial Salary)		
Contribution %	**25**	**35**	**45**
4.0%	$ 644,939	$ 281,575	$ 109,717
graded*	$ 842,480	$ 341,592	$ 121,910
8.0%	$ 1,289,878	$ 563,150	$ 219,435
*graded rates 4% for the first 10 years, 5%, 6%, 7% for each 10-year period thereafter			

Table 4b

DB Plan - Bootstrapping - LS amounts payable at age 65			
	Service Start Age ($50,000 Initial Salary)		
Contribution %	**25**	**35**	**45**
4.0%	$ 643,437	$ 282,039	$ 110,111
graded*	$ 840,631	$ 343,587	$ 123,018
8.0%	$ 1,286,875	$ 564,078	$ 220,222
*graded rates 4% for the first 10 years, 5%, 6%, 7% for each 10-year period thereafter			

CONCLUSION/DISCUSSION

Retirement planning is a constant challenge for employees and employers. Employers are eliminating or converting traditional defined benefit plans into benefits derived from account balances. The trend of eliminating DB plans has slowed in the past 20 years, but the conversion of those plans into account balance plans has pushed traditional final average pay formulas almost to extinction.

The strength of cash balance pension design is to offer stable projected benefits as retirement, not subject to the wide market variability that exists in defined contribution (401k) plans. This paper presents comparisons of account balance projections based on current trends in contribution levels for both DC and DB account plans.

Simulations help identify the trade-off between the highly volatile DC accounts with generally greater payoffs and the stable DB counterparts with lower payoffs. Also, the very large discrepancy between the higher contribution levels and number of years contributing to the accounts. Finally, a graded contribution structure does not result in as high a projected retirement fund as one might expect.

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BUSINESS ANALYTICS AND KNOWLEDGE MANAGEMENT - ABSTRACTS

A METHOD TO DETERMINE THE SIZE OF THE RESAMPLED DATA IN IMBALANCED CLASSIFICATION

Classical positive-negative classification models often fail to detect positive observations in data that have a significantly low positive rate. This is a common problem in many domains, such as finance (fraud detection and bankruptcy detection), business (product categorization), and healthcare (rare disease diagnosis). A popular solution is to balance the data by random under sampling (RUS), i.e. randomly remove a number of negative observations or random over sampling (ROS), i.e. randomly reuse a number of positive observations. In this study, we discuss a generalization of RUS and ROS where the data is balanced to a level between the size of the positives and negatives. We also propose a data-driven method to determine the size of the resampled data that most improves classification models.

Keywords: binary classification, imbalanced learning, under-sampling, over-sampling, rare event

AN EXAMINATION OF THE PERCEIVED USEFULNESS OF ONLINE REVIEWS

Keywords: online reviews, review usefulness, trust, text analytics

Consumer reviews have a significant impact on online consumer behavior and purchase intentions (Lee and Ma, 2012). The assumption is that the reviews are written by other consumers and are unbiased, which leads individuals to trust the comments (Cheung, Sia and Kuan, 2012; Huang, Tan, Ke and Wei, 2018; Robinson, Goh and Zhang, 2012). There have been many instances of retailers writing their own reviews (called sock-puppeting) or paying for review writing services. Consumers are now much more skeptical of reviews, however there is little understanding of how they ascertain which reviews to trust. This research will address two broad questions. First, how does a review's intrinsic, contextual and representational quality (operationalized with verified purchase, reviewer name, review length; spelling, grammar and formatting errors) impact a consumer's perceived usefulness of a product review? Business and artificial intelligence are being used to gain insight into user generated text data (Rambocas and Pacheco, 2018; Xu, Wang, Li and Haghighi, 2017). The second question makes use of text analytic tools to determine how structural elements (writing level, parts of speech, n-grams or word combinations, word frequency and inverse frequency, etc.) impact a consumer's perceived usefulness of a product review. A sample of 711 Amazon reviews for a household product from July 2016-August 2018 will be used to address these questions.

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MINDFULNESS: BUDDHISM AND THE TRANSFORMATION OF AMERICAN BUSINESS

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Abstract

In all quarters there is an expanding use of the Eastern term "mindfulness" and its seeming applicability to everything from cooking, couples counseling, anger management, and personal growth to business prosperity. Unfortunately the clamoring for simplistic solutions in the business arena has led to a type of coffee table mindfulness that has divorced itself from mindfulness' truly transformative and life altering power beyond that of just being calm and peaceful. Indeed in an ever uncertain global business environment, leadership of all stripes requires in the main, being peaceful and calm. However positive personality traits alone, no matter how desirable, are not wholly dispositive or predictive of business growth. That mindfulness is most effective when placed in its proper context, along with practical adaptive strategies, which can literally be transformative for individuals, organizations and business' desired outcomes. The author demonstrates how mindfulness when placed in a modern theoretical Buddhist framework can be used to transform contemporary American business. This paper examines mindfulness its genesis from Buddhism and how it can be used in conjunction with modern strategic intervention approaches to produce morally compelling, predictive and financially beneficial results.

Keywords: mindfulness, leadership, business, Buddhism

MONITORING LENGTH OF STAY THROUGH CONTROL CHARTS: A COMPARATIVE CASE STUDY ON DIABETIC PATIENTS

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Taking into consideration the rising demand for improved and safe healthcare along with increasing costs, both healthcare providers and managers at the micro level, as well as healthcare policy makers at the macro level, strive to figure out how to improve healthcare outcomes and value for all stakeholders in healthcare industry. The President Obama's healthcare plans strongly mentioned the necessity of implementing effective managerial approaches and methodologies in the nation-wide healthcare services (PCAST report, 2014).

The healthcare industry has accounted for relatively high proportion of developed countries' gross domestic products (GDP) in the last six decades, and the U.S. has had the highest level of health spending in the world (c.f. Borger *et al.*, 2006; Congressional Budget Office). Specifically, due to the fact that approximately 45% of the healthcare budget is spent by hospitals in the U.S., hospitals must try to find acceptable strategies to reduce cost without loss of quality (Niemeijer et al., 2010). Considering that the healthcare cost per person increases exponentially among the elderly population, cost reduction and quality improvement efforts are considered a necessity in the healthcare industry.

Given the fact that there is a tremendous need in overall healthcare industry to improve performance, administratively and clinically, this study aims to increase process performance in healthcare organizations by specifically focusing on length of stay (LOS) performance indicator. Excessive LOS results in costly services and care in healthcare industry (Sandweiss et al., 2013). Using various methods and tools, a great variety of papers focused on how to optimize LOS in various clinical settings in the literature over the last four decades. However, to the best of our knowledge, how LOS of diabetic patients admitted to the hospitals can be statistically monitored

and improved was not analyzed in the previous literature. Essentially, this paper focuses on how to employ control charts in monitoring diabetic patients' LOS performance indicator in two different national healthcare systems and demonstrate how to integrate control charts in decision-making processes for both administrative and medical decision makers. The data used in this study were collected from a teaching and research hospital located in Ankara, Turkey and a 500-bed teaching hospital in Southwest Virginia in the USA. The data collected in the USA contained 11,722 internal medicine patients while the the data collected in Turkey included 24,619 internal medicine patients. From the academic point of view, based on a comprehensive literature review, this study presents an approach that stems from SPC to monitor and improve LOS. From a comparative perspective, the outcomes of the comparison between the U.S. and Turkish healthcare systems enable decision-makers to focus on critical factors that cause differences or similarities for long-term policy making processes.

Keywords: control charts, statistical process control, length of stay (LOS)

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DECISION SCIENCES INSTITUTE

Nonresponse bias in student survey

ABSTRACT

Surveys of students are one of the primary data sources for research in higher education. Student surveys suffer from increasing level of nonresponse. This paper investigated the demographic factors that have contributed to non-responses in Mapworks student survey. The study found that there were significant differences between respondents and non-respondents. Implications for academic administrators are discussed.

Introduction

College and universities have been conducting surveys to understand student experiences, attitudes, satisfaction, and involvement. Institutional researchers regularly use survey data to inform institutional policy (Porter, 2004). Higher education institutions have been pressured to retain students because American universities have experienced a major problem retaining students, especially non-traditional students since the 1980s. Higher rates of student attrition usually lead to greater financial loss and a lower graduation rate for the institutions (Lau, 2003). In order to better retain students, some colleges and universities have relied on the Mapworks retention platform to identify at-risk students, inform and coordinate timely and effective intervention by faculty and staff to reduce attrition rate. University administrations have used Mapworks online survey to collect data about students' perceptions and experiences during their transition to college. The survey was normally used to predict individual student's risk for experiencing academic difficulty within their first year of college. However, surveys of college students suffer from increasing level of nonresponse, as response rates have declined in general population surveys in the United States and worldwide (Groves et al., 2009; Signer, 2006). Given the importance of survey responses, it is necessary to explore the factors/variables that are related to survey non-responses and possible nonresponse bias. Nonresponse bias occurs when systematic differences exist in important variables between respondents and non-respondents (Reio, 2007). High non-response rates often challenge survey validities due to the risk of non-response bias (Lahaut et al., 2003). Nonresponse error posed a very serious methodological threat to mail surveys of college students (Astin, 1970b). At present, there is a limited understanding of survey nonresponse in college student populations and therefore the extent to which survey results may be biased (Kolek, 2012). This paper intends to explore demographic attributes that may affect nonresponse in surveys of college students in order to strengthen our empirical and conceptual understanding of this phenomenon.

KEYWORDS: response rates, nonresponse bias, Mapworks survey, on-campus residence, retention

ON MODELING AND FORECASTING OF NATURAL GAS CONSUMPTION IN RESIDENTIAL AND COMMERCIAL SECTOR

Abstract

Since the deregulation in the mid-1980s, the natural gas industry has been experiencing fundamental transformations across many areas. The supply, demand and prices of natural gas are becoming more volatile and less predictable, which affect natural gas production and sales, and eventually the bottom-line of energy industry. The project aims to develop effective models to improve the accuracy of point forecast of natural gas consumption in the U.S. Based on the U.S. Energy Information Administration (EIA) monthly natural gas consumption data, we establish a parallel method to make a natural gas consumption forecast. The method models the scrape data and ratio data individually in two modules and then combines the outputs of the two modules to generate the forecast. Semi-parametric models are developed to improve the flexibility of natural consumption model and the potential problems of such models are also addressed.

Keywords: Forecasting; Analytics; Energy

NEDSI Conference 2019
Predicting the Winner in a Soccer Game: Which Features Should You be Watching?

Being able to predict the winner of a soccer game has attracted so many insightful applications emerged both from industry and academia. As much as it is a passion for fans, researchers have also been interested in identifying the most important features and/or statistics of the winner team in a game. This research demonstrates the implementation of powerful supervised machine learning algorithms such as random forest (RF), neural networks (NN) and principal component analysis (PCA) on the individual game statistics occurred in the past five seasons of La Liga (Spanish men's top professional soccer league system) to detect the top features that impact the outcome of the game. Towards this objective, we developed a multi-stage methodology that consists of (i) collecting and cleaning the game statistics data on each game in the La Liga in the past five seasons, (ii) eliminating the factors that have direct impact on the final score such as the number of goals scored, penalties secured by home and away teams, (iii) keeping only the game statistics such as the number of shots on target, corner kicks, red and yellow cards conceived, (iv) training the model, (v) predicting the final outcome and deriving the most important features of the winning team.

In addition to implementing pure RF, NN and PCA algorithms, we also tested the combinations of RF and PCA, NN and PCA, and PCA with logistics regression to test the model statistics (sensitivity, specificity, accuracy, etc.). The results demonstrate that some models can get as high as 80% accurate in predicting the winning team. We will also share the potential advantages and disadvantages of the hybrid machine learning algorithms over this case study.

Keywords: Sport analytics, soccer, machine learning, neural network, random forest

BUSINESS ANALYTICS AND KNOWLEDGE MANAGEMENT - PAPERS

Enterprise Social Network for Knowledge Sharing and Learning: Impact of Learner Types and Network Structure

Abstract

This paper studies the use of an enterprise social network (ESN) in facilitating knowledge sharing and learning. Focusing on different types of learners and the network structure in an ESN, we explore how they influence the design of reward systems that motivate workers to share knowledge. This research provides valuable insights for practitioners to implement appropriate reward systems to promote knowledge sharing and learning in ESNs.

Keywords: Enterprise Social Network, Knowledge Sharing, Learning, Reward

Introduction

In the modern economy, digital devices, products, and services have posed new challenges and opportunities for companies, demanding them to seek innovative ways to organize and manage their digital assets.

Social media has been recognized as an effective platform to facilitate firms' communication with their customers and employees to achieve various business objectives. An enterprise social network (ESN) is a specialized online social media platform in organizations that allows employees to form online communities and streamlines connections across different functional departments. Some popular ESNs on the market include Chatter, Connections, Convo, Jive, Kaltura, SociatCast, Socialtext, Tibbr, Workplace, Yammer, and Zyncro (Fee, 2013).

One of ESNs' main applications includes knowledge sharing and learning. The success of applying ESNs in promoting knowledge sharing and learning among individuals highly depends on many different technological, organizational, social, and individual factors (Chin et al., 2015). Although many of these factors are identified and discussed in the literature (e.g, Kwahk & Park, 2016; Oostervink et al., 2016), very few studies have explored the impact of the learners' types on knowledge sharing and learning in ESNs, which is the focus of our research. Specifically, we study how different types of learners and the structure of an ESN affect the design of reward systems motivating knowledge sharing and learning. We next present a brief outline of our analytic model and analysis.

Outline of Model and Analysis

We consider an ESN used by a firm to facilitate knowledge sharing and learning among N knowledge workers. The firm announces a reward to motivate knowledge sharing. Observing the

reward policy, workers share knowledge and learn through the ESN accordingly. Then, they apply their knowledge in their work which benefits the firm. Finally, the firm allocates the sharing rewards to workers based on the pre-announced reward policy.

The ESN is modeled as a network with nodes and arcs in which nodes represent the workers and arcs represent connections between individual workers. We assume that there are many categories of knowledge being shared and learned in the ESN. For a specific category of knowledge, a knowledge worker in the ESN will have either high- or low-knowledge. We permit a worker to be a high-knowledge worker for some categories, but a low-knowledge worker for others. In the ESN, when a high-knowledge worker shares knowledge, all of her followers will receive the notification. In order to describe how the followers may react to such a message, we extend a model of ESNs similar to the one proposed in Sundaresan and Zhang (2018) and differentiate two types of learners in this research: avid vs. impressionable learners.

Avid learners will access the message to review the knowledge shared with them in the ESN. Being the most active participants in the social network, they tend to grasp every opportunity to absorb new information and knowledge available to them. In contrast, an impressionable learner may disregard the message that informs her of the new knowledge being shared, especially if the knowledge is not of interest to them. However, when they receive more notifications, they are more likely to read it. Whether a low-knowledge worker is an avid or impressionable learner, after the learner reviews the knowledge shared with her, she will make a rational and pragmatic learning decision by evaluating the usefulness of the shared knowledge against the potential learning cost. If she learns the knowledge, she becomes a high-knowledge worker in the category.

In addition to the two types of learners, we also model different structures of ESNs in terms of the connectivity overlap in the network. Based on such a setting, we are developing an analytic model and investigating how best a firm should design a reward policy to motivate high-knowledge workers to share their knowledge, while considering the impact of different types of learners and various network structures of the ESN.

Conclusion

Prior research has recognized the important role of ESNs in knowledge sharing and learning, but very few studies have fully explored the design of reward systems in ESNs. Through our analytic model, preliminary results show how the network structure and the dominant type of learners in an ESN strongly influence the design of the reward system for knowledge sharing. Our research will provide valuable insights for practitioners to implement appropriate reward systems to promote knowledge sharing and learning in ESNs.

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Factors affecting Foreign Direct Investment (FDI) from China to U.S.?

1. Introduction

In the next decade, the two sides of the Pacific Ocean will have the strongest economic growth (Fernald and Jones, 2014), the strongest military strength (Fravel, 2008), and the closest trade links (Friedberg, 2005). The economic and political relations between China and the United States are the core of world affairs (Xgyhys1212, 2017). Studying the flow of capital between China and the United States has become very important for the financial world.

Research from the Rhodium Group (https://rhg.com/) shows that in the first five months of 2018, China's foreign direct investment (FDI) in the United States, achieved through acquisitions and other transactions, fell to a negative value. However, in the area of loosely regulated venture capital, China's venture capital investment in the United States reached nearly $2.4 billion dollars between January and May 2018, which is close to its full-year investment record set in 2015. China's capital is flowing to the cutting-edge technology of the United States at a record rate this year.

From 2000 to May 2018, China participated in more than 1,300 rounds of financing for US start-ups, with an estimated total investment of about $11 billion dollars (Hanemann et al. 2018). In 2017, there were 126 example of Chinese capital investment in the United States and 13 mergers and acquisitions involving a total amount of approximately 16.88 billion dollars (RMB 116.32 billion), accounting for nearly 30% of the total investment M&A events of Chinese capital overseas.

The relationship between China and U.S. has entered a new stage. Researchers need to understand what factors affect capital flows between China and the United States. Since data on the capital flow between China and the United States is difficult to find, this paper only collects data on China and the United States' foreign direct investment (FDI), and only considers the FDI from China to U.S..

This paper investigates the impact of a set of domestic and global factors on the level and volatility of FDI from China to U.S.. A panel dataset is used between China and U.S. to measure the impact and significance of **economic factors**, and **social factors.** A simple linear regression model was established to choose the variables which affect the Chinese's direct investment to U.S. After that, we used PCA to combine the variables into two groups in an attempt to reduce the number of dimensions.

2. Literature Review

There are numerous empirical studies dealing with the determinants of capital flow. Some have examined internal and external factors that cause capital flows to surge or drop in market economics (Reinhart et al., 1994). A growing body of literature also focuses on the determinants of different types of capital flows (Taylor and Sarno,1997). We therefore research a number of economic and social factors.

2.1 Military expenditures

Alptekin and Levine (2012) stated that increases in military expenditures supported growth only in developed countries, but did not confirm a negative relationship between expenditures and growth for either undeveloped or developed countries. Hassan et al. (2003) has shown that Military expenditure has significant positive impact in economic growth equation, but a negative impact in FDI.

2.2 High-technology exports

Kogut and Chang (1991） indicated that Japanese-U.S. joint ventures appear to be motivated by the sourcing of U.S. technology. Gilboy (2004) concluded that business and political leaders in the United States feared China's growing shared world exports, especially of high technology and industrial goods, signals, although exports of high-technology had benefits. Competition among the major countries has strongly increased in high technology industries, and their competitive positions have been significantly altered. Because high technology industries play a key role to all economies' long-term economic performance. It shows that the competitive positions of the United States, Japan and the EU countries had changed during the past decades. (Archibugi and Michie, 1998).

2.3 GDP growth

Alvarado et al. (2017） showed FDI has a positive and significant effect on product in high-income countries, while in upper-middle-income countries the effect is uneven and non-significant. However, the effect in lower-middle-income countries is negative and statistically significant. While, FDI plays an important role in contributing to economic growth, but the level development of local financial markets is crucial for these positive effects to be realized. (Alfaro et al., 2000)

2.4 Trade Openness

Peter(2002) showed that some correlations between trade-related variables and FDI turned out to be weaker. Along with Taylor (2000), the authors found that openness to trade and FDI is positively correlated in manufacturing only. According to the econometric results, Demirhan and Masca (2002) suggested that growth rate of per capita, telephone main lines and degree of openness are positive and are statistically significant, along with the negative but significant relationship between FDI and Inflation and taxes.

2.5 Human capital

Noorbakhsh and Paloni (2001) concluded that human capital is a statistically significant determinant of FDI inflows and one of the most important determinants. They suggest human capital's importance becomes more important through time. The authors highlighted the important role of human capital involving a large sample of developing countries.

Borensztein et al.(1997) suggested that FDI is an important vehicle for the transfer of technology. Compared to domestic investment, FDI contributed more to growth. Only when the host country has a minimum threshold stock of human capital, FDI can produce higher productivity for FDI holds. Thus, FDI contributes to economic growth only when a sufficient absorptive capability of the advanced technologies is available in the host economy (Borensztein and Lensink, 1997). Cleeve et al. (2015) showed that all measures of human capital have a significant influence on FDI, as are the traditional variables. While, they also concluded that there is no evidence of the increasing importance of human capital on FDI over time.

2.6 Electricity consumption

Ibrahiema (2015） showed that renewable electricity consumption and foreign direct investment are cointegrated indicating and have a long-run positive effect on economic growth. There exists unidirectional causality running from foreign direct investment to economic growth when using granger causality test. In addition there is bidirectional causality between economic growth and renewable electricity consumption.

2.7 Financial openness

Fratzscher and Bussiere (2004) concluded the size of FDI inflows and the sequencing of the liberalisation process are found to be important driving forces for growth in the medium to longer term, while, financial openness has little effect on the size of FDI flows.

2.8 Broad Money

Kim McPhail (2000) suggested that broad money is a useful indicator of inflation at long horizons and thus a useful monetary policy tool. However, Boateng et al., (2015), contrary to other research Harford (2005), found in a small setting, Norway, that an increase in broad money might lead to FDI reduction The inflation of United States by the government let thousands of American's print money to China, in order to earn huge profit since 1980 because Beijing's fixed exchange rate with dollars. Since the RMB underestimation and Chinese human capital is unimaginable low. (Yevon, 2015)

2.9 Research Question

Based on a brief literature review, we seek to find a better understanding of the key variables that can be an indicator of Foreign Direct investment. Therefore, we develop the following research question:

RQ1: What factors might be indicators of Foreign Direct Investment from China to United States.

3. Methodology

3.1. Data and Descriptive Statistics

A dataset was constructed from datasets obtained from the Bureau of Economic Analysis and world bank for the empirical analysis. The variable of interest is the FDI from China to U.S. 2002-2015. Figure 1 presents an annual chart of FDI from China to the US.

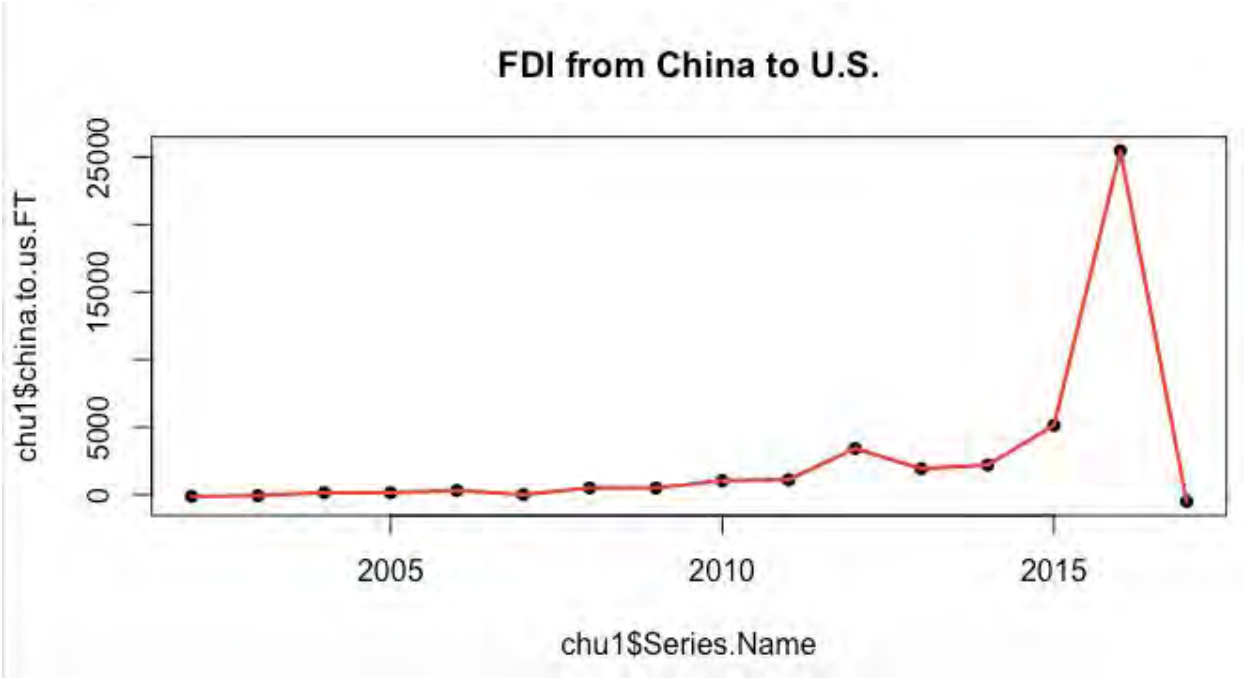


Figure 1: FDI flow from China to U.S., 2002-2017, (Millions of dollars)
Source: https://www.bea.gov/international/di1fdibal

Capital flow increased dramatically from China to U.S beginning around 2015 (5127 million of dollars), but decreased in 2017 （-504 million of dollars). It is believed that Beijing's policy on "Make China rich and strong" is the cause of the increase of 2015. In 2015, the One Belt- One Road Campaign, enacted by the central government in February 2015, established ocean direct investment promotion agencies to facilitate cross-border trade and investment (European Parliament, 2016). More than 20 provinces out of 31 province-level administrative areas expressed strong interest to invest overseas in their governments' annual work reports. (European Parliament, 2016). Much of the decline at 2017 was attributable to Beijing's regulatory crackdown on outbound capital flows. But the growing regulatory hurdles in the US was the second main reason suppressed Chinese investors. (Hamemann and Rosen, 2018)

This paper examines a number of independent variables including China and U.S.'s economic and social factors (see Table 1), with respect to Foreign Direct Investment (FDI).

3.2 Simple linear regression

We built a series of linear regressions to determine which variables might be significant. Since we only have 13 observations, we cannot consider all variables simultaneously. Therefore, we conducted individual linear regressions. However, simple linear regression might not show the relationship between independent variables which multivariate linear regression can indicate.

The dependent variable in each of the regressions is FDI from china to us, and thus simple linear regression models were created to remove the variables which were not significant for the y variable.

Table 1 shows the results of the linear regressions. It is worth noting that military expenditure of China (p-value=0.0658) was not significant at the .05 significance level, therefore, we did not find support for Hassan et al. (2015).

The same held true for trade openness of United States (p-value=0.0509). It was not significant at the .05 significance level, but it is near with the significance level. Considering the statistical mistake, it support the Demirhan and Masca 's (2002) conclusion that degree of openness is positive and statistically significant.

The variable "population in the largest city in China" is not statistically significant since the p-value=0.707. That's surprising because according the article mentioned before about human capital. A minimum threshold stock of human capital has a relationship with the population of large city. The more large population in large city, the lower human capital price. The more inflow FDI for developing countries lead to less FDI outflow.

Industry (including construction) for China (p-value = 0.001202) is a statistically significant for FDI outflow to United States, but Industry for United States (p-value= 0.6345) is not significant to the invest inflow. We need to examine the reason why United States' industry development does not have a relationship to attract investment from China. This is the same to GDP growth of United States(p-value =0.628). Although electric power consumption has a positive and statistically significant relation with the dependent variables (p-value=0.0138).

According Alfaro et al. (2000) who concluded that the development of financial markets is pivotal for positive contribute to economic growth to increase FDI inflow. However, our conclusion is that market capitalization of listed domestic companies (p-value = 0.646 and 0.628, respectively) are not statistically significant both in China and United States. It supports Fratzscher' s results that capital openness has little effect on the size of FDI flows. This might also support by the real broad effective exchange rate of United States (p-value= 0.204).

So we believe that an economically strong China and open trade of US leads to increased investment from Chinese investors. The independent variables significant for FDI outflow from China to U.S. are as follows.

TABLE 1 : Linear Regression for Societal

	China	U.S.

Electric power consumption (kWh per capita)	**0.9882** (0.0002 ***)	**-2.4732** (0.0138 *)
High-technology exports (% of manufactured exports)	-245.1 (0.244)	**-176.81** (0.004167 **)
Industry (including construction), value added (annual % growth)	**-472.5** (0.001202 **)	74.34 (0.6345)
Military expenditure (% of GDP)	-7009 (0.0658 .)	-506.3 (0.597)

(coefficients are in the table and p-values are in parenthesis)

Table 2: Linear Regression for Economic Factors

Difference of Interest Rates between China and U.S.	438.7 (0.0519)	
	China(p-value)	U.S.(p-value)
GDP (current US$)	**3.870e-04** (6.12e-05 ***)	**3.870e-04** (0.000298 ***)
Broad of money	**71.85** (6.18e-05 ***)	**126.87** (0.0103 *)
Trade openness	**-11847** (0.01907 *)	26273 (0.0509 .)
GDP growth (annual %)	**-523.5** (0.00525 **)	131.6 (0.628)
Total Share Prices for All Shares (index 2015=100)	23.58 (0.190)	**61.55** (0.0133 *)
Market capitalization of listed domestic companies (% of GDP)	7.757 (0.646)	19.96 (0.353)
Real Broad Effective Exchange Rate	**98.61** (1.93e-05 ***)	-61.29 (0.204)
Population in the largest city (% of urban population)	-12549 (0.707)	**-5177** (0.000509 ***)

(coefficients are in the table and p-values are in parenthesis) Source: world bank data.

We discovered that some variables do not have tightly relations with direct investment from China to U.S..

Table 3: The following variables were not found to be significant

High-technology exports of China
Industry of United States
Military expenditure of United States
GDP growth of United States
Total share prices for all shares of China
Both market capitalization of listed domestic companies of China and United States
Real broad effective exchange rate of United States
Population in China's largest city

3.3 Principal Component Analysis

Due to the limitations of the number of observations available for regression, we used Principal Component Analysis (PCA) to derive key components and reduce the number of dimensions.

PCA can correspond the variables to directions of maximal variance in the data. This can be performed via a singular value decomposition of the data matrix or through an eigenvalue decomposition if the matrix is a covariance matrix (Aspremont et al.2005).

The principal components analysis can identify a set of variables and synthesize most of the total information to a few factors, usually two or three, which is the latent basis of the variables intercollinearity (Kulcsar,2010).

Olawale and Garwe (2010) use principal component approach to investigated the obstacles to the growth of new small and medium-size enterprises in South Africa. The principal component analysis was used to reduce the variables into five clusters: Financial, Economic, Markets, Management, and Infrastructure from originally thirty variables which were identified as obstacles.

Abdul et al.(2009) discovered that principal components a powerful methods to examine the links between growth and financial development when they re-examines the finance-growth nexus in China, using principal components analysis and Autoregressive Distributed Lag method to cointegration.

PCA allows us to determine the key variables in each dimension. After running the PCA, we found that 89.7% of the variance can be explained by two dimensions. The variables in each dimension and their loadings can be found in the table below(see Table 4)

Table 4: Values of the components and the variance explained

	Dimension 1	Dimension 2
Variance	11.052	3.294
% of var.	69.073	20.585
Cumulative % of var.	69.073	89.658

From Table 4, the eigenvalues, Dim.1 and Dim.2, "cumulative % of var" is 69.073 and 89.077, Since over 80% of the cumulative variance was explained by the two dimensions we can ignore the other dimensions in the PCA (Kulcsar, 2010)

Table 5: Matrix of correlation coefficients between the variables analyzed

Variable	Dimension 1	Dimension 2
dir	0.7157355	-0.58407305
rbexc	**0.9589844**	-0.18916028
bmc	**0.9262968**	-0.06688224
bmu	**0.9267746**	0.06129624
tou	0.7767309	0.56352364
cgdp	**0.9889892**	0.09979988
ugdp	**0.9147294**	0.38620026
indc	-0.7286591	0.47696364
mec	-0.7147877	-0.60472768
epc	**0.9692322**	0.23321995
hteu	**-0.9603366**	-0.05431844
plu	**-0.9553674**	-0.26554546

ggc	-0.6894998	0.63228265
epu	-0.7153185	0.57542364
toc	-0.5928568	**0.73434486**
tspu	0.5743224	**0.66379808**

We named the two group is market situation and business friendly environment. According Table 5, for group 1, there are 8 variables which load on the first dimension in both the positive and negative direction. The variables that includes real board exchange rate of China (rbexc), broad money of China(bmc), broad money of United States (bou), China's GDP(cgdp), United States' GDP (ugdp), electric power consumption of China(epc), high-technology exports of United States (hteu), population in the largest city in United States (plu). We group those variables as a function of market situation. (see Table 6: PCA results)

The High-technology exports of United States shows a very highly negative relationship with foreign direct investment inflow to United states. Because the patent protection of US, Chinese capital has a strong willing to inflow to United States.

Table 6: PCA results

Variable	Market situation	Business friendly environment
rbexc	**0.9589844**	
bmc	**0.9262968**	
bmu	**0.9267746**	
cgdp	**0.9889892**	
ugdp	**0.9147294**	
epc	**0.9692322**	
hteu	**-0.9603366**	
plu	**-0.9553674**	
toc		**0.73434486**
tspu		**0.66379808**

For group 2, kindly shows the business friendly environment. There are two variables which load on the second dimension in the positive direction, including trade openness of China (toc), total share prices for all shares of United States (tspu).

The respective GDP of the United States and China had a positive impact on the amounts of Chinese FDI flows, however, research indicated that the real per capita GDP should have had a negative impact on FDI stocks (Cheng and Ma 2010).

From a strategic United States perspective, imposing additional restrictions on inward FDI from emerging economies, including China, heightens risks that United States firms will be subjected to reciprocal increases in restrictions on investments in the same emerging economies. In this regard, Chinese government authorities have made it known that direct and indirect access to China's domestic market extended to United States-based companies might well be influenced by the legal ability of Chinese companies to make investments in, and construct alliances with, United States-based companies (Globerman and Shapiro, 2009).

For military expenditure of China (mec) , it might mean that no matter which group it belongs, it kinds of negative effect to pull the capital outflow China. Hussain (2012) used military expenditure as percent of GDP as the instrument. The reason is that they believed that military expenditure is strongly correlated with GDP per capita and affects foreign direct investment only through GDP per capita. And they concluded that foreign direct investment has no relationship with military expenditure.

Figure 2: Variables factor map for PCA

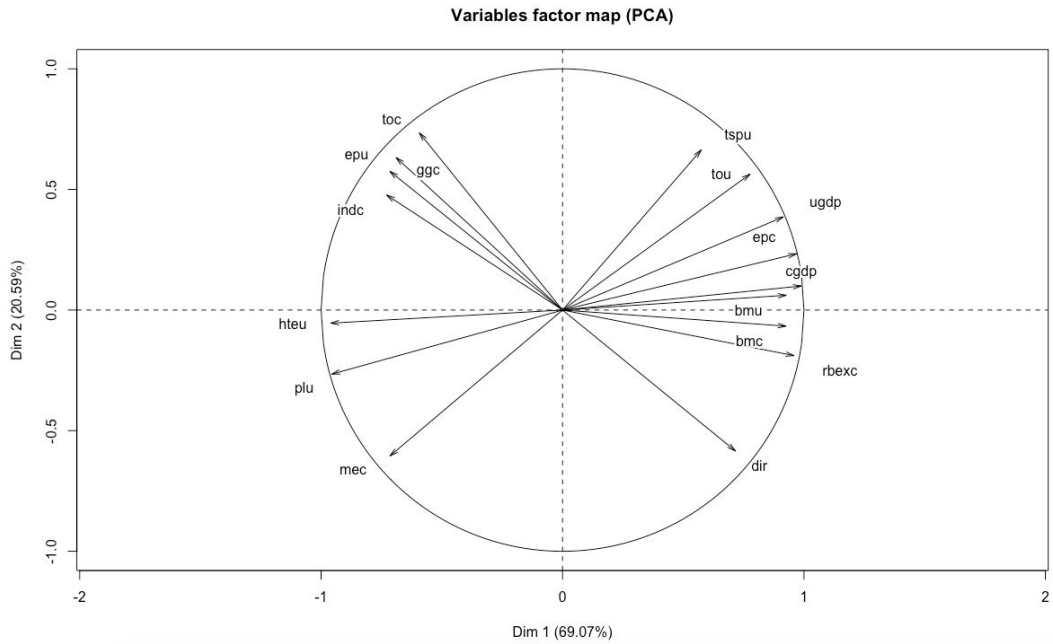
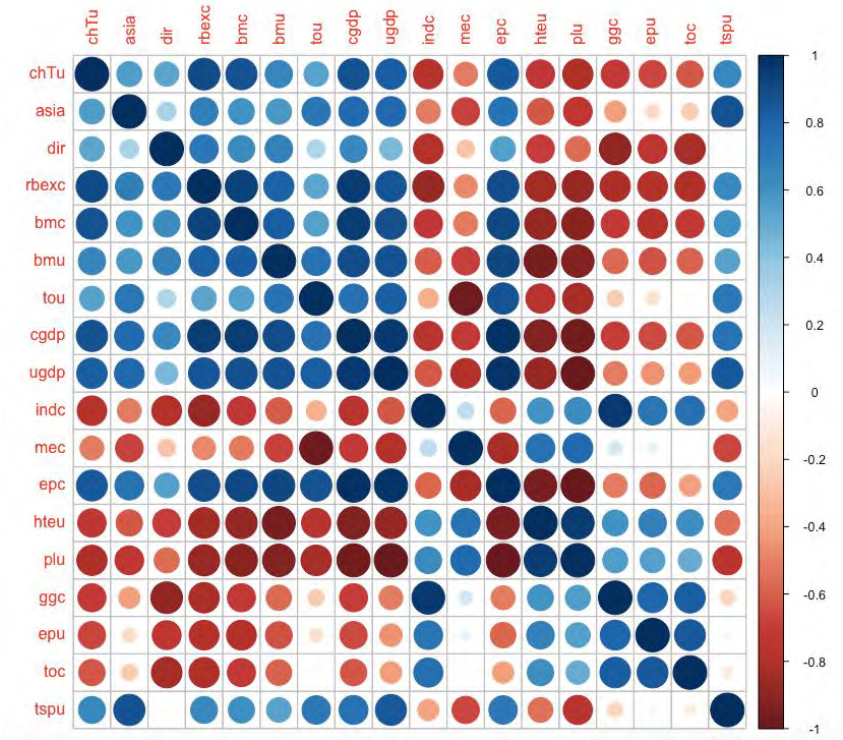


Figure 3: correlation plot for variables



4. Limitations

The research shows as expected a high correlation between many of the variables. If we suppose that the variables which are correlated with FDI from China to United States is >.5, we find all the variables are related with the dependent variables. The most positive variables are real broad effective exchange rate of China, board money of China and China's GDP and electric power consumption of China. It also highly negative correlated with population in United States's largest city and high-technology exports of United States.

Table 7: Correlation of FDI from China to U.S. with variables

	China to US	Asia and Africa to US
China to US	1.000	0.497
Asia and Africa to US	0.497	1.000
dir	0.571	0.264
rbexc	**0.820**	0.650
bmc	**0.822**	0.526
bmu	0.711	0.530
tou	0.721	0.740
cgdp	**0.875**	0.740
ugdp	0.797	0.758
indc	-0.692	-0.421
mec	-0.667	-0.691
epc	**0.845**	0.736
hteu	**-0.807**	-0.582
plu	**-0.816**	-0.692
ggc	-0.657	-0.312
epu	-0.661	-0.187
toc	-0.462	-0.111
tspu	0.502	**0.852**

Due to the limited number of observations, yearly data points, we ran a number of simple linear regressions to determine the predictive effects of each variable. This method might not show the complex relationship between the independent variables when using multivariate regression model. Also, the components which affect the FDI from China to United States are complex and varied, we cannot list all the variables and the political situation between the two giant countries.

In addition, world economic measures and stability might also affect capital flow and need to take a notice. Our aim in the future would be to examine these metrics as a factor of investment. However, the data on the other important determinants, like labor costs and the capital flow flight to United States may be considered as another limitation of our study. Thus, all above are the points that can be improved further by availability of data and a better multivariable analysis model.

5. Conclusion

This paper mainly focus the driving variables of FDI from China to United States, during this increasing speed China's capital flows. We use simple linear regression model to remove the variables which are not significant to the dependent variable, and then we use PCA method to correspond the independent variables into two groups. Group 1 shows the market situation, and group 2 indicated the business friendly environment between the two countries.

Among all the indicators, we find that market situation is the most critical determinant of the foreign direct investment from China to United States. A stable macroeconomic environment, such as low and stable inflation can attract investors, while better financial institution of foreign direct investment may not be statistically significant.

As our analysis indicates, high-technology is a important situation to attract capital flow to United States. In the next ten years, China will continue to invest in military power, high-tech companies, such as planes, large warships, semiconductors, aerospace systems and artificial intelligence, in order to enhance the "national hard power", and therefore, might increase investment in the United States. However, in the next decade, one of the biggest factors, might not be economic, but political, especially geopolitics, which will affect large investments, and how the larger macroeconomic variables are affected by the political environment. Therefore the FDI, could be impacted by the the changing political winds.

Datasets used:

Real exchange rate
https://fred.stlouisfed.org/series/RBCNBIS

Direct Investment by Country and Industry,
2017https://www.bea.gov/data/intl-trade-investment/direct-investment-country-and-industry

Stock market capitalization
https://data.worldbank.org/indicator/CM.MKT.LCAP.GD.ZS?view=chart

Capital account openness index taken from Chinn-Ito Index
http://web.pdx.edu/~ito/Chinn-Ito_website.htm

Interest Rates, Discount Rate for China
https://fred.stlouisfed.org/series/INTDSRCNM193N#0

FDI from China to US:
https://datacatalog.worldbank.org/dataset

Human capital index
https://datacatalog.worldbank.org/dataset/human-capital-index

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PROBLEMS AND OPPORTUNITIES IN QUALITATIVE RESEARCH: A CRITICAL PERSPECTIVE IN BUSINESS ANALYSIS

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Abstract:

The acceptance of qualitative research in the realm of overwhelming quantitative research studies is indeed a hard process and requires intense explanation, justification, and analysis (MSW & Laura N., 2015). The objective of this critical analysis is to address three factors that make the qualitative research approach more suitable to analyze the education field in social aspects. More precisely, this comparative analysis addresses the similarities and differences between quantitative and qualitative approach and key defining factors of qualitative research in studying the educational growth in a community and a power disparity relationship in qualitative research studies. Finally, this study focuses on two major concerns for conducting qualitative research, such as ethics and credibility. Finally, this study recommends that both qualitative and quantitative research practitioners will be benefitted from developing a mutual understanding for each other, research design, techniques, and perspectives and find efficient ways to connect and to work collaboratively to tackle the misunderstandings and miscommunications.

Keywords: Issues in Qualitative Research, Power disparity relationship in qualitative research studies, Research Practitioners, Policy Makers.

Introduction

In general, a qualitative research method consists of systematic observations, interviews, case studies, surveys, background studies, and historic document analysis in order to find a social behavioral pattern(s), certain attainment gap(s), and/or any relevant issues that match with the objective of the study. Qualitative research is enriched with certain trademarks as it does not try to alter the settings and most of the time it does not intend to manipulate the natural environment in order to conduct the research. The questionnaires are environment-specific and try to address the issues at hand as accurately as possible with rich description and adequate information. Finally, the objective of qualitative research is to understand the settings as deeply as possible in order to conduct the study more effectively and efficiently.

The acceptance of qualitative research in the realm of overwhelming quantitative research studies is indeed a hard process and requires intense explanation, justification, and analysis (MSW & Laura N., 2015). The objective of this critical research study is to address three factors that make the qualitative research approach more suitable to analyze the education field in social aspects. More precisely, this research study addresses the similarities and differences between quantitative and qualitative approach and key defining factors of qualitative research in studying the educational growth in a community and a power disparity relationship in qualitative research studies. Finally, this research study addresses two concerns for conducting qualitative research, such as ethics and credibility of the study. This research study recommends that both qualitative and quantitative research practitioners will be benefitted from developing a mutual understanding for each other,

research design, techniques, and perspectives and find efficient ways connect, and to work collaboratively to tackle the misunderstandings and miscommunications.

Qualitative Research: A Critical Perspective

Maxwell argues that the quantitative research method for causal investigation could be a better fit when there are no qualitative elements associated with the study and meet the following three conditions. These three conditions are,

“

a. First, there should be a well-developed theory that informs the intervention and research design and allows interpretation of the experimental results.

b. Second, the causal process investigated should be manipulable, straightforward and simple, and relatively free from temporal and contextual variable

c. Third, the situation should not be conducive to the direct investigation of causal processes ” (Maxwell, 2004, p9).

While all the above-mentioned conditions could be met in biology and medical research, but in the field of education, it is quite difficult to meet these conditions. The background setting of each situation is so diversely different. For example, the social structure in Bangladesh based on religious belief and social class varies so significantly that to understand the true obstacles that cause gender disparity in education one set of the experiment does not capture the true meaning in different communities. There are significant contextual variability exists and it is needed to be addressed appropriately via

qualitative research in order to address the main reasons. After that, it will be easier for the policymakers and Changemakers to design and develop solutions to reduce the problematic scenarios.

Furthermore, Bangladesh is currently hosting a significantly large number of Burmese refugees, and they are lacking proper access to education and health care. But this situation is much more contextual-based and to understand their problems the research setting needs to be more contextual grounded in the religious and cultural background. As Maxwell argues that, "In such situations, qualitative methods have distinct advantages for identifying the influence of contextual factors that can't be statistically or experimentally controlled, for understanding the unique processes at work in specific situations, and for elucidating the role of participants' beliefs and values in shaping outcomes" (Maxwell, 2004, p9). In contrast, qualitative research suffers from certain issues as well. For example, while studying educational attainment for the Burmese refugees in Bangladesh, the researchers are strongly advised to have an open and expanded view of the human subjects. Secondly, getting ongoing consent from human participants while conducting a qualitative study is also very important. Finally, interpreting the qualitative study interaction between the qualitative researcher and the human subject might get blurred due to personal biases and might risk the objective of the study. So, the researchers need to be careful about these ethical concerns and address them accordingly based on the current condition (Alvesson & Sköldberg, 2017; Bailey & Bailey, 2017; Bernard, 2017; Lindlof & Taylor, 2017; Manen, 2016; Maxwell, 2004).

Power dynamics also play an important role in determining the quality and maintaining the objectivity of the qualitative research. Most of the times, the marginalized participants do not feel comfortable sharing their true concerns and feelings with the researchers/interviewers if there are unequal power relationship present. As Jelsma describes this situation in the following manner, "Unequal power relationships might make it difficult for the participants to withdraw from the study. It is incumbent upon the researcher to actively flatten the power gradients and ensure that the subjects can freely exercise choice regarding their continued involvement in the study. For example, students might not feel free to express their preferences if interviewed by one of their lecturers" (Jelsma & Clow, 2005, p.5). This study supports the idea of reducing the power disparity between researchers and the participants while conducting the qualitative study in order to get a more accurate picture of the ongoing situation. It would make the study more appropriate, situation-based, and realistic. Although Jelsma argues that power disparity is a bigger issue for conducting qualitative approach, I would say that regardless it is qualitative and/or qualitative research, we always need to maintain such an overall approach in the study where the power ingredients are as suppressed as possible in order to maintain the integrity of the study (Brannen, 1995; MSW & Laura N., 2015; Yilmaz, 2013; Yin, 2015).

Conclusion and Final remarks

In conclusion, there are always ongoing confusions and miscommunications between qualitative research and quantitative research methods. It hurts the research settings as well as the objective of the study. Maxwell aptly summarizes this problematic situation the

following manner, "For this to happen productively, practitioners of both approaches will need to develop a better understanding of the logic and practice of the other's approach, and greater respect for the value of the other perspective. Thus, Our argument is directed to qualitative researchers who deny the legitimacy or relevance of experimentation or causality for education research as well as to quantitative researchers who dismiss or distort the potential contributions of qualitative research to the task of developing causal explanations" (Maxwell, 2004, p.9). Our primary objective of this research study is to address a few key issues associated with qualitative research, such as an ethical dilemma, power disparity, and credibility issues. Further issues are also associated with qualitative research. It does not mean that qualitative research is specifically focused on one major study or field and cannot be implemented in any other field of studies. It is better to understand the shortcomings of both qualitative and quantitative research methods comprehensively. This will help both types of research practitioners to understand each other's point of views, perspectives and research settings. Ultimately, this will result in a more robust, efficient, and effective research design settings that will be able to address the variability in settings and integrate those factors more suitably into the study. This will provide more equality and equity-based research setting and would significantly reduce the hierarchical dominance of either perspective from a quantitative or qualitative approach.

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SMALL COUNT DATA AND OUTLIER ANALYSIS: AN EXPLORATORY STUDY OF PATIENT SAFETY

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INTRODUCTION

There has been increased interest on more accurately modeling count data (Du et al, 2011; Plan 2014). Analyzing count data more accurately can lead to better conclusions in medical care, such as reducing costs, improving patient safety and increasing quality. Small count data represents significant problems for analytics in any field, due to the restrictions of using discrete probability distributions. In the healthcare industry, small count data represents critical and often life threatening events.

We obtained a data set that contains information on retained surgical device count at various hospitals in NY state. We examined the data to determine the exact distribution of data. Further, using a variance difference method we examine the outliers and posit their possible effects on individual groups within the data set. Finally, we examine group differences using non-parametric tests and provide a rationale for using these tests.

LITERATURE REVIEW

Patient Safety Indicator for Retained Surgical Device

The Centers of Medicare and Medicaid Services (CMS) refers to and includes in their quality rating metrics a Patient Safety Indicator (PSI) for Retained Surgical Device. The program determines penalties and fines given to hospitals. The PSI are a set of indicators providing information on potential in-hospital complications and adverse events following surgeries, procedures, and childbirth. The government includes PSI 05 RSD in this program as a significant preventable healthcare event.

Retained surgical devices (RSD) are foreign objects unintentionally left in a patient after surgery or other procedure. Objects include surgical sponges, broken parts of instruments, stapler components, parts of laparoscopic trocars, guide wires, catheters, needles and instruments (Sentinel Event Alert, 2013). Retained surgical devices (RSD) often result in significant patient harm that involves reoperation, readmission/prolonged hospital stay, sepsis, bowel obstructions, visceral perforation, and death (Gawande et al, 2003; Steelman et al 2018).

Collecting data for large RSD studies has been difficult due to miscommunication as to when and if the event occurs. The severity of medical and legal implications may prompt inaccurate medical coding or purposeful non reporting (Bowman, 2013). For example, research indicates that approximately 4,500 to 6,000 surgical item cases occur annually in the U.S (Gluncic et al. 2013), RSD events occur in 1:5500 surgeries (Cima R.R. et al, 2008) and RSD occur in approximately 1 per 1,000 abdominal operations (Stawicki, 2013).

Outliers

Outlier analysis and identification is important to ascertain observation points that influence assumptions of parametric testing and then managing the outliers to reduce bias on summarized results. Outliers may occur by chance in any distribution, but they often indicate data entry and ensuing measurement error, heavy-tailed distribution or by the presence of a unique population (Leys et al., 2013). When the sample size is small the effect of outliers could be more pronounced (Cousineau and Chartier, 2010).A number of methods have been proposed to screen for outliers, and many of these methods have been shown to sensitive to sample size, skew of the distribution, and arbitrary selection of cutoff criterion (Miller, 2010; Van Selst and Jolicoeur, 1994).

METHODOLOGY

We obtained a dataset from the New York government health website (https://health.data.ny.gov/Health/All-Payer-Patient-Safety-Indicators-PSI-Volume-Mea/ge6u-uxxf/data). The data set titled *"All Payer Patient Safety Indicators (PSI) Volume Measures by Hospital: Beginning 2009"* includes two PSI count data. The two PSI's are, PSI 05, retained surgical item or unretrieved device fragment count, and PSI 16, transfusion reaction count. The data includes reported counts for the years 2009 through 2016.

The downloaded data set was filtered to include only records associated with PSI 05. The number of hospital discharges with a retained surgical item or unretrieved device fragment (secondary diagnosis) among surgical and medical patients ages 18 years and older or obstetric patients (www.qualityindicators.ahrq.gov).This count does not include patients returning to surgery that had not been discharged, returning to the hospital as the primary reason for return, or those patients who are unaware of the issue.

For this study, only the last three years, 2014-2016, of data was analyzed. Our choice of limiting the analysis is based on the effort and investment in quality programs, and safety processes to reduce the number RSI cases over the last few years. We determined that the period of 2014 - 2016 is a valid time frame for assessing the current state of the problem. T

ANALYSIS

Distribution Identification

One goal was to identify the possible distribution of the data at the individual region level. Each observations represents the number incidents that occurred in a given hospital, and these observations are then grouped by regions. We first try to accurately determine the distribution of the data with the ultimate goal of the analysis to determine if a single incident within the data set should be included or removed as an outlier. Using the data available, we analyzed the incidents and compared them to the described theoretical distributions (Table 1).

Count	**Observed**	**E[X] - ZTP**	**E[X] -ZTNB**
1	96 (.744)	86 (.667)	88 (.682)
2	24 (.186)	37 (.287)	28 (.217)
3	5 (.038)	4 (.031)	10 (.077)
4	4 (.031)	2 (.015)	3 (.233)
χ^2		4.717 (p=.85)	4.082 (p=.90)

Table 1: Table of Observed Probabilities and Theoretical Probabilities

Examining the χ2 against the actuals, the zero-truncated negative binomial distribution appears to the best fit, since it has the lowest significant χ2 value. One concern that needs to be more closely examined is the possibility for underdispersion, i.e. mean greater than the variance.The Zero-Truncated Negative Binomial is an appropriate distribution in healthcare analytics and has been used in mental health statistics for patient visits (Eihai, et al., 2008) , race and stroke readmission (Kennedy, 2005), and outliers in patient outcomes (Stylianou et al., 2017).

Identifying outliers

Next, we seek to identify outliers in the dataset to approach the issue of outliers. Outliers are observations considered to be very different or deviate from other observations significantly. Similar to the issues raised above regarding dispersion, outliers can also cause misleading analysis or improper predictions (Pelaez et al., 2018). Outliers can come about from simply a difference between the other observations or signal that a particular observation or observations were the result of something different, from which the data was collected (Grubbs, 1950; Hawkins, 1980). Identifying and proper removal of outliers will yield different results in most cases and are thus indicative of more appropriate results (Grubbs, 1950).

Using the variance difference method (Pelaez et al., 2018), we aim to identify the difference in results obtained by remove outliers from the healthcare dataset. The primary objective is to narrow outliers identified using the inner fence method, which maybe too conservative, and the

outer fence methods. The negative binomial distribution is small count data distribution with differences in observations around 1 or 2. In the case of the current data, the range of observations is from one to four.

Region	**Total Incidents**	**97%**	**98%**	**99%**	**Tukey Outliers**
Central NY	21	1	0	0	5
Kings	12	0	0	0	0
Manhattan	19	0	0	0	1
Western NY	17	0	0	0	4
Total	**69**	**1**	**0**	**0**	**10**

Table 2: Outliers identified by method (Variance Difference and Tukey)

Table 2 provides the quantity of possible outliers at the various levels of the Chi-Square distributions for selected regions. The last column contains the number of outliers identified using the Tukey, inner fence, method. Overall, for each region the Tukey method identified 10 outliers, while using our proposed method, only 1 outliers were identified. In the instances where the variance difference method suggest not removing outliers, while the Tukey method does, more analysis on these observations may be warranted. As such, quality programs and development of cost metrics based on small count data set may benefit from comparing various outlier approaches.

CONCLUSION

The data observations included in this study are those reported to NY state patient safety. Medical providers might fear adverse consequences as a result of "full disclosure" with potentially, public records such as discharge abstracts. Therefore, incomplete reporting is an issue when examining the results for accuracy of count.

Small count data is vulnerable to removal of outliers (Cousineau and Chartier, 2010). Generally, statistical analysis removes outliers based on the interquartile range, and is independent of the parameters of the distribution. In small count data sets, even if n is large, this may not perform adequately.

This study reports only on New York State hospitals and future studies might apply the variance difference method and compare the outliers analysis to a different study of hospitals in the United States. In addition, most government required reporting of PSI data are (PSI) are

reported as a rate value. The methodology presented in this study may be developed and extended for rate data.

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THAT MESSAGE WENT VIRAL?! EXPLORATORY ANALYTICS INTO THE PROPAGATION OF TWEETS.

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Abstract:

Messages on platforms such as Twitter have become the default mode of company communications replacing lengthier public announcements and updates. Businesses and organizations have increased their use of Twitter to connect with stakeholders. As a result, it is important to understand the key drivers of successful information exchange and message diffusion via Twitter. We conducted an exploratory analysis on a dataset of over a million Tweets. We identified the most popular messages and analyzed them using exploratory and textual analytics. We found some interesting patterns and uncovered new insights to help us understand tweet behavior, which are presented here in this paper as a small extracted part of a larger research project on the same topic.

Key Words: Tweet Analytics, textual analytics

Introduction

Much has already been written about the popularity and ubiquitous nature of Twitter. Twitter has a global presence and influences a variety of important issues and events including election results, consumer confidence, brand development, crisis communication, day to day social interactions and much more. From a behavioral analysis standpoint, the efficacy of information influence has been mapped to the nature of the information artifact (Samuel, 2017) and this has meaningful implications for how information is presented, interpreted and used. Past research has studied Tweet phenomena from a variety of perspectives including the analyses of specific users, topics, and markets. Studies have also focused on case scenarios (Pressgrove, et. al., 2018; Kalsnes, B., & Larsson, A. O., 2017), while examining the type of news propagated

(Vosoughi, S., et. al., 2018; Wahba, G., 2017), and the extent of information richness (Samuel & Pelaez, 2017). However, past studies have lacked integrative frameworks and necessary theoretical abstractions. Hence, despite their intrinsic value, they highlight an urgent need to study viral information through the lens of appropriate theoretical frameworks (Alter, S., 2017).

Literature review

Twitter's reach is global and there is a strong interest in using tweets from thought leaders and influencers, including government leaders (Weller, et. al., 2014; Dubois, et. al., 2014;). One of the ways in which Twitter data is analyzed includes estimating the 'sentiment' associated with a message – past research has used sentiment analysis to observe patterns in stock price movements and observed that the sentiment of tweets was related to the stock market dynamics (Kretinin et al., 2018). Machine learning and intelligent analytics can help reduce time to gain insights (Samuel et. al., 2018). We expect our analysis to help us identify valuable insights from exploratory analytics, sentiment analysis and textual analytics. The present research stream intends to explore the many tweet associated variables that have the potential to make tweets go viral, and to identify factors that evoke emotion and interest when new messages or information in the form of tweets become available.

Tweets can also become popular based on the "information richness" they display – this includes the use of special characters, pictures, links and visual or semantic enrichment of the core message. Information richness has been shown to be an important cognitive influence (Samuel & Pelaez, 2017) with potential to sway how users respond to tweets. Furthermore, tweets can also be viewed as categories or information modules with specific properties. For instance, stock market tweets, sports tweets, funny tweets, political tweets, official tweets, trivia and other such categories are bounded by the objective of categorization. Information categories, even with the same net information content, can have varying influence on users (Samuel, et. al., 2017).

Research Objectives

- Our research objective with the present study is to provide early stage insights into the characteristics of viral tweets.
- We also aim to identify key variables that can be associated with viral tweets.

Methodology

We used two twitter accounts to download Twitter Status IDs, Twitter User IDs, and number of recounts, among a number of variables. At our starting point of our analysis we collected over a million tweets with over eighty variables. We used MySQL to store the raw Twitter data and 2 Different R scripts were written, which leveraged the `rtweet` package and the `RMySQL` packages.

Tweet Characteristics

When a request is made to the Twitter API, by default, Twitter will provide over 80 different characteristics regarding the tweets requested. We analyze Twitter variables to gain insights into the various information and social dynamics between and about users on Twitter. These tweet characteristics are categorized into types of tweet-specific information and user-specific information. Table 1 offers a summary of the most relevant tweet and user characteristics that we found important in relation to our research questions and objectives. Given that our research was primarily exploratory, we first defined our intended population of interest, designed a data-gathering process, designed code to clean the data once it was fully gathered, and then ran an exploratory data analysis.

Tweet Variable Name	Description
user_id	A unique identification number of the twitter user.
status_is	A unique identification number for the specific tweet, retweet, or quote.
created_at	The timestamp of creation for the tweet.
text	The actual text of the tweet. This will contain text, hashtags, and urls.
source	The type of device from which the tweet was generated. Many possibilities can be assigned here. For example, "Twitter for iPhone" is one example.
display_text_width	The number of characters of the tweet that can be seen by the user.
favorite_count	The number of "likes" for this specific tweet.
retweet_count	The number of times this tweet was retweeted by other users.
hashtags	A list of hashtags that were used within the tweet.
media_type	An indicator to determine if the tweet had a photo embedded within it.
lang	The language of the tweet.
location	The location of the user account.
follwers_count	The number of followers that this user currently has.
friends_count	The number of users that this user follows.
listed_count	The number of public lists for which this user is a member.
statuses_count	The total number of tweets,retweets, or quotes that this user has posted.
favourites_count	The total number of tweets that this user has "liked".
account_created_at	The timestamp of the creation of the user's account.
verified	An indicator variable to determine if Twitter has verified this user's account information.
account_land	The language of the user.

Table 1: Selected variables within a processed response from the Twitter API.

Exploratory Analytics

A descriptive analysis was conducted, which reported the measures of central tendency, dispersion, and other moment information. The results for the numerical variables are shown in Table 2. Our final data set for analysis comprised of over 1000 unique and distinct tweets. Almost all of the tweets in the data set were created within Fall of 2018, during the time we were collecting information. Most tweets tend to occur at the beginning to the middle of the month. In addition, there are significantly less number of tweets during the middle of the day.

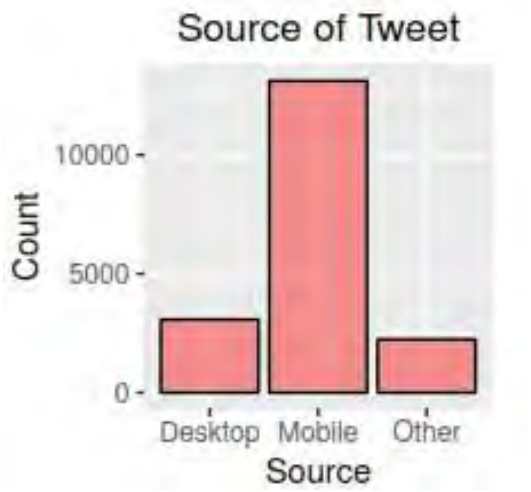

Figure 2

We also notice that most of the tweets originated from a mobile device rather than a more traditional desktop. Last, we notice that the highest tweet activity seems to occur from Tuesday to Thursday, during the heart of the work week. This would seem to indicate that most Tweets are posted and retweeted during the middle of the work week.

Results

The number of users that a user follows, their chance of being retweeted is greater than the contribution to retweets from the number of followers. That is, it is more beneficial for an account to connect with other users by "following" than it is to seek "followers". We also notice that the number of favourites the user liked negatively impacted the number of retweets. These observations are unique and interesting and warrant additional research into associated causalities.

Conclusion

Our research has the potential for providing unique insights for understanding the viral nature of tweets which can be used by organizations to develop policies to support the development of best practices in disseminating information using Twitter. Future research can certainly be guided by our unique findings. As a result of our research, we propose additional research questions that would be addressed within future research – How would time-dependent effects be used to further explain and measure the construct of viral tweets? Does there exist a better lexicon, which is currently not being leveraged which would more appropriately describe the overall emotional sentiments of tweets? How would time-dependent effects on sentiment affect viralness. Furthermore, do there exist any interaction effects among the variables we have identified, and if so, what is the theoretical justification underlying these? In addition, we have not studied our construct of viralness from a network perspective. Which network structural characteristics impact viralness? Would these interact with the variables we have identified in this research?

These briefly stated findings which help us understand tweet behavior, are presented here in this paper as a small extracted part of a larger research project on the same topic.

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UNIX ADMINISTRATOR INFORMATION SECURITY POLICY COMPLIANCE: THE IMPACT OF KNOWLEDGE SHARING INTERVENTIONS ON TRUST, BIAS, THREAT APPRAISAL, AND COPING APPRAISAL

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2019 NEDSI Annual Conference

Philadelphia, PA

April 4-6, 2019

Abstract

Information security policy (ISP) compliance is crucial to the success of organizations due to the evolving security threat landscape and the potential for significant financial loss resulting from security breaches. UNIX systems administrators build and secure infrastructure that supports critical organizational business processing and their compliance with ISP is crucial to the confidentiality, integrity, and availability of these servers. Unfortunately, some UNIX administrators perceive evolving threats to be primarily directed at Windows servers and Windows users which may lead to incomplete or inconsistent implementation of ISP on critical servers. A great deal of information security compliance research has focused on end-user compliance with ISP, however, UNIX systems administrator ISP compliance remains to be an area of limited research. This study will fill that gap by helping to understand the antecedents to UNIX systems administrators' compliance with ISP. The goal of this study is to evaluate the effect of organizational knowledge sharing, in the form of security, education, training, and assessment workshops on the trust, bias, threat appraisal, coping appraisal and ultimately ISP compliance of UNIX systems administrators.

Keywords: SETA, knowledge sharing, ISP compliance

Research Problem

Most research in information security policy (ISP) compliance has focused on the end-user compliance intention and compliance behavior (Albrechtsen, 2007; Hanus & Wu, 2016; Kraemer & Carayon, 2007). While end-users are critical to organizations reducing the threat of information security breaches, another group of specialized users has the highest privilege levels and legitimate access to the vast amount of confidential data stored on their systems—server systems administrators (Kraemer & Carayon, 2007). Systems administrators are super users on servers and are responsible for operating system installation, configuration, patching, user management, monitoring, data backup, implementation of security controls, disaster recovery, and testing (Calder & Watkins, 2009). Common information security threat vectors include network, security, or operating system misconfiguration, unpatched operating systems or device firmware, privileged account access, and unsecured data or backups (Donaldson, Siegel, Williams, & Asalm, 2015). These vulnerabilities demonstrate the importance for server administrators to consistently follow organizational ISP (Renaud, 2012).

The research problem that this study will address is that some UNIX systems administrators (UXA) fail to completely implement organizational ISP leaving servers open to potential systems disruption, loss of proprietary or confidential data, harm to organizational reputation, potential loss of revenue, or financial loss due to litigation or fines (Donaldson et al., 2015; Kraemer & Carayon, 2007). This research is needed as implementing security is key to the successful protection of organizational assets (Ng, Kankanhalli, & Xu, 2009); therefore, it is crucial that systems administrators comply with ISP to reduce the frequency of loss due to breaches (Donaldson et al., 2015).

The main goal of this research is to empirically assess how organizational information security knowledge sharing processes influence UXA knowledge of security vulnerabilities and their severity, information security response-efficacy, information security self-efficacy, and ultimately compliance with ISP. Additionally, this research will seek to understand how affective-based and cognitive-based trust moderate the relationship between security knowledge sharing and UXA threat appraisal and coping appraisal. Finally, the present study will assess if UXA cognitive biases impact threat appraisal and how the knowledge sharing intervention impacts those biases.

Literature Review

Information security knowledge is frequently scattered throughout organizations, and many organizations have not developed an effective information security knowledge sharing program (Flores, Antonsen, & Ekstedt, 2014; Ifinedo, 2014). Organizational silos, where there is a rigid functional division between teams, can negatively impact social interaction and knowledge sharing (Oparaocha, 2016). Unimplemented or partially implemented information security policies and controls may leave organizations open to potential systems disruption, loss of proprietary or confidential data, harm to organizational reputation, and potential loss of revenue (Donaldson, et al., 2015; Kraemer & Carayon, 2007). In 2018, the worldwide average cost to an organization for a single data breach was $3.86 million, and in the United States the average cost was $7.91 million which included the costs of detection, notification, response, and lost customer revenue (Ponemon Institute, 2018).

Human factors have gained prominence as a significant risk factor for information systems security (Colwill, 2009; Ifinedo, 2014; Safa, Sookhak, Von Solms, Furnell, Ghani, & Herawan, 2015). To strengthen the human aspect of information security, ISPs were developed that enhance security and decrease vulnerability to security breaches (Furnell & Clarke, 2012; Ng, et al., 2009). Unfortunately, researchers have found that employees frequently circumvented ISPs when workload increased (Albrechtsen, 2007; Guo, Yuan, Archer, & Connelly, 2011; Kraemer & Carayon, 2007) or when they felt the ISPs were a nuisance (Renaud, 2012; Sedighi, van Splunter, Brazier, van Beers, & Lukosch, 2016). Siponen, Mahmood, and Pahnila (2014) identified employee failure to follow ISPs as a key threat to the security of an organization. An additional risk is that employees can make errors due to cognitive limitations, task demands, or other organizational, social, or environmental factors (Dismukes, Berman, & Loukopoulos, 2007; Safa & Von Solms, 2016). Most of these studies have evaluated end-user ISP compliance. Compliance of UXA, however, is even more significant as the data housed on the back-end UNIX servers may contain protected health information (PHI), personally identifiable information (PII), financial data, or intellectual property.

Several key theories have been used to assess and predict information security compliance behaviors. Ng et al. (2009) integrated the theory of planned behavior (TPB), healthcare behavioral theory, and expectancy-value theory to create their framework. Siponen, Pahnila, and Mahmood (2010) integrated protection motivation theory (PMT), deterrence theory, theory of reasoned action (TRA), diffusion of innovation theory, and rewards theory to predict

compliance behavior. Siponen et al. (2014) integrated the TPB, TRA, cognitive evaluation theory, and PMT to understand user's intention to comply with policy. Ifinedo (2012) combined PMT and TPB to assess employee compliance with ISP. While all these theories help to predict compliance behavior another key component may influence behavior and perception: cognitive bias (Kahneman & Tversky, 1973; Tversky & Kahneman, 1974). Kahneman (2011) referred to the two cognitive systems of decision making as System 1 and System 2. System 1 is an intuitive system, implicit, involuntary, and nonverbal cognitive system (Kahneman, 2003). The intuitions provided by System 1 come to mind quickly with little reflection (Evans, 1984). Intuitions, due to their reliance on similarity and associative frequency rather than true probabilities, can be flawed due to inappropriate use of heuristics or cognitive biases (Kahneman, 2011; Tversky & Kahneman, 1974). System 2, the reasoning and analytical system, is where deliberate thought occurs (Kahneman, 2011). System 2 is activated whenever a problem presents itself to which System 1 cannot provide a reasonable answer (Kahneman, 2011). System 2's responsibility is to monitor System 1 to ensure correct decisions are made (Kahneman, 2003). To reduce cognitive load, however, System 2 may accept faulty System 1 responses due to "lazy monitoring" (Kahneman, 2011). Kahneman's work has had significant influence on the finance industry in researching investment decisions, but using his concepts in the information security area, to the author's knowledge, has been limited. Building on Kahneman's (2011) heuristics and biases work, this study will also assess how cognitive bias may influence UXA decision regarding their security threat appraisal.

The sharing of information security knowledge, experience, and insights can improve organizational performance and help to ensure the confidentiality, integrity, and availability of data (Safa & Von Solms, 2016). Unfortunately, some information security professionals consider security knowledge to be personal property, and they may be reluctant to share that information with others in the organization (Belsis, Kokolakis, & Kiountouzis, 2005). Development of a formal governance structure for information security knowledge sharing can help to foster sharing of ideas, experiences, tools, and processes to improve security and protect an organization's information systems assets (Flores, et al., 2014). Making users aware of the current and evolving information security risks, threats, vulnerabilities, and their severities, the speed with which the threats propagate, and the potential impact to the organization is crucial to information security policy compliance (Guo, et al., 2011; Safa, Von Solms, & Furnell, 2016;

Siponen, et al., 2014). Dang-Pham, Pittayachawan, and Bruno (2017) found that security awareness also improved the diffusion of information security practices (knowledge sharing) throughout the organization. Safa and Van Solms (2016) found that information security knowledge sharing benefitted business, increased employee information security self-efficacy, and improved ISP compliance.

The development of an information security knowledge sharing culture is an important goal for any organization that has critical information systems assets (Flores et al., 2014; Razmerita, Kirchner, & Nielsen, 2016; Safa & Van Solms, 2016). End-user education is important but developing knowledge sharing processes that include the information security team and UXA is crucial to any organization that has UNIX servers hosting business critical data (Bauer, Bernroider, & Chudzikowski, 2017). It is beneficial to build both formal and informal knowledge sharing networks within organizations as they have been found to be significant contributors to awareness and mitigation of information security risks (Dang-Pham et al., 2017; Safa & Von Solms, 2016; Yoo, Sanders, & Cerveny, 2018). Encouraging relationships between employees across team boundaries is key to developing and enabling an effective social network that fosters knowledge sharing (Bauer et al., 2017; Ifinedo, 2014; Oparaocha, 2016). Connelly and Zweig (2015) found that distrust was a predictor of knowledge hiding behaviors. Consequently, it is important to encourage trusting relationships between the information security team and the UXA for an effective information security knowledge sharing culture (Dey & Mukhopadhyay, 2018; Rutten, Blaas-Franken, & Martin, 2016). Sedighi, et al. (2016) found that social interaction was a key component of knowledge sharing. Therefore, creating both formal and informal interactions between the information security team and UXA is crucial to development of reciprocal, trusting relationships that enable knowledge sharing and improved security awareness and ISP compliance.

Security education, training, and awareness (SETA) programs are a means for organizations to minimize the risk of insider caused security failures (Burns, Roberts, Posey, Bennett, & Courtney, 2015). SETA programs are an important antecedent and positively influence information security behavior, and appropriately designed SETA programs can help reduce the human information security risk to organizational assets (Whitman & Mattord, 2012). Users are the weakest link for information security and SETA programs can help to reduce the potential attack surface of organizations by improving the ability of users to identify and prevent

information security breaches (Gardner & Thomas, 2014). Posey, Roberts and Lowry (2015) found that SETA programs were positively correlated with both perceived threat severity and response efficacy indicating that they are an effective way of encouraging information security behavior and ISP compliance. SETA programs should be regular and recurring due to the dynamic nature of information security threats and vulnerabilities (Posey et al., 2015). In a study of SETA effectiveness, Yoo et al. (2018) found that the psychological flow factors including feedback, immersion, challenge, autonomy, and social interaction significantly improved psychological ownership and SETA program effectiveness. Yoo et al. (2018) suggested using relatable security scenarios that challenged employees could improve ownership and ISP compliance. Bauer et al. (2017), in a study of ISP compliance at banks, found that developing a comprehensive, multi-modal information security awareness program was key to successfully establishing an information security culture in an organization.

Albrechtsen and Hovden (2010) developed and tested information security workshops where security personnel acted as facilitators for end-users to discuss relevant security scenarios. This small group atmosphere lead to collaborative, two-way dialogs and fostered participation and collective reflection to gain insights from one another. Safa et al. (2016) integrated social bond theory and involvement theory and found that knowledge sharing, collaboration, intervention, experience, commitment, and personal norms were all correlated to an attitude toward compliance with ISP. Sedighi, et al. (2016) found reputation, reciprocity, altruism, and knowledge self-efficacy were all positively related to quantity and quality of knowledge sharing while effort and time were negatively related to both.

While there have been many studies surrounding information security compliance of end-users, research into UXA ISP compliance is, to the authors knowledge, unresearched. Unlike traditional end-users whose information security focus relates to traditional attack vectors (i.e. phishing, locking computers, passwords), UXA are trained systems engineers whose compliance with ISP can significantly impact vulnerability and risk to organizational data assets. In terms of knowledge management, Flores, et al. (2014) developed a knowledge sharing organizational framework and found that formal organizational structures, formal coordinating structures, business-based information security management, and coordinating information security processes lead to effective formal and informal knowledge sharing arrangements. Their study focused on the organizational information security structure and the impact on end-users. The

present study will extend this organizational framework to specifically focus on UXA. Additionally, this study will incorporate Protection Motivation Theory (PMT) to understand how the information security knowledge sharing program influences UXA compliance with information security policies. Also, as trust is a significant contributor to knowledge sharing, the relationship between the security knowledge sharing and threat and coping appraisals will be analyzed with trust as a potential moderating variable. Finally, this research will investigate the influence of cognitive biases on threat appraisal and will seek to understand how the knowledge sharing program impacts those biases.

Research Questions

RQ1: How do formal knowledge sharing arrangements and support for knowledge transfer, in the form of security, education, training, and awareness (SETA) workshops, influence UXA security threat appraisal and coping appraisal?

RQ2: How does trust moderate the relationship of security knowledge sharing and threat and coping appraisals?

RQ3: How does information security knowledge sharing, in the form of SETA workshops, impact UXA ISP compliance?

RQ4: How do the availability heuristic, overconfidence bias, optimistic bias, and confirmation bias influence UXA threat appraisal?

Initial Concept

Flores et al. (2014) emphasized the importance of organizational support and coordinating information security processes on the development of an information security knowledge sharing culture. According to their model, security knowledge sharing is made up of formal knowledge sharing arrangements and support for knowledge transfer (Flores et al., 2014). Formal knowledge sharing arrangements include formal training on information security policies, threats, and vulnerabilities (Flores et al., 2014). Support for knowledge sharing transfer includes informal and formal processes used to spread information security awareness throughout the organization (Flores et al., 2014).

Development of interpersonal relationships and social networks are significant contributors to knowledge sharing (Oparaocha, 2016). Communities of practice can help in both formal and informal sharing of knowledge and the development of collaborative relationships (Dang-Pham et al., 2017). Supportive social networks can also improve relationships and

encourage fostering of cognitive-based and affective-based trust (Dey & Mukhopadhyay, 2018; Rutten et al., 2016). Trust is key for knowledge sharing relationships (Dang-Pham, Pittayachawan, & Bruno, 2016; Safa & Von Solms, 2016).

Protection motivation theory (PMT) is frequently used to understand compliance with information security policies and procedures (Hanus & Wu, 2016; Safa, et al., 2015; Siponen, et al., 2014). The key constructs of PMT are threat appraisal and coping appraisal. Threat appraisal encompasses perceived severity and perceived vulnerability of potential information security threats (Posey et al., 2015). The factors related to coping appraisal include individual's information security self-efficacy and response efficacy (Posey et al., 2015). Siponen et al. (2014) found perceived severity of threat and perceived vulnerability to be positively correlation with ISP compliance. Appropriate threat appraisal is manifest through increased knowledge and awareness of information security risks, vulnerabilities, and organizational policies and procedures (Albrechtsen & Hovden, 2010; Guo, et al., 2011; Safa & Von Solms, 2016; Siponen, et al., 2014). Coping appraisal can be also be positively influenced by information security knowledge sharing and awareness (Safa, et al., 2015; Siponen et al., 2010). Cognitive biases influence daily decision-making without our awareness (Kahneman, 2011). As such, it is important to understand how biases may influence the threat appraisal of UXA. If threats are perceived as "Windows problems" the precognitive choice to resist ISP implementation on UNIX servers may put the organization at considerable risk. Figure 1 graphically displays the model being investigated by the present research.

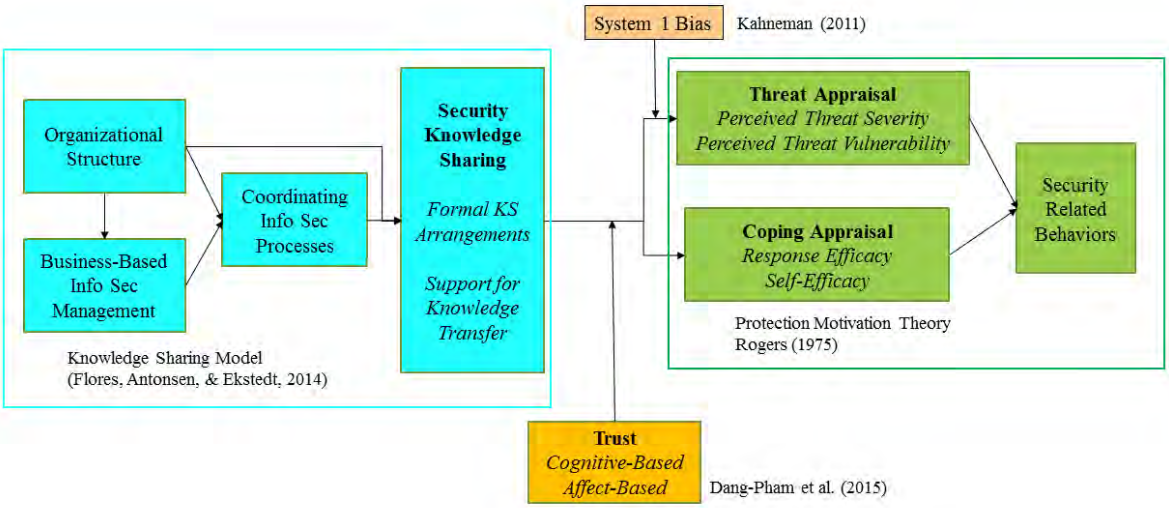

Figure 1. Knowledge sharing impact on ISP compliance.

This research will focus on information security knowledge sharing, formal knowledge sharing arrangements, and support for knowledge transfer to understand how these organizational factors influence UXA threat appraisal, coping appraisal, and ISP compliance behaviors. This will consist of several phases. First, a web-based survey will be developed, based on prior research, to empirically evaluate perceived organizational support, perceived business-based information security management, perceived coordinating information security processes, perceived formal knowledge sharing arrangements, perceived support for knowledge transfer, perceived trust, perceived threat appraisal, perceived coping appraisal, biases, and ISP compliance intention. This survey will be administered electronically through the company's email and intranet and will be sent to both UNIX and Windows systems administrators. Including both UNIX and Windows server administrators will help to determine if there is a significant difference between the threat and coping appraisals for the two different groups.

During the second phase of the research a set of security scenarios applicable to the business environment and related to server management will be developed. These will be utilized during a SETA program. The SETA program will be developed and conducted as a series of small-group security workshops that include information security team members and UXA within an organization. The goal of the workshops will be to encourage connection, collaboration, discussion, and information security knowledge sharing between the participants.

After a scenario is reviewed with the workshop participants and discussion has completed the information security team members may suggest additional ideas, tools, or processes that had not been considered.

At the conclusion of phase three the initial questionnaire will be distributed to the UXA and Windows administrators to evaluate any significant changes in scoring for any of the model's factors. Partial least squares structural equation modeling with confirmatory factor analysis will be used to assess the measurement and structural model.

The research hypotheses are below:

H1: Formal organizational structure positively influences knowledge sharing between the information security team and UXA.

H2: Formal organizational structure positively influences coordinating information security processes.

H3: Formal organizational structure positively influences business-based information security management.

H4: Coordinating information security processes positively influence information security knowledge sharing between the information security team and UXA.

H5: Business-based information security management positively influences coordinating information security processes.

H6: Formal knowledge sharing arrangements, in the form of SETA workshops, positively influence UXA information security threat appraisals.

H7: Formal knowledge sharing arrangements, in the form of SETA workshops, positively influence UXA information security coping appraisals.

H8: Support for knowledge transfer, in the form of SETA workshops, positively influences UXA information security threat appraisal.

H9: Support for knowledge transfer, in the form of SETA workshops, positively influences UXA information security coping appraisal.

H10: Cognitive-based and affect-based trust positively influence the relationship between security knowledge sharing and UXA security threat and coping appraisal.

H11: Heuristics and biases negatively influence UXA information security threat appraisals.

H12: UXA security threat appraisal positively influences UXA ISP compliance.

H13: UXA security coping appraisal positively influences UXA ISP compliance.

Conclusion

The failure to follow organizational information systems security policies (ISP) leaves organizations open to potential systems disruption, loss of proprietary or confidential data, harm to organizational reputation, and potential loss of revenue (Donaldson et al., 2015; Kraemer & Carayon, 2007). Human factors are a significant source of risk factor for information systems security (Carlton & Levy, 2015; Colwill, 2009; Ramim & Levy, 2006). UNIX systems administrators have the highest level of security access and are responsible for implementing and maintaining the security of their servers (Calder & Watkins, 2009). If UNIX server administrators do not follow organizational ISP, significant vulnerabilities may manifest which can be acted on by malicious individuals risking the confidentiality, integrity, and availability of organizational assets (Scarfon, Jansen, & Tracy, 2008). The present research hopes to understand how organizational knowledge sharing in the form of security, education, training, and awareness workshops influence UNIX systems administrator compliance with ISP.

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DECISION MAKING - ABSTRACTS

Decision Making on Offering Free Services in Healthcare

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It is becoming common for profit-minded service providers to offer their services for free to customers that cannot pay in healthcare in emerging countries. Our model provides decision support for healthcare providers to understand the financial, operational, and social benefits of offering free services that could maximize the interests of patients, doctors, and hospitals all together, even if these interests are from selfish purposes.

DECISION MAKING - PAPERS

A HITS-BASED MODEL FOR LOCATION DECISION

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Abstract

Determining the facility location is an important decision in the manufacturing and service environment. In this paper, we propose a model combing hyperlink-induced topic search (HITS) algorithm and data envelopment analysis (DEA) for selecting the best or most efficient location. In the first stage, using DEA and its extension benchmarking, we identify a set of good locations. Second, adding the HITS algorithm the best location can be identified. Finally, we validate our framework with a case study.

Keywords: Location Decision, Data Envelopment Analysis, HITS

1 Introduction

Facility location has a well developed theoretical background. Since the formulation of the classical Weber problem (Weber, 1929), location theory has been an active area of research, particularly during the last 30 years. Today, facility location theory is viewed as a substantial body of knowledge with a rich variety of models, methodologies, and solution techniques, it can be found in literature pertaining to fields such as industrial engineering, operation research, operation management, urban economics and political science (Avella et al., 1998; White et al., 1974).

In recent years, other authors have speculated on virtual site location to determine which websites are more important than others. Location decision has been recognized as an essential task in web search applications. Some techniques such as PageRank, Hyperlink-Induced Topic Search (HITS), and RankBrain have been used for prioritizing websites. For example, Y. Zheng et al. (2009); V. W. Zheng et al. (2010) used the HITS algorithm to identify location interests based on travelers' GPS trajectories. Long & Joshi (2013) proposed a HITS-based algorithm incorporating

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the effects of social relationships to recommend location. Currently, web based studies on location determination mainly focus on leveraging the social and geographical properties, displaying their dependence on the data set they are evaluating. What remains absent from the web based location decision literature is not the development of new data-driven models, but rather a novel solution framework which can be applied to various situations. The purpose of this article is to describe a new analytic model for facility location. This model is based on Data Envelopment Analysis (DEA) and HITS algorithm to determine the best location for a facility.

2 Methodology

The selection of a good location is very important to ensure good business performance. Therefore, the problem considered in this paper is to find the most authoritative location in a community by combing the DEA and its extension benchmarking method (Sinuany-Stern et al., 1994) with HITS algorithm (Kleinberg, 1998) .

In the first stage, it identifies the criteria important to customers, corresponding data available and using DEA it determines the best location for a facility. However, there may be more than one efficient location, in the second stage we use HITS algorithm to differentiate between these efficient locations.

3 Discussion and conclusions

In this paper, we developed a new model combining the HITS algorithm and DEA method to search apartments around a university. In the first stage, we use DEA to identify the efficient locations. In the second stage, we used HITS algorithm coded in python to identify the priorities of locations. Based on this finding, we hope this model will be a useful decision support tool for location recommendation and also have useful applications in industries. Furthermore, this study can be extended in various directions such as tourism, manufacturing and planning the transport hubs.

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COMPARISON OF IMPUTATION METHODS FOR PREDICTING LENGTH OF STAY IN HOSPITALS

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Keywords: Fully Effective Fractional Imputation**,** Multiple Imputation**,** Missing Data, Machine Learning, Binary Classification, Length of Stay

Abstract

Accurately predicting length of stays in hospitals helps increase efficiency of the health care system because it would allow medical professionals to better prepare for incoming patients. Although more challenging, predicting patients with prolonged length of stays (10 or more days in the hospital) would be even more beneficial because these are the patients that consume the most hospital resources. Due to the nature of hospital data, there is large number of missing values that may drastically lower model performance if handled improperly. This research aims to find the approaches for handling these missing values that work well across multiple machine learning models including decision trees, random forests, logistic regressions, neural networks, support vector machines, and ensemble methods before and after feature engineering. Using 80,000 observations from Hospital Discharge Data from the Rhode Island Department of Health, the models listed above are trained with a variety of imputation methods before being scored on a consistent 20,000 observation testing set. The research finds that, for this data, the approach of not using patients with missing values and multiple imputation result in the highest balanced accuracy while mean imputation and multiple imputation approach lead to the highest sensitivities across all models trained. Furthermore, this paper suggests that, although commonly used for survey data, Fully Effective Fractional Imputation has a potential to be used in non-survey data because of the high-quality results it produced across many models.

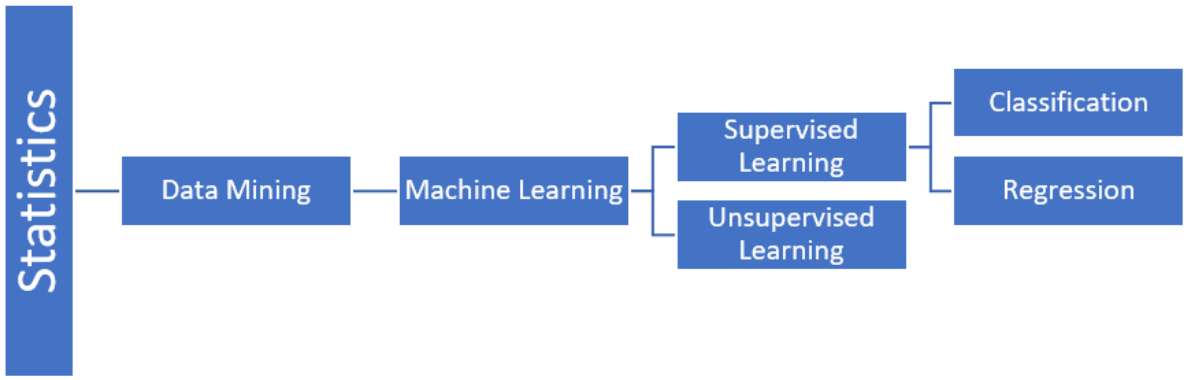
Introduction

Increased processing power of computers in the last few decades has made it possible for statisticians to design new methods of analysis that have the capability of improving on their own without being specifically coded to do so. Discoveries on this subject have resulted in a whole new field of study called machine learning. Machine learning is considered a subset of statistics and data mining although many argue these areas are becoming essentially the same thing. Put simply, machine learning is the idea of repetitively applying data mining and statistical

techniques to an uninformative data set in order to gain information and explain or predict something intricate (James, 2017). These processes can be split up into two groups: unsupervised learning and supervised learning. Unsupervised learning is used to discover organization and connections in data without a stated target while supervised learning finds relationships between specific input variables and output variables. The two main categories of supervised learning are classification, categorizing a discrete response variable based on inputs, and regression, predicting a continuous target variable based on inputs. This paper focuses on supervised learning and uses classification models. Figure 1 below gives a visual representation of the hierarchy of models described.

Building predictive algorithms allows individuals and businesses to be more efficient with their time and resources, avoid risk, and become more profitable. Past research proves these rewards like David Whiting, James Hansen, and James McDonald's study "Machine Learning Methods for Detecting Patterns of Management Fraud" where they were successful in creating a supervised model that can discover and mitigate financial fraud (Whiting, 2012). Furthermore, in the study "Machine Learning for Direct Marketing Response Models", Geng Cui, Man Leung Wong, and Hon-Kwong Lui's provided new insights on consumer behavior through supervised learning that led to better targeted advertising and increased sales (Cui, 2006). Beyond these two examples, there are many more instances where researchers accurately predicted response variables leading to better business outcomes, more lives saved, or better personal decisions.

Figure 1: Breakdown of where machine learning fits in statistics and the categories of machine learning



In this study, the focus is predicting prolonged length of stays (LOS) of hospital patients. LOS is often used as an "indicator of efficiency of care" with shorter average length of stays indicating

less expenditure per patient (Pei-Feng, 2016). Being able to predict and know what impacts this information in advance allows medical professionals to allocate human and physical resources more appropriately as well as admit patients on a preferred schedule (Acharya, 2011). In an industry that is vital to the health and safety of a population yet still has particularly high costs, this research could reduce unused resources and provide better care for patients. Furthermore, foretelling the release of length of stays can benefit accountants' financial accuracy who sometimes rely on estimates for financial statements and reimbursements (Turgeman, 2017). Although more difficult to calculate, being able to predict prolonged length of stays would be even more beneficial to hospitals because these are the patients that take up the most resources and have the most detrimental side effects including increased risks of sleep deficiency and infections (Guide, 2018).

Also, within this work, we study the impact of several techniques for imputation or dealing with missing values in the data set. Comparing imputation methods is a common research topic in data mining because a strong imputation method helps limit bias and allows the program to run more efficiently when training a model. Past studies comparing imputation methods and presenting the problems with bad imputation include Batista & Monard (2010), Shrive, Stuart & Quan (2006), and Stern, White, & Carlin (2009) although there are numerous other examples available. The goal of this research is to evaluate several imputation methods across a variety of models before and after variable manipulation in order to find an imputation method that is consistent and unbiased throughout the data mining process. To do this, four imputation methods are tried and examined including deletion of observations with missing values, mean imputation, multiple imputation, and fully effective fractional imputation (FEFI). Based on the results of testing 50 predictive models on the same testing dataset, this research finds the deletion of observations with missing values leads to the most consistent results across all the models although there are benefits to the other imputation methods. Furthermore, this paper argues that although FEFI is generally used for survey data, there is potential for more use in the data science field as an imputation method because of the high accuracy results it yields.

We use the SAS programming language integrated in SAS Enterprise Guide for our computations.

Data Exploration

Description of Data

The data used in this study is from the Rhode Island Department of Health and consists of over 1.5 million observations of hospital admissions and 135 variables. With the goal of predicting the length of stay of a patient when they first enter the hospital, many of the variables were instantly removed because they would not be known upon the admission of the patient. Among the deleted variables were total charges, subtotal costs for categories of uses, and ending diagnosis. Removing these unnecessary variables cut the number of input variables down to 42. Of the 42, another 26 variables were removed because over 50 percent of the values were missing. With that many values missing, imputing the data is not an accurate representation of the population. These variables included cause of injury and illnesses present on admission. This left the data set with 16 variables including the target (length of stay) which are listed along with a brief description in Figure 2 below.

The response variable, length of stay, was a numerical variable in the original dataset, representing the time from admission to the time of discharge but was converted to a binary variable with categories prolonged stay and short stay. A prolonged stay for this study is defined as an individual who stays in the hospital 10 or more days. According to NHS (National Health Service) Improvement, a stay longer than 10 days has the potential to result in 10 years of muscle aging for certain groups of people (Guide, 2018). Additionally, as stated in the introduction, predicting extended stays proves more value because they are the patients that require the most time, space, and resources. Only one of the input variables (age) in this data set is numerical while the rest are nominal categorical variables. The variables with the most levels, or categories, are admitting diagnosis (diag_adm) with 6,107 levels, state with 75 (pt_state, Canada and territories are included), and admission source (asource) with 18. These, along with the rest of the variables, can be seen in Figure 2. In the initial models trained in the Model Building section, none of these variables are manipulated in order to see the importance and information each one of them contains. In the Model Building with Variable Manipulation section, these variables are reduced in order to build a simpler, more efficient model.

Figure 2: List of variables with description and the number of levels in the variable

Number of Variable Levels		
Variable	**Label**	**Levels**
age	patient age at admission	137
sex	patient sex (1=M,2=F) alpha	2
raceethn	patient race/ethnicity	8
provider	Medical provider	14
moa	month of admission mm	12
yoa	year of admission yy	14
admtype	admission type	5
asource	admission source	18
service	Hospital service requested	16
payer	Expected source of payment	14
pt_state	Patient's state of residence	75
diag_adm	Admitting diagnosis (ICD-9 code)	6107
campus	Geographic location of hospital campus	5
er_mode	Mode of arrival	6
los_group	Target: Short (<10 days) or prolonged (>=10 days)	2
pay_ub92	Expected source of payment detailed	13

Missing Values

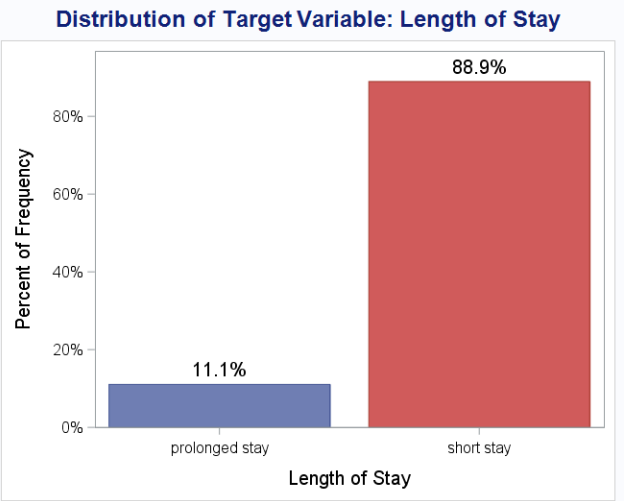
The only variables of the final 16 selected without missing values were LOS (length of stay), MOA (month of admission), and YOA (year of admission). Before the data is imputed, observations missing over half the variables were removed because they were considered incomplete. Furthermore, observations with "9s" in certain variables and observations that break syntax rules were deleted because they were considered errors according to the data set documentation provide by the Rhode Island Department of Health. All of this is done before the imputation methods and the creation of the testing data (described later) in order to maintain consistency. In total, 705,202 observations of the over 1.5 million had no missing values and, of the variables used, mode of arrival (er_mode), admitting diagnosis (diag_adm), patient's home state (pt_state), and location of hospital (campus) had the most missing values at 31.93%, 18.31%, 18.29%, and 18.28% of observations respectively. All other variables had less than 8% of observations missing.

Balancing Data

In this data set, and across the country, prolonged stays are significantly more rare than short stays. 88.79% of all observations are short stays while only 11.21% are prolonged stays as shown visually in Figure 3. When the target is not equally distributed, it is important to balance data before modeling because, without it, the trained model would be heavily biased towards predicting the more common event. For example, if trained with imbalanced data, the trained model could predict all short stays and be accurate 88.79% of the time. Although it sounds

accurate, it does not help medical professionals distinguish prolonged stay patients from short stay patients because it does not predict prolonged stays correct at any time. To reduce this bias, the data is balanced by resampling the data so there are the same number of short stay and prolonged stay observations in the training data. In this research, this is done by undersampling which randomly deletes observations of the dominant target class until there are an equal number of observations in each target class. After undersampling, the data set is reduced to 271,180 observations which is about 20% of the data set.

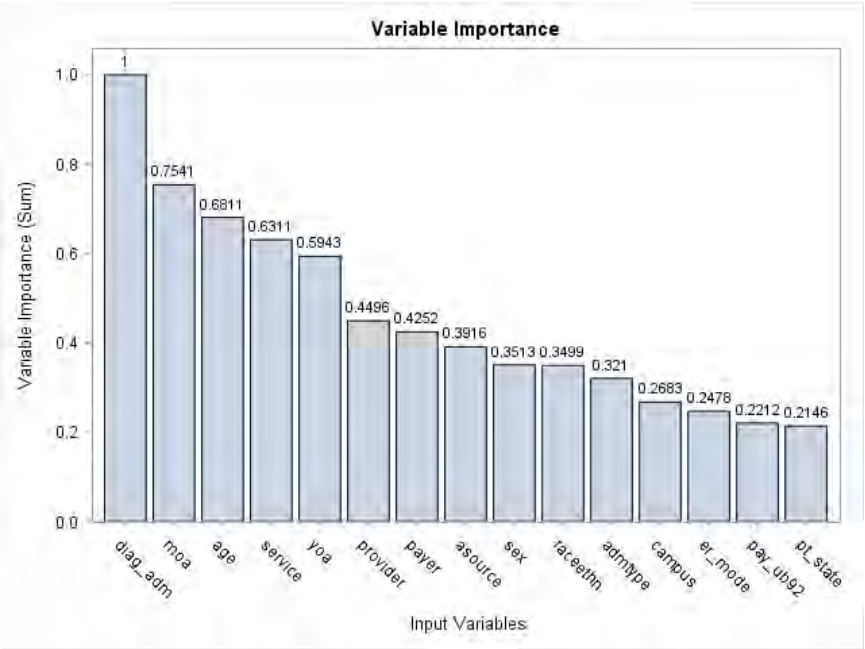
Figure 3: Distribution of the target variable, length of stay.



Variable Importance

We look at the importance each variable provides relative to the target variable. One method to rank variable importance is growing a decision tree (described in detail later) to its full depth and analyzing the information gain each input variable accounts for. For predicting length of stay, the admitting diagnosis, month, and age are the three most important variables according to the decision tree method used yield information gains of 1.00, 0.754, and 0.681 respectively. The patient's mode of arrival to the hospital, detailed predicted payment level, and home state have the least importance at 0.248, 0.221, and 0.215 respectively. These are important to keep in mind, especially during the variable manipulation and selection phase. The variable importance by decision tree is report in Figure 4.

Figure 4: Variable importance based on maximum decision tree depth



Imputation Methods

The vast number of missing values and relative size of the data set led to the focus of imputation methods for this research. In this research, four methods of imputation are focused on: deleting observations with missing values, mean imputation, multiple, and fully efficient fractional imputation (FEFI). Deletion, mean, and multiple imputation methods were all chosen because they are common in the data science field whereas FEFI was chosen because it is generally not used for predictive models. Other studies, like the ones listed earlier, focus on the commonly used imputation methods, but the idea of this research is to find an imputation method that works well across multiple models, so a new method was tried.

Deleting Observations with Missing Values

Deleting observations with missing values is the simplest method of dealing with missing values because it does not require replacement of missing values. The concern with this strategy is it limits the number of observations the data can be trained on. With a data set as large as the Rhode Island Department of Health one used in this study, this is much less of a concern. Furthermore, missing data sometimes contains information about the observation. If this is the case, then deleting observations with missing values creates a bias towards observations without missing values when the model is evaluated on separate data.

Mean Imputation

With mean imputation, missing values are replaced with the mean or mode of the column the missing value is in. For smaller data sets and lower level categories, this method tends to work well which is why it is one of the most widely used methods. It also has the benefit of simplicity. The major concern with mean imputation is the tendency to change the distribution of the variables by making them more skewed around the mean. Training models on data that does not resemble the population again causes biases that lead to inaccuracy on outside data which is why using mean imputation for large data sets in generally not an accepted strategy.

Multiple Imputation

Multiple imputation is a more complex method that requires three steps: filling in the missing values based on logistic regression multiple times, analyzing the numerous imputations from step one, and choosing the best imputations (based on the analysis in step two) to create the final clean data set (Stern, 2009). This method has the advantage of allowing randomness which helps limit changes in the distribution of variables. Multiple imputation assumes variables are normally distributed and can take a long time to compute though so bias can be introduced and more time is needed.

Fully Efficient Fractional Imputation

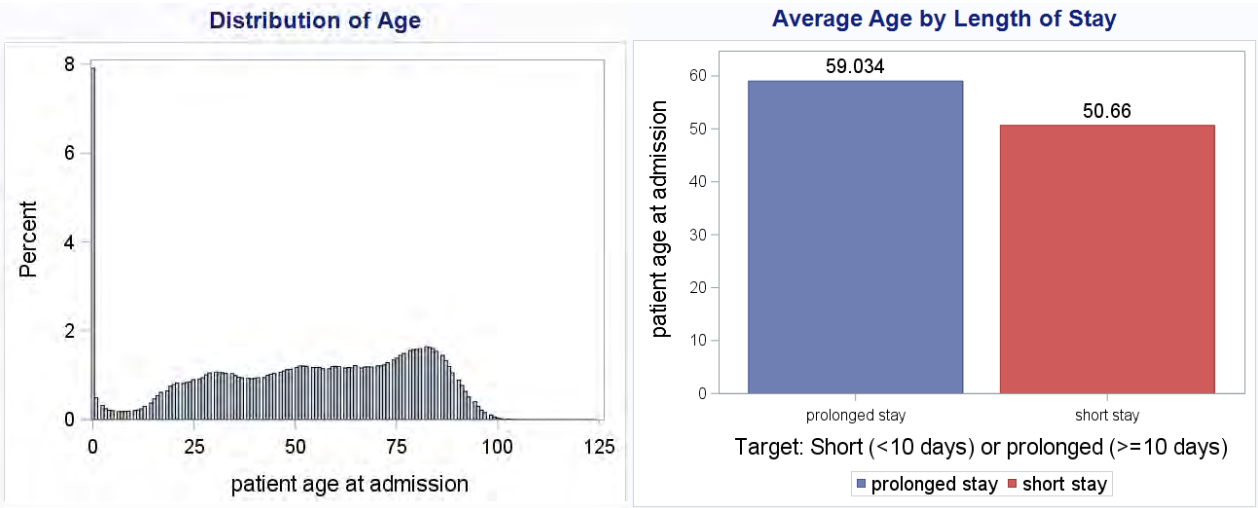
FEFI does not use a specific model or method like the other imputation methods described. Instead, it replaces missing values based on the occurrences of each level in the variable. For a given observation with a missing value, called the recipient, weights are applied to all other observations, the donors, based on how closely they resemble the observation with the missing value (Yang, 2015). If a donor is weighted higher, it implies the donor is more closely related the recipient. Based on these weights, the donors are then used to estimate the missing value in the recipient. This method is often used for survey data and has not been extensively utilized in the data mining field which is why it is analyzed here.

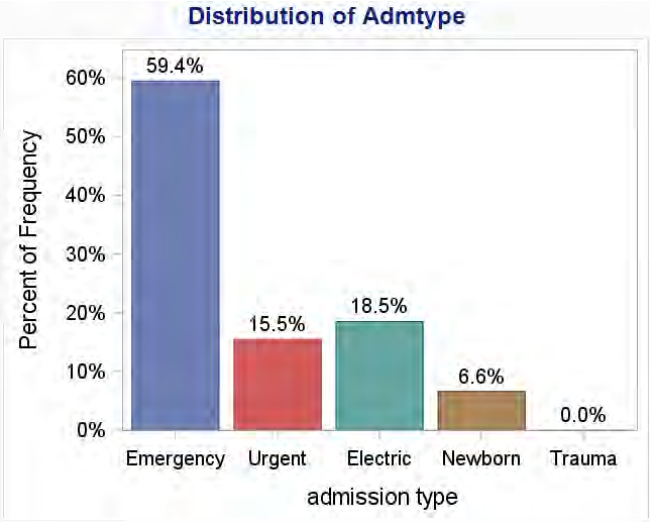
Variable Exploration & Visualization

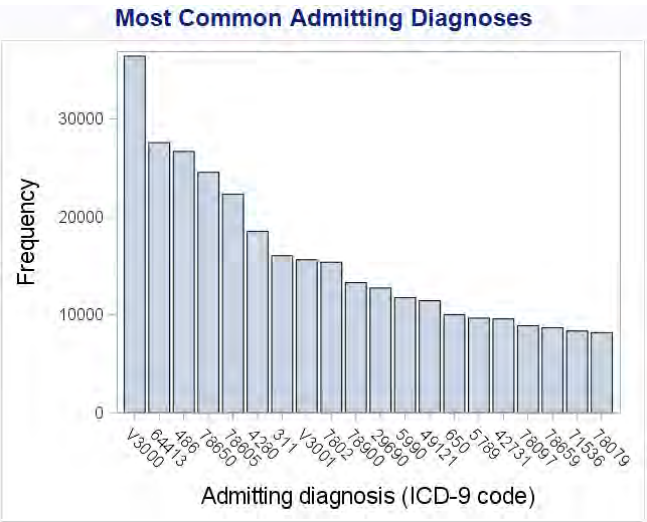
Like the target variable length of stay, many of the input variables are not evenly distributed. For input variables though, this is a good thing because it shows the variables are not constant across both levels of the target variable. If the predictors are constant, it shows the target variable does not depend on the other variables, so no model can be trained. Graphs of the input variables age,

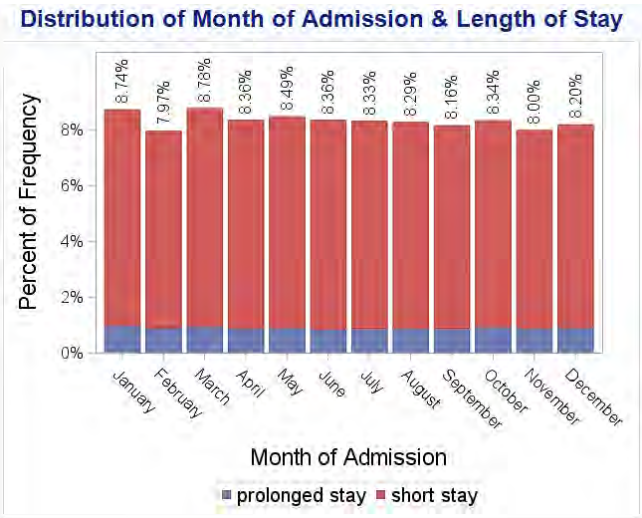
admission type, admitting diagnosis, month of admission, and sex are provided below. The numerical variable age is almost normally distributed except for a major spike at the age of 0. These are all the newborns in the dataset which represents about 7% of all observations. About 36.89% of the observations are above the normal retirement age (65) which is represented by the hump on the right tail of the graph. On average, prolonged stay patients are 8.04 years older than short stay patients as can be seen below as well. Furthermore, a majority of the patients are emergency room admissions with 59.4% of observations going to the emergency room and only 15.5% and 18.5% going for urgent and electric care respectively. The top 20 most common diagnoses are also displayed with over 30,000 patients going for birth (ICD-9 code V300), 27,552 going for an anesthesia injection (ICD-9 code 64413), and 26,742 going for pneumonia treatment (ICD-9 code 486). There is also no statistical difference between months even though month of admission is one of the variables the max tree used the most as described above. This shows the importance is likely due to the high number of categories in month rather than dependence between month of admission and length of stay. Finally, the data set has 16.6% more female observations, but there is no statistical difference between length of stay for males and females.

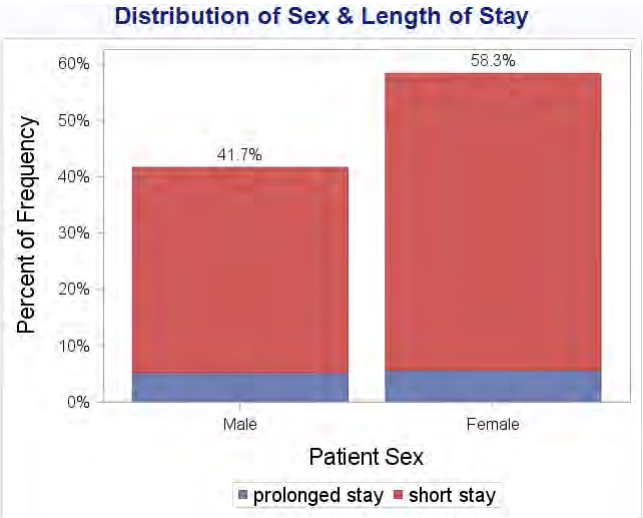
Figure 4: Distributions of the variables age, length of stay, admission type, admitting diagnosis, month, and sex.











Model Building

Data Partition

When developing a predictive model, one of the most notable traps to avoid is creating a model that cannot predict outside data well because the model is trained too specifically on the original data. This pitfall is called overfitting and results in models that are not robust. In order to prevent overfitting, data scientists partition their data into training and testing data sets. The training data is used to train the model (find the parameters) while the testing data is used to test the accuracy of the model. This ensures that the model is evaluated on data it has never seen before and therefore develops an unbiased assessment. In this study, a random sample of 20,000 observations with no missing values is removed from the data set to be used as testing data. The testing data is held constant for all model scores and consists of only observations with no

missing values in order to certify that no imputation method is preferred in the assessment process. After the 20,000 testing observations are removed, the remaining observations are then imputed using the various methods to create four data sets (one for each imputation method). 80,000 observations are then taken out of each of these imputed data sets and used as the training data for each of the models. The imputation methods are done before this sampling but after the testing data is removed in order to ensure the replacement values are representative of the entire data set but still not favored to be similar to the testing data.

Types of Models Used

Another method to ensure high performing models is to train multiple models and take the best qualities from each. As the "no free lunch" theorem states, there is no algorithm that is the most accurate for every situation (Gomez, 2015). For this reason, building many models, including a combination of many models (ensemble models), is the best way to find the highest accuracy model for a particular classification or regression problem. Furthermore, discovering an imputation method that works well across multiple models would be an advantage because it implies the data is less biased. To predict prolonged length of stays in this study, seven models were trained and compared including a decision tree, random forest, logistic regression, neural network, and support vector machine, along with models built using boosting and bagging ensemble methods. Each of these models is described in more detail in the sections below.

Decision Tree

Decision trees are one of the most popular supervised classification models. In decision trees, the data is divided into subsets using splitting rules on variables. Decision trees allow for nonlinear relationships to be predicted as well as easy interpretation. On the downside, if they are not restricted or pruned, they can easily create overfit models by splitting until they classify each observation individually. This results in a model that fits the training data with 100 percent accuracy, but likely does not do well on outside data. Decision trees also do not offer explicit numerical relationships, or regression function, between the predictor and response variables which does limit the understanding of the data.

Random Forest

Random forests are an ensemble learning method that create a diverse number of decision trees. These trees are trained on subsets of the data with only a few variables being considered at each

split. The forest predicts by the majority vote in the trees. This is another widely used classification model because it automatically does variable reduction, does not overfit models, and is generally viewed as one of the most accurate models. Like decision trees though, no numerical relationships are provided between predictor and response variables. Furthermore, random forests can take a long time to train because the number of models to train can increase exponentially based on the hyperparameters (the number of variables is considered at each split, the splitting rule, and the minimum samples a node must include) chosen. If a range of hyperparameters is specified, the model can take even longer to train.

Logistic/Probit Regression

Logistic/Probit regressions differ from other models in that they use probability to determine the classification of a binary target variable. Using a link function like "probit" or "logit", the regression can be converted to a probability between 0 and 1 where closer to 1 implies the observation is more likely to be the positive occurrence. There is also only one unique solution to a logistic regression because it has no hyperparameters; the data scientists cannot specify certain aspects of the building model other than the type of link function. The benefit of this model though is it offers the relationship between each predictor variable and the target variable which helps the analyst uncover concealed patterns.

Neural Network

Neural networks are one of the more complex machine learning algorithms but often lead to some of the most powerful models. In neural networks, the input variables are transformed through different stages, called hidden layers with the final stage being the output variable (output layer). A layer is a list of nodes, or neurons. A node is the output of an activation function applied on a weighted linear combination of nodes in the previous layer. Here the network finds the parameters, i.e. the weights, that that minimize the selected loss or error function. Classical linear regression model is the simplest neural network with no hidden layer. For linear models, this is relatively easy to solve for, but it becomes quickly more difficult as more layers are added. The complex structure of neural networks makes them difficult to interpret. The model does not intuitively explain relationships among variables. Again though, this model is still extremely powerful and, even though they are extremely complex, parallel processing (one computer performs multiple parts of a program concurrently) can be used which

can decrease the training time of the model (unlike decision trees and neural networks which require one part be finished before the next part starts).

Support Vector Machine

Support vector machines (SVMs) split data with the largest margin of decision boundary (the minimum distance of the boundary to all the observations). For the most part, SVMs are categorized into two groups: hard margin (does not allow error) and soft margin (allows error). The data scientist can specify whether they want to use hard or soft SVM by adjusting the "cost" or penalty hyperparameter. Increasing the penalty means the model punishes mistakes more and limits the amount of error whereas a decrease in penalty allows for more mistakes and therefore more error. This flexibility in design is an advantage for the modeler, but they must be carefully investigated because decreasing the penalty too much can lead to an overfit model. Furthermore, SVM often uses transformations ("kernel tricks") in order to solve non-linearly separable data.

Boosting

Boosting is an ensemble method that can help turn a weak model into a strong one through a repetitive process of improvement. First, a regular model is trained that will produce a very broad model that may not even classify the target variable well. Then, the model gets trained again, but this time with a focus on the weaknesses of the first model. In order to focus on the weaknesses, the misclassified observations are weighted more heavily in the next round of training. This process if then repeated until a specified "n" models are created. A final model is then created by using a majority vote method that takes the best attributes of the many models created. Boosting methods result in highly accurate models because they take a diverse group of models and combine them into one. The biggest drawback of this method is it requires models to be build one at a time because the previous iteration is needed for the next one to run. This can take a long time and requires a lot of processing power.

Bagging

Similar to boosting and random forest, the idea of bagging is to create a wide variety of models before combining them into one by majority vote. First, the data is split using a certain percent of data many times by resampling. Different variables can also be selected for each training set. Models are then trained on all the splits of data before they are combined by taking the best elements of each. Again, this is very powerful because a diverse set of models is used to make

one. Furthermore, parallel processing can be used to develop this model because the different models do not rely on each other to run. On the downside, interpretability does decrease because the final "bagged" model is usually not able to be visually represented.

Evaluation Metrics

There are many numerical and visual ways to evaluate the accuracy and abilities of a predictive model. Being able to accurately assess a model is just as important as knowing the concepts of building one. Without the ability to gauge the precision of a model, then there is no purpose in spending the time to construct one. In order to evaluate models, the trained model is used to predict the target variable in the testing data from the data partition described earlier. Different evaluation metrics are then used to numerically and visually represent how accurate the model is by comparing the correct predictions and the incorrect predictions. The evaluation metrics used for this research are the misclassification rate, sensitivity, specificity, and balanced accuracy which are described in detail below

Misclassification Rate

The easiest evaluation metric is the misclassification rate which is simply the number of misclassified observations in the prediction over the total number of observations. As can be expected, a lower misclassification rate means the model predicts the target variable better while a higher misclassification rate verifies the model needs to be improved.

Sensitivity & Specificity

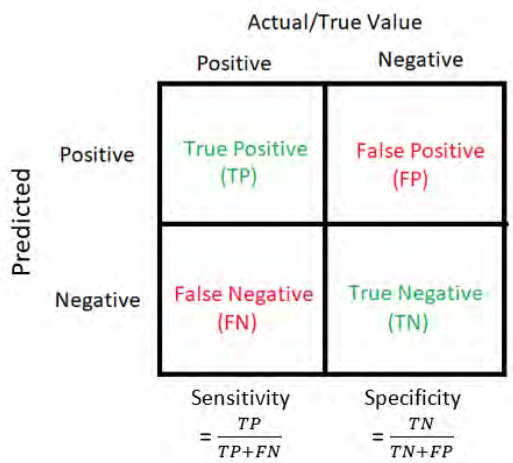
Sensitivity and specificity measure the types of error the trained model makes on the testing data. The true positive rate, the number of positive values that are predicted correctly, is measured by sensitivity while the true negative rate, the number of negative values that are predicted correctly, is measured by specificity. To calculate these values, a classification table, or confusion matrix, is used like the one depicted below. Along one axis is the actual positive and negative target and along the other are the predicted positive and negative target. The numbers in the matrix represent the total of the row and column it aligns with. A perfect model would have all values in the positive/positive and negative/negative sections signifying sensitivity equal to one and specificity equal to one while the worst model would have the same number of observations in each box resulting in a sensitivity of 0.5 and specificity of 0.5. This would be the worst possible model because it would imply the model randomly guesses. With imbalanced data

against the positive event like prolonged length of stay, high sensitivity is extremely important because it shows a strong capability of predicting the event that is more cared about.

Balanced Accuracy

After sensitivity, the most important evaluation metric used for predicting rare events is the balanced accuracy. The balanced accuracy is the average of the sensitivity and specificity and gives the analyst a better understanding of how the model predicts both positives and negatives rather than just all values. With imbalanced data, the balanced accuracy is especially important because it is a less bias evaluation metric that overall accuracy.

Figure 5: Example confusion matrix or misclassification table that can be used to find accuracy measures



Base Model Evaluations

As stated earlier, for every model trained, four imputation methods are used: deleting observations with missing values, mean imputation, multiple imputation, and fully efficient fractional imputation. With the seven models described above, this resulted in 28 models to compare. The model with the best balanced accuracy when scored on the testing data is the random forest trained on the fully effective fractional imputed data while the least accurate model on the testing data is the boosted model trained on the FEFI data. In Figure 7, "SuveyImpute" refers to FEFI, but is labeled differently because of procedure used in SAS Enterprise Guide. The bagging and boosting models are the worst models likely due to overfitting. These models all predicted the training data with over 80% accuracy but barely achieved 60% on outside data. The boosting and bagging models do have some of the highest sensitivities though at 75.37% for the boosted model on only clean observations and 74.08% on

the bagged model with FEFI. These models predict positive occurrences, prolonged length of stays, with higher accuracy than other models but cannot predict negatives as accurately as can be seen by their low specificities. FEFI and mean imputation resulted in the models with the highest sensitivities again showing strong accuracy at predicting the rare event. Random forests and neural networks are the two best models used both with a median balanced accuracy of just under 70% across all imputation methods. Median is used as the comparison because the bagging and boosted models drag down the average and misrepresent overall accuracy. The data with only clean observations trained the best models on average yielding a 69.29% balanced accuracy across all models although the FEFI method is not far behind at 69.24% balanced accuracy. It is important to note the FEFI method resulted in three of the top four models and improved the balanced accuracy of the random forest with only clean observations by over a percent. Even though the median may not be the highest, it produced some of the best models.

Figure 7: Evaluations of base models sorted by balanced accuracy or sensitivity

Base Model Accuracy on Test Data

Obs	Model	Accuracy	Specificity	Sensitivity	Balanced_Accuracy
1	Random_Forest: SurveyImpute	0.69970	0.69559	0.73241	0.71400
2	NN: SurveyImpute	0.68620	0.68141	0.72434	0.70288
3	Random_Forest: OnlyCleanObs	0.70765	0.70945	0.69350	0.70148
4	Logistic_Reg: SurveyImpute	0.69280	0.69109	0.70641	0.69875
5	Random_Forest: MeanImpute	0.69485	0.69451	0.69748	0.69600
6	NN: OnlyCleanObs	0.70015	0.70190	0.68642	0.69416
7	Random_Forest: MultImpute	0.67565	0.67039	0.71694	0.69366
8	NN: MeanImpute	0.67305	0.66712	0.71959	0.69336
9	Logistic_Reg: OnlyCleanObs	0.69505	0.69564	0.69040	0.69302
10	SVM: OnlyCleanObs	0.69460	0.69514	0.69040	0.69277
11	SVM: SurveyImpute	0.68290	0.68017	0.70462	0.69240
12	NN: MultImpute	0.66595	0.65866	0.72313	0.69090
13	Logistic_Reg: MeanImpute	0.68310	0.68115	0.69836	0.68976
14	Boost: OnlyCleanObs	0.63915	0.62456	0.75365	0.68910
15	SVM: MeanImpute	0.67415	0.67027	0.70456	0.68742
16	SVM: MultImpute	0.66330	0.65658	0.71605	0.68632
17	Logistic_Reg: MultImpute	0.68330	0.68273	0.68775	0.68524
18	Decision Tree: OnlyCleanObs	0.69795	0.70348	0.65458	0.67903
19	tree: SurveyImpute	0.70550	0.71523	0.62797	0.67160
20	Decision Tree: MultipleImpu	0.64555	0.63882	0.69836	0.66859
21	Decision Tree: MeanImpute	0.62300	0.61012	0.72402	0.66707
22	Bag: MultGroup	2.66265	0.69188	0.63945	0.66566
23	Bag: CleanGroup	2.63865	0.70418	0.61515	0.65966
24	Bag: MeanGroup	2.62965	0.58755	0.72728	0.65741
25	Bag: SurveyImpute	0.58780	0.56830	0.74082	0.65456
26	Boost: MeanImpute	0.58355	0.57365	0.66121	0.61743
27	Boost: MultImpute	0.56470	0.54969	0.68244	0.61607
28	Boost: SurveyImpute	0.66950	0.68628	0.53782	0.61205

Median Balanced Accuracy of Different Imputation Methods

Obs	Imputation_Method	Median_Balanced_Accuracy
1	OnlyCleanObs	0.69290
2	FEFI	0.69240
3	Mean	0.68742
4	Multiple	0.67692

Median Balanced Accuracy of Different Models

Obs	Model	Median_Balanced_Accuracy
1	Random Forest	0.69874
2	NN	0.69376
3	Logistic Regr	0.69139
4	SVM	0.68991
5	Decision Tree	0.67010
6	Bagging	0.65854
7	Boosting	0.61675

Median Sensitivity of Different Imputation Methods for Grouped Data

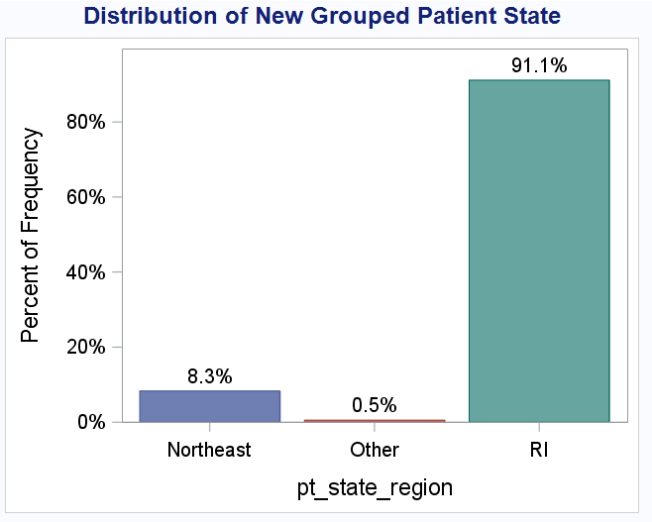
Obs	Imputation_Method	Median_Sensitivity
1	FEFI	0.70641
2	Mean	0.70456
3	Multiple	0.69306
4	OnlyCleanObs	0.69040

Model Building with Variable Manipulation

Although some of the above models do result in strong predictors of prolonged length of stay, they do not result in the simplest models. One of the problems is some of the variables have too many levels. As described above, the admitting diagnosis variable has over 6,000 levels and patient's home state has over 50. This greatly increases the inefficiency of the run time of the model training as well as lead to overfit models. With such large categories, the models get trained to split at certain rare occurrence in the training set that may not be representative of the entire population. To deal with this, the diagnosis and state inputs were reduced to more appropriate levels. For state, the observations were split into Rhode Island, northeast (CT, MA, ME, NH, NY, VT), and other. Because the data set is from Rhode Island, a majority of the patients are from Rhode Island and other states close by. The new distribution of this can be seen below. For admitting diagnosis, the ICD-9 codes were trimmed to the category of treatment by taking the first three digits in the full diagnosis code (Andrus, 2017). In the raw data set, they are at the "vital detail" level which provides information about the specific injury or illness. The first three digits represent the broader category the injury or illness is in though which means there

are far few categories. By doing this, the number of levels decreased to 786. Although still large, the reduction of over 5,000 levels will help prevent overfitting and increase model efficiency.

Figure 8: Patient state distribution after being grouped into three categories instead of 75



Another problem with the data set is many of the input variables are dependent of each other. When models are trained with dependent input variables, the excess variables just add complexity to the model without adding any additional information. In this hospital data set, the variables admission type and source of admission, expected payment method and expected payment method detailed, and campus and provider are dependent of one another. These are known to be dependent because certain levels of the first variable must be paired with certain levels of the second variable. For example, if the type of admission is “Newborn” then the source of admission must be “Normal”, “Premature”, “Sick”, or another type of birth. To deal with this, the dependent variables are concatenated into one new variable. Although this creates a new variable that has a higher number of levels, it reduces the dimensionality of the data set while not creating any additional levels that did not exist before. With these simplifications, the number of variables is trimmed to 13 from 16. To understand the new variables better, the variables are listed and described below.

Figure 9: New description of variables after being grouped

Number of Variable Levels		
Variable	Label	Levels
los_group	Target: Short (<10 days) or prolonged (>=10 days)	2
age	patient age at admission	109
sex	patient sex (1=M,2=F) alpha	2
raceethn	patient race/ethnicity	8
moa	month of admission mm	12
yoa	year of admission yy	13
service	Hospital service requested	16
er_mode	Mode of arrival	6
pay_ub92	Expected source of payment detailed	13
diag_adm_class	Category of ICD-9 diagnosis code	786
provider_campus	Concatenated provider and campus	57
pt_state_region	New grouped patient home state	3
type_source_code	concatenated admission type and source	49

Model Evaluations with Variable Manipulation

After the variables were manipulated, the same 28 models as the previous section described were trained. The most accurate model when scored on the test data came out to be the random forest trained on only clean data. With this model and imputation method, the variable manipulation increased the balanced accuracy by 2.42% from the unmanipulated model. Rather than one imputation method developing the best models like with the base models, with variable manipulation the model accuracy depended more on the type of model. Random forests and neural networks trained six of the top seven models. Overall, random forests still trained the best model while bagging and boosting still developed overfit models that do not do well on outside data. Interestingly, the logistic regression model with mean imputation predicted only short stays on the testing data which resulted in an 88% overall accuracy (percent of short stays in the raw data) but a sensitivity of 0 and a balanced accuracy of 50%. Deleting observations remained the best imputation method based on median across all models, but the median balanced accuracy decreased slightly from 69.29% to 68.99% compared to the base models. The fully effective fractional imputation models lost the most balanced accuracy after manipulation dropping from 69.24% to 67.91%. Mean imputation models produced the highest sensitivity at 79.29% showing a strong ability to predict prolonged stays which is one of the main reasons for this research. The closest method after that was multiple imputation which predicted prolonged length of stays correctly 71.13% of the time on the testing data. FEFI again dropped the most from a sensitivity of 70.64% with unmanipulated data to 68.00% with manipulation.

Figure 10: Evaluations of models sorted after data manipulation sorted by balanced accuracy or sensitivity

Model with Grouped Variables Accuracy on Test Data

Obs	Model	Accuracy	Specificity	Sensitivity	Balanced_Accuracy
1	Random_Forest: CleanGroup	0.71265	0.70858	0.74293	0.72576
2	Random_Forest: SurveyGrou	0.70620	0.70105	0.74720	0.72413
3	Random_Forest: MultGroup	0.69055	0.68277	0.74842	0.71560
4	NN: CleanGroup	0.71235	0.71737	0.67497	0.69617
5	Logistic_Reg: CleanGroup	0.68745	0.68567	0.70072	0.69319
6	NN: SurveyGroup	0.70055	0.70274	0.68310	0.69292
7	NN: MultGroup	0.66845	0.66151	0.72014	0.69082
8	Logistic_Reg: MultGroup	0.67110	0.66502	0.71634	0.69068
9	SVM: CleanGroup	0.68615	0.68499	0.69481	0.68990
10	SVM: MultGroup	0.67200	0.66672	0.71127	0.68900
11	tree: CleanGroup	0.66470	0.65839	0.71169	0.68504
12	Logistic_Reg: SurveyGroup	0.67585	0.67438	0.68758	0.68098
13	SVM: SurveyGroup	0.67845	0.67826	0.67996	0.67911
14	tree: MultipleGr	0.66035	0.65651	0.68890	0.67271
15	SVM: MeanGroup	0.54955	0.51341	0.81849	0.66595
16	Bag: MultGroup	0.66566	0.69188	0.63945	0.66566
17	tree: SurveyGroup	0.68750	0.69407	0.63514	0.66461
18	Random_Forest: MeanGroup	0.56210	0.53077	0.79527	0.66302
19	Bag: CleanGroup	0.65966	0.70418	0.61515	0.65966
20	Bag: MeanGroup	0.65741	0.58755	0.72728	0.65741
21	Bag: SurveyGroup	0.64583	0.67690	0.61475	0.64583
22	NN: MeanGroup	0.46595	0.41081	0.87632	0.64356
23	tree: MeanGroup	0.41465	0.35432	0.86366	0.60899
24	Boost: SurveyGroup	0.56851	0.48348	0.65355	0.56851
25	Boost: MeanGroup	0.56724	0.45888	0.67560	0.56724
26	Boost: MultGroup	0.54690	0.57160	0.52220	0.54690
27	Boost: CleanGroup	0.53678	0.70283	0.37073	0.53678
28	Logistic_Reg: MeanGroup	0.88155	1.00000	0.00000	0.50000

Median Balanced Accuracy of Different Imputation Methods for Grouped Data

Obs	Imputation_Method	Median_Balanced_Accuracy
1	OnlyCleanObs	0.68990
2	Multiple	0.68900
3	FEFI	0.67911
4	Mean	0.64356

Median Balanced Accuracy of Different Models for Grouped Data

Obs	Model	Median_Balanced_Accuracy
1	Random Forest	0.71986
2	NN	0.69187
3	Logistic Regr	0.68583
4	SVM	0.68405
5	Decision Tree	0.66866
6	Bagging	0.65854
7	Boosting	0.55707

Median Sensitivity of Different Imputation Methods for All Models

Obs	Imputation_Method	Median_Sensitivity
1	Mean	0.79527
2	Multiple	0.71127
3	OnlyCleanObs	0.69481
4	FEFI	0.67996

Figure 11: Median balanced accuracies and sensitivities for all models trained

Median Balanced Accuracy of Different Imputation Methods for All Models

Obs	Imputation_Method	Median_Balanced_Accuracy
1	OnlyCleanObs	0.69133
2	Multiple	0.68578
3	FEFI	0.68005
4	Mean	0.66022

Median Sensitivity of Different Imputation Methods for All Models

Obs	Imputation_Method	Median_Sensitivity
1	Mean	0.72180
2	Multiple	0.70482
3	OnlyCleanObs	0.69040
4	FEFI	0.68534

Conclusion

This research shows that fully effective fractional imputation has potential to be a viable imputation method for predicting length of stay at hospitals. Although it did not train the best model after variable manipulation, it was able to produce results similar to other more popular methods of imputation in data science. Furthermore, with a data set as large and diverse as this one, using only clean observations resulted in the highest balanced accuracies. Before and after variable manipulation and across all models, using only clean observations resulted in the highest accuracies. When looking at sensitivity, which is important for imbalanced data like the one analyzed in this study, mean imputation proves to be the best model. The mean imputed data with variable manipulation predicted prolonged length of stays particularly well at almost 80% accuracy. This is something that should be analyzed more in future studies as these results are only based on one testing set rather than multiple meaning the results could be unfairly skewed based on the seed of the testing data. In the future, a larger sample of this data set should be used, and more variable selection and manipulation techniques should be analyzed. Unfortunately, computer processing power was limited at the time of research so the magnitude of the models trained had to be controlled.

With concern to predicting length of hospital stays, this is something that needs to continue to be studied as health care costs rise and the need for greater efficiency in health care develop. The models and research here promote these goals, but again there is still a lot of room for improvement.

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INFORMATION SYSTEMS AND DECISION SUPPORT - ABSTRACTS

AN EXPLORATORY STUDY OF THE CONTEMPORARY STATE OF CRYPTOCURRENCIES

ABSTRACT

Cryptocurrencies (perhaps most notably the Bitcoin) have outperformed most market expectations as a revolution in investments, and are considered the money of the future. Compared to traditional investments like stocks, funds, cash, and cash equivalents, cryptocurrencies manifest characteristics such as high return, high liquidity, highest privacy, and lowest barrier of entry. Moreover, the technology behind these is sophisticated and powerful, and therefore worth investigating.

Given that Bitcoin is drawing a lot of attention, investors would nevertheless be interested in identifying market trends - both long and short term - of cryptocurrencies, and in using this to make wise investment decisions. Despite the promise of cryptocurrencies, especially Bitcoin, there is skepticism surrounding such 'untraditional' investments. There are a few experts who predict the price of Bitcoin going down due to several factors, most importantly national legislations.

The focus of this research is to analyze the features of cryptocurrencies, as well as discover past trends and possible future directions for crypto currencies. The research includes but is not limited to Bitcoin. Specifically, it explores the relationships among price variables relating to Bitcoin, and assesses the overall trend. It also identifies indicators that would be ideal in predicting the price of Bitcoin in the future. If an indicator can provide an early signal of how the economy would react to Bitcoin, investors can act on this to trade the Bitcoin for profit. By extension, the same strategy could then be applied to other cryptocurrencies such as Litecoin, Ethereum, and NEM.

In our research the cryptocurrency data is downloaded from a public source for the years 2009 to 2018 for the variables of transaction count, on-chain transaction volume, value of created coins, price, market cap, and exchange volume. The data was analyzed using the Time series and correlation analyses.

Our data analysis shows that, overall, the number of unique bitcoin addresses used per day shows an increasing trend. This growing interest in mining Bitcoin has placed it as a highly ranked cryptocurrency. Though Bitcoin mining continues to be popular with thousands of new

investors and miners every day, significant challenges are predicted for the future. Newcomers should be careful about investing in cloud mining, especially in Bitcoin. For one, even though the transaction costs and the median fees for Bitcoin are currently low, including Bitcoin prices, investors should exercise caution in evaluating if the fall is triggered only by declining demand or by other intervening factors at play. It is important to consider the challenges that are predicted to arise in the future with respect to cryptocurrencies, specifically the Bitcoin.

Bitcoin has come a long way in the last few years since its existence, but it still has a long way to go before the digital currency gains wide acceptance as a virtual currency for goods and services. Some of the biggest future challenges in the arena lie in the areas of ease of use, price volatility, potential for theft, utilization in criminal activity, scalability, and lastly sustainability.

"Business Agility at Comcast: Continuous Development and Ideation"

Robert DiTirro, Director Digital PMO, Comcast Corporation, Philadelphia, PA

The author will discuss a pilot he is leading on "Business Agility" at Comcast. Put simply, this is the formation of a cross functional team much like a development agile team, but focused on front-end ideation (new ideas) for putting into the development pipeline. He will speak about the opportunity that generated the need for the pilot, how the team formed, and what the team hopes to achieve.

DIFFERENT CULTURE PERCEPTIONS OF BLATANT BENEVOLENCE ON SOCIAL MEDIA

People like to share different posts on social media. The posts on social media people always share range from traveling, special events, animals, funny video, conspicuous consumption, political views, sports, etc. Prosocial behavior, a type of behavior that benefits others instead of oneself, receives little investigation in the literature. Nowadays, people always see others post their prosocial behavior, such as mission trips, Go Fund Me page, birthday fundraiser, environmental protection, charitable activities for rare diseases, and help save the small animals, etc., on social media. However, posting the prosocial behavior on social media may be perceived controversial. People may have totally different view points on the sharing of prosocial behaviors on social media. This study explores the behavior that people post their prosocial behavior on social media. We first explore people's opinions on publicizing prosocial behavior on social media. Then we explore whether people form different countries will have different opinions toward posting the prosocial on social media. The cultural dimensions we focus in our research study are individualism and collectivism. We compare people from China, a country representative of the collectivism country, and people from the United States, a country representative of the individualism country, to investigate whether cultural differences will impact people's perceptions on sharing the prosocial behavior on social media. We are going to address the following research questions: 1). why people share their prosocial behavior on social media; 2). how people think about the sharing of the prosocial behavior on social media; 3). whether people want to make friends with those who share the prosocial behavior on social media. We go a step future and investigate whether people from different countries will have different opinions on these questions. We investigate the more specific questions: 1). whether people from different countries will have different opinions on sharing the prosocial behavior; 2). whether people from different countries think about the posting of prosocial behavior differently; 3). whether people from different countries all are more likely to make friends with those who share their prosocial behavior on social media. We will apply interview as the method in the study. Because interview can explore the phenomena and we can generalize the patterns from the interview method. We select our participants from China and the U.S. We compare the cultural difference between the U.S and the China. Our study will contribute to the knowledge of prosocial behavior on social media in information system research literature.

Keywords: Blatant benevolence, interview, cultural difference, social media

EMPIRICAL INVESTIGATION OF CLOUD ERP ADOPTION IN HEALTHCARE SERVICES

Recently, Cloud ERP system adoptions accelerated in many service and manufacturing industries. However, there is little research investigating the extent of Cloud ERP adoption in healthcare industry. Our literature review showed that many healthcare organizations plan to implement Cloud ERP systems, despite the fact that the actual rate of adoption is at a slower pace than the other industries. We investigate motivating and hindering factors for Cloud ERP adoption in healthcare organizations. While the managers of different types of organizations may consider a common set of factors for Cloud ERP adoption (e.g., cost reduction, functionality, convenience, level of security), their preferences and priorities could be different. Our literature review showed that main factors that are considered when adopting a Cloud ERP system are 1) cost and support, 2) System speed and performance, 3) System upgrade and enhancement, and 4) ERP mobility. On the other hand, we found that main concerns preventing the adoption of a Cloud ERP system include: 1) Transparency and data privacy, 2) Data security, 3) Vendor lock-in, 4) Integration difficulties, and 5) Organizational challenges. We will interview managers of select healthcare organizations to find out which factors are more central in healthcare organizations in the adoption of a Cloud ERP system.

Keywords:

Cloud ERP, healthcare, adoption

INTEGRATING CROSS CORRELATION FUNCTIONS AND LAGGED REGRESSIONS WITH LONG SHORT-TERM MEMORY NETWORK TO PREDICT STOCK VALUE

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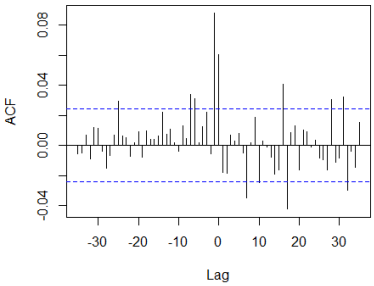
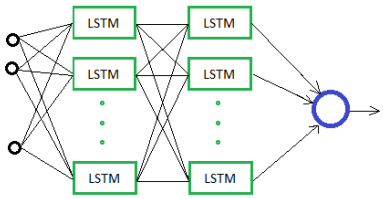
Keywords: Lagged correlation, LSTM, Stock Prediction

Abstract

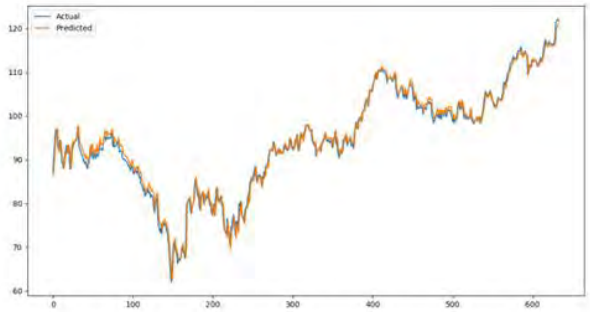
In this study, the effect of commodity prices, bonds, and national and foreign market indices on the US stock prices have been evaluated. Besides looking at U.S. market prices, we want to make sure global markets affirm what we see in our own market. The major foreign markets we look at are Europe and China which are the U.S. main trading partners, and therefore, our economies share similar cycles. We used Cross Correlation Functions and Lagged Regressions to select the best correlated lags of market values and indices with stock prices. We then developed an LSTM (Long Short-Term Memory) neural network to predict daily stock prices. LSTM is a powerful model in predicting multi-variate time series. The correlated lags of the market indices and values used as inputs to the network improved the daily stock price prediction.

The figure on the right is an example of a CCF function that shows Chevron Corporation (NYSE: CVX) stock value has a weak positive correlation with Lag -1 of Shanghai Index. The lags with the highest correlations were fed into a regression model, and variables whose p-values were significant were selected. Those variables were then used as input to the LSTM network. Our network has 2 hidden layers each with 50 LSTM neurons and a fully connected output layer. We used 15 years of daily market values from 2000 to 2014 for training the network, and 3 years of data from 2015 to 2017 for testing. The following graphs show the daily stock value prediction for Chevron Corporation with and without lagged correlations.





Daily stock value prediction using an LSTM network trained with all variables (no lagged correlation)



Daily stock value prediction using an LSTM network trained with selected lagged correlations

Root Mean Square Error of the daily prediction with all variables and no lagged correlation is:
RMSE: 2.47767

Root Mean Square Error with the correlated lags of selected variables is:
RMSE: 1.50381

We can see that RMSE falls significantly by removing the variables that did not have correlation with the stock value and including the most correlated lags of selected variables.

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Laptops vs. Tablets: A Performance-Based Assessment of Task-Technology Fit

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Many corporations have traditionally provided windows-based laptops to their employees along with IT support for these devices. Since the introduction of iPads in 2010 there have been many questions about how they can be used in companies and whether they will replace laptops as the principal computing device. The use of tablet computers in the workplace will likely increase if they are found to perform as well as laptops on more complex business analysis tasks. There is no previous research that has addressed the comparative performance of laptops and tablets on such tasks. For this study we selected business intelligence (BI) tasks as being representative of the type of analytical tasks that practicing managers might perform.

We developed a set of integrated experimental procedures to enable us to test how actual business professionals perform BI tasks of varying complexity on laptop and tablet computers. We considered three treatments for completing the experiment: subject seated using a laptop, subject seated using a table, and subject asked to stand and walk slowly using a tablet (to test the effect of mobility).

The theoretical basis for our research is derived from the perspective of the task technology fit (TTF) model. We present a modified TTF model, or "Performance-based" TTF, which is used to guide this research. To test this model, we report on the results of a field experiment that evaluates user performance (accuracy and time), satisfaction and confidence in using tablets on Business Intelligence (BI) tasks of varying complexity and compare the results to the current standard (laptops). The proposed methodology takes advantage of advances in

cloud-based systems to conduct field studies of actual users performing complex tasks using a mobile lab. Since we can now obtain experimental performance data, we can turn the TTF model around, with performance driving fit and not vice versa.

The study population was restricted to working professionals in a business environment. Professionals working for SAP Corporation were excluded, since we used SAP software for this study. A pilot study was completed to determine the viability of the experimental procedures. Eighteen individuals completed the pilot. Their performance and feedback led to some minor modifications in the experimental procedures.

There were 239 subjects that completed the study. The sample shows a representative mix of gender, age, education, work experience, and business positions. There is a good balance between respondents from small, medium and large companies in the sample.

In terms of accuracy, laptop subjects performed significantly better than tablet subjects in both stationary and mobile computing environments when completing BI tasks of basic and medium complexity. No difference in accuracy was found between laptop and tablet subjects in both computing environments concerning tasks of advanced complexity. The latter finding may be due to the difficulty of the question. Laptop subjects also had significantly higher total number of tasks answered correctly as compared to tablet subjects in both computing environments. From a comparative performance perspective as measured by accuracy, laptops are preferred to tablets for completing BI tasks of varying complexity.

Concerning the second performance measure, no significant difference between laptop and tablet users in both computing environments concerning time used to complete BI tasks of varying complexity was found. Laptops had significantly higher levels of user satisfaction and confidence over all levels of BI task complexity and overall for completing the BI tasks. Taken

together, the performance accuracy, user satisfaction and confidence results provide strong evidence that laptops are a better fit than tablets in completing BI tasks. Interestingly, the results also show that tablets fit BI tasks equally as well in either stationary or mobile computing environments.

Leveraging Innovations in Real-time Data Collection to Support Sustainable Decision-Making in Indoor Agricultural Production

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For many applications, sustainability requires the ability to make highly informed real-time decisions based on large quantities of continuously collected data from many diverse data points. Fortunately, (IoT) technology (Internet of Things) now makes this kind of data collection both possible and cost-effective using low-cost sensors and controllers linked via a flexible, low-cost communications grid.

One of the questions is how to determine exactly what data is needed to support the decision-making process, and how the various data points relate to one another. A pilot project in southeast Pennsylvania is looking at these questions and the role that IT can play in the fast-evolving field of high tech indoor agricultural production. We share some preliminary results of the application of IoT technology at a plant production facility outside of Philadelphia.

MEASURING PARADOXES OF TECHNOLOGY

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Abstract

With the development and proliferation of the Internet, mobile devices, and smart devices, technologies are ubiquitous than ever before. Our relationship with technology will only become more complex. The benefits of technologies are well documented. The "darker side" of individual usage of technologies draws attentions in media studies and sociology fields (Turkle, 2011). Although not the main focus in Information Systems field in the past, more and more studies have paid attention to the job stress caused by new information technology – technostress (Ayyagari et al., 2011; Hoeven et al, 2016; Tarafdar et al., 2007; Tarafdar et al., 2010; Tarafdar et al., 2015). Other negative effects of information technologies include computer and Internet addition (Lee et al., 2014; Li et al., 2012; Turel et al., 2008; Turel et al., 2011, Young, 1998; Xu et al., 2012), information and social overload (Maier et al. 2012; Weinert et al, 2012), cyber bullying (Juvonen and Gross, 2008; Schneider et al., 2012), work-family conflicts (Galluch et al., 2009), and privacy invasion and identity theft. Not only newer generations of technologies arouse users' feelings of both positive and negative, but users develop habits both good and bad when using technologies (Turel and Serenko, 2011). It seems that using social networks makes people feel miserable (Kross et al., 2013). Heavy users of Facebook.com had hard time developing mature interpersonal relationship (Foubert and Mason, 2014). Examples of paradox phenomenon are plenty. Observing the dual effects of technology, researchers have raised the concept of paradoxes of technology (PT) (Mick and Fournier, 1998), which include eight pairs of polar effects of technologies on users (Control/chaos, Freedom/enslavement, New/obsolete, Competence/incompetence, Efficiency/inefficiency, Fulfills/creates needs, Assimilation/isolation, and Engaging/disengaging). Similar paradoxes were identified in mobile technology usage.

Paradoxes can be the cause of user behavior, either adoption or rejection. They are also the result of interplay of personal values, cultural, educational, social, economic, political, and technological forces (Schiffman et al., 2003; Ting et al., 2005). The dual effects of technology should not only be recognized but examined in a much closer manner. In order to better understand this phenomenon and make comparative examination across technologies possible, we need a measure for paradoxes of technology. In this research we propose a measure for paradoxes of technology. We take a holistic view of technology and try to develop a complete scale for PT by following the general steps of scale development and recommendations of best practice in this research (DeVellis, 2012; Worthington and Whittaker, 2006). Research plan is outlined in the following table and partial result may be available during conference presentation.

Steps		**Status**
1	Determine clearly what to measure	Done
2	Generating an item pool	Done
3	Determine a format of the measure	Done
4	Expert review	Currently engaged in
5	Inclusion of validation items	Currently engaged in
6	Focus group	April 2019
7	Pilot study	May 2019
8	Item evaluation	June 2019
9	Final scale	August 2019

Developing a valid and easy to use measurement for PT is important to deepen our understanding of innovation diffusion and technology adoption. It can also help shed light on designing better technologies that with more positive traits to sustain continued use and are beneficial to the whole society.

Keywords: paradoxes of technology, scale development, individual use of technology, the dark side of technology

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Technology Enablement, Distracted Students and Disabilities

As a term instructor and also a parent of a child with autism, I am seeing more and more students in my classes struggling with traditional methods of learning in the academic setting. Requirements need to be mandated to provide students more time to complete standardized assessments (i.e. exams), reserve a location where they can be monitored (e.g. Disability Services Center), and materials that should be universally designed and accessible.

The purpose of this abstract and associated paper will be to provide educators and instructors ways to complement technologies into a curriculum to accommodate students with particular needs. For example, students with gross motor core challenges need not struggle and be frustrated with handwriting. E-machines (e.g. Chromebooks) can be deployed to these students to enhance their adaptive learning experiences. Teachers need to be educated and trained on these adaptive learning choices.

With the advent of online education and training, materials need to include a comprehensive framework to guide the design of learning goals, assessments, and methodology that considers the diversity and needs of learners. This will ensure a more inclusive program and awareness by educators to collaborate in accessibility strategies for current and future curriculums.

THE NATURE AND CAUSES OF CYBER BREACHES: AN EMPIRICAL STUDY

ABSTRACT

Cyber security refers to technologies, processes, and practices that are designed to protect networks, devices, programs, and data from attack, damage, or unauthorized access. Cyber security may also be referred to as information technology security. A difficult challenge in cyber security is the ever-evolving nature of the security risks themselves. Traditionally, most organizations and governments have focused their cyber security resources on perimeter security to protect only their most crucial system components and defend them against known threats. However, this approach does not enable organizations to keep up with the pace at which the threats are advancing and evolving.

The introduction of universal regulations such as the European Union's General Data Protection Regulation (GDPR), New York's Cybersecurity Requirements for Financial Services Companies, and Australia's Notifiable Data Breach (NDB) scheme emphasize the importance assigned to the phenomenon. The rationale behind these regulations is to help organizations understand their specific risks and plan for their systems to be resilient to cyber breaches. Most importantly, they emphasize the need for organizations to better protect data privacy and security.

In the current research we use the information on data breaches in 4,362 companies for the years 2004-2018, from a publicly available source. Using empirical data, we analyze the phenomenon of data breach in terms of the trend over the years, the types of breaches that are most serious and prevalent, and the sources of the breaches in terms of the industry and the country of occurrence. We use the independent variables of the year of breach, the type of breach, the source of the breach, the industry that the breach related to, and the country in which the breach occurred, and study the influence on the dependent variable of the number of records breached.

Our results offer interesting insights at a global level. The analysis indicates how the number of data breaches peaked in 2003, reduced from 2003 to 2005, stabilized from 2005 to 2017, and rose again in 2018. Among countries, the United States has the most number of data breaches. Among industries, the web, technology and financial industries experienced more data

breaches than others, with the rate expected to increase over the years. Among the types of breaches, account access and identity theft are prevalent in most countries. The source of data breach, in contrast, shows great variation among industries. In the web industry, hacking is the most prevalent source, while in government it is accidental loss.

Our study implies that there is a need for a concerted, global effort towards cyber security. Cyber security solutions need to encompass technological as well as behavioral measures. Employees need to be trained in adopting caution in handling data. In addition to safeguarding against hacking, proper and legitimate use of data and protection of privacy are integral concerns. Considering the variety in types and sources of breaches mushrooming worldwide, there is a need for a systematic and analytic approach to understand the nature and causes and devise a targeted strategy to ensure security and privacy.

Keywords: cyber security, data breach, type of breach, source of breach, privacy

UNSUPERVISED CLUSTERING ON E-COMMERCE USERS: THE VALUE OF ONLINE CUSTOMERS

Abstract

Because of its fickle and elusive features, customer value is a constant topic in businesses for a long time. Unlike traditional perspective, which concentrates on achieve high customer satisfaction, modern view of customer value focuses on providing specific targeted advertising dynamically and enhancing customer belongingness. The explosive growth in data volumes and complexity of information categories has created a unique opportunity for the use of data mining techniques. The main purpose of this study is to apply specific RFM model on customer data and provide decision support for e-commerce companies seeking development. Customers are clustered into different patterns by using *k*-means clustering algorithm. Each pattern is defined according to the results for different segments, and then relevant recommendations are put forth as references. Further researches will have concerns on clustering reliability and subdivision, as well as deep analysis on strategy making process.

Keywords: e-commerce, customer value, data mining, customer clustering, RFM model

Introduction

Along with the rapid development of information technologies such as internet and interactive Web applications, e-commerce is taking over from traditional marketing(Ward, 2013). Accordingly, large data sets have been collected by either e-commerce companies or online advertising agencies(Tucker, 2010). Unlike traditional retail stores, which are difficult to collect the complete information of customers, e-commerce companies can easily capture the data by monitoring the customer activities such as browsing records, purchasing history and online searching on website(Chen, Sain, & Guo, 2012). Each customer is no more treated as an individual walk-in guest, but an interactive node in a large network that can be retrieved at any time.

Some researches focused on the impact of online customer reviews on e-commerce(Hu & Liu, 2004)(Mudambi & Schuff, 2010)(Zhu & Zhang, 2010), while other researches have concerns about pricing strategy(Ghose & Sundararajan, 2006), business process innovation(Yu, Pelaez, & Lang, 2016), and sales forecasting(Kulkarni, Kannan, & Moe, 2012). In this paper, however, the

purpose is to classify the online customers by differentiating their value. According to the article "*Customer value: The next source for competitive advantage*" written by Woodruff R. in 1997(Woodruff, 1997), the next major source for competitive advantage likely will come from more outward orientation toward customers, and thus implementing the customer value strategies is critically important for business decision making process. E-commerce owners are eager to figure out a common question from the seemingly disorganized customer data set in their businesses: what is the feature of most/least valuable customers? Through classifying registered users into high-value, low-value, and valueless groups, e-commerce companies can customize specific advertising strategies, concentrating limited resources on high-value users and maximizing profits(Khajvand, Zolfaghar, Ashoori, & Alizadeh, 2011). Plotting strategies for valuable customers has become an essential way to increase core competence.

In this research proposal, we present the application of unsupervised learning technique on RFM model and explore the theoretical background. In order to demonstrate the validity of customer value classification, customer data set from a particular e-commerce company has been chosen as an example. Data information with principle parameters will be displayed and different clustering techniques will be shortly discussed. Based on the analysis result, further niche marketing strategies and advertising methods can be generated for e-commerce customer value management.

Background and Method

Although data mining techniques are popular in customer clustering for large e-commerce companies, many small ones are still lack of expertise to apply such techniques on their business(Chen et al., 2012). Were they to do so, they can easily avoid wasting resources on valueless customers(Shih & Liu, 2003). Many e-commerce companies have shared their customer data on online research platform such as Kaggle.com for technical help. The major point of this study is to filter out the most influential factors that have strong impact on customer value calculation, and then apply data mining technique to cluster.

We therefore propose the following research questions:

RQ1: How can clustering methods be applied in a unique way to identify customer value according to e-commerce customer data?

RQ2: What business recommendation can be provided to customer patterns defined by clustering methods?

To improve the marketing strategies, many researchers applied machine learning techniques associated with classical customer value models: RFM (Recency, Frequency and Monetary) model(Wei, Lin, & Wu, 2010) and CLV (Customer Lifetime Value) model(Gupta et al., 2006). The advantage of RFM model is that it focuses on the customers who have high recency and frequency, therefore standing for those who are very likely to return and buy again(Wei et al., 2010). In this case, we propose an improved RFM model that suitable for e-commerce data. According to this model, R is defined as "the number of weeks that have passed since a customer last purchased"(Christy, Umamakeswari, Priyatharsini, & Neyaa, 2018); F is defined as "the number of purchases by a customer in the last 52 weeks"(Christy et al., 2018); M is defined as "the total value of all purchases by a customer in the last 52 weeks"(Christy et al., 2018). Considering that the length of membership is an influential factor of customer value, we add an additional parameter L as "the number of weeks since a customer has become a membership" into this model(Khajvand et al., 2011)(Christy et al., 2018). Likewise, because different merchandises have varied discount rate in a period of time, parameter D defined as "the average discount rate of all the purchases by a customer in the last 52 weeks" is added into the model as well(Khajvand et al., 2011)(Christy et al., 2018). These five parameters (R, F, M, L, D) consist of the primary indicators to identify customer value(Yang, 2004).

Compared with various clustering algorithms(Sehgal & Garg, 2014)(Cheng & Chen, 2009), improved k-means clustering algorithm(Yadav & Sharma, 2012) is employed in this case on the basis of RFM model. We propose in our final paper to split the process into several stages

- Stage 1: customer data in a particular period of time will be exported and cleaned, discarding the purchasing record with transaction amount that is zero or negative.
- Stage 2: calculate and assign the value to the five parameters.
- Stage 3: apply improved k-means clustering algorithm on unlabeled customer data.
- Stage 4: review the clusters and conduct the feature analysis on clustering result.

Each cluster has distinct feature, which can be analyzed to help e-commerce companies mining the patterns of their customers. There are four patterns that can be defined for meaningful insights:

High-value loyal customers, high-value churn customers, potential high-value customers and low-value customers(Dursun & Caber, 2016). In the RFM model scoring analysis(Pakyurek et al., 2018), High-value loyal customers have low D (expensive merchandises usually have low discount rate) and R, high F, M and L. According to Pareto Principle(Harvey & Sotardi, 2018), these customers account for small fraction of total customers but contribute most profits. This is the ideal customer pattern for e-commerce companies that should have highest priority to access resources(Griffin, 2002). High-value churn customers are those who are leaving(Zhang, Gao, & Huang, 2009). They have either low D or high M but high R and low F. Although it is difficult to increase customer retention rate, their customer lifecycle can be extended by using retargeting marketing strategy. Potential high-value customers have low D, L and F but high M. They are new to the membership and have a certain amount of expenditure. They can be updated to high-value loyal customers through satisfactory services provided by e-commerce companies. Low-value customers are those require least resources. Most of them have low M, L and F but high R and D. They are made of one-time discount consumers or customers who are unsatisfied with the e-commerce company(Khajvand et al., 2011)(Dursun & Caber, 2016).

By clustering customers into these four patterns, e-commerce companies can generate customized campaigns and services to each customer segmentation(Chen et al., 2012). For example, better services such as one-on-one assistance and reserved hot collections can be provided for high-value loyal customers. Furthermore, monitoring the mutual changes among patterns is essential for business owners to better understand the trend of customer value toward to product categories. High-value churn and potential high-value customer patterns give a strong hint of what customers like and dislike in terms of the products, providing valid information for successful business transformation in the future.

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INFORMATION SYSTEMS AND DECISION SUPPORT - PAPERS

A CASE STUDY-BASED ANALYSIS OF INNOVATIVE CLOUD TECHNOLOGIES IMPLEMENTATION: CHALLENGES, TOOLS AND BENEFITS OF AMAZON AWS

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Abstract

Amazon AWS is the biggest provider of cloud services in the world, with a higher market share than its three main competitors combined. The goal of this study is to find the reasons the organizations prefer AWS to other cloud providers. We use business case studies of the organizations that adopted AWS to analyze the challenges and the technology needs that make them migrate their IT architecture to the cloud. We identify the most common cloud tools that the organizations select and the reasons that make them decide in favor of AWS in choosing their cloud provider.

Key words: *AWS, cloud services, cloud technology*

Review of Literature

Cloud technologies are included – in one way or the other – in most businesses. Most organizations are either using the cloud services, or looking for their way to the cloud (Gaur, Gaud, and Jain, 2017). Cloud technologies have a brief, but eventful history. Although the term virtualization existed in 1990s, the modern understanding of the cloud and the cloud technologies did not come until the late 2000s. The term "cloud" itself was introduced and spread in the media in 2008 by Eric Schmidt of Google (Arutyunov, 2012). Within three consecutive years 2006-2008 Amazon, IBM, and Google launched their cloud platforms (Foote, 2012). Microsoft introduced Azure in 2008 by the name of "Project Red Dog" (Luescher, 2018), but did not complete the project till a couple years later.

All cloud pioneers differed in the services that they offered and had very different business models. Google came up with Google Docs, a unified cloud service for storing and managing the documents and spreadsheets. IBM launched SaaS and IaaS on its own platform, named IBM SmartCloud for Social Business and IBM Business Storage Cloud (Harvey, 2017). Microsoft designed Azure, a Windows-based platform that originally supported mostly Microsoft products – Windows as the OS, MS Visual Studio .NET as the development platform, and SQL Azure relational database.

Amazon Web Services (AWS), first launched in 2006, had not only the first comer advantage, but more independence from any specific platform. AWS Elastic Compute Cloud (EC2) instances could run mostly any OS, and its Simple Storage Solution (S3) was scalable and compatible with any platform.

According to the 2017 data, Amazon currently occupies 34% of the market – more than its next three competitors combined. Microsoft Azure's share is 11%, IBM and Google cloud are 8% and 5% respectively (Rama, 2017). Amazon offers over 90 web services in different areas, including EC2, storage solutions, relational and non-relations database systems, and data analytics tools. In addition to the specific services AWS includes multiple tools for networking, scaling the cloud infrastructure, managing it, and many other. With the variety of services offered, AWS are not specifically tied to any platform. For example, an EC2 instance can run virtually any OS – if there is no desired operating system in AWS library, there are thousands of machine images in Amazon marketplace, many of which are free. What are the reasons to such popularity, and what makes businesses choose AWS as their cloud service provider? In this research we analyze the case studies of the companies who adopted AWS cloud services and migrated entirely or partially to the Amazon cloud. We use the analysis of the business cases to answer the following research questions:

RQ 1. What are the business challenges and issues that make organizations seek cloud services such as AWS?

RQ 2. What are the common tools that are being deployed from AWS to meet business requirements?

RQ 3. What are the benefits of using AWS to businesses migrating to cloud environment?

Methodology

According to Turban, King, Lee, Warkentin, and Chung, 2002, a purchase process includes four steps: identification of needs, information search and evaluation of alternatives (often combined in one stage), purchase decision, and post-purchase maintenance (Figure 1). This model is applicable to any purchase, including the purchase of a service such as the cloud services, and can be mapped to our research questions.

(A). In Turban's model, the shopping process starts with the identification of needs. In this study we identified the issues that each company experienced when considering the Cloud technologies (RQ 1).

(B). The information search step in Turban's model was mapped as the expectations that the businesses had in searching for the cloud service providers and the degree to which AWS matched these expectations.

(C). Evaluation of alternatives was mapped to the services and solutions that AWS provided that matched the organizations' needs better than the alternative cloud solutions (RQ 2).

(D). The Maintenance step was mapped as benefits and outcomes for the companies after switching to the AWS cloud (RQ 3).

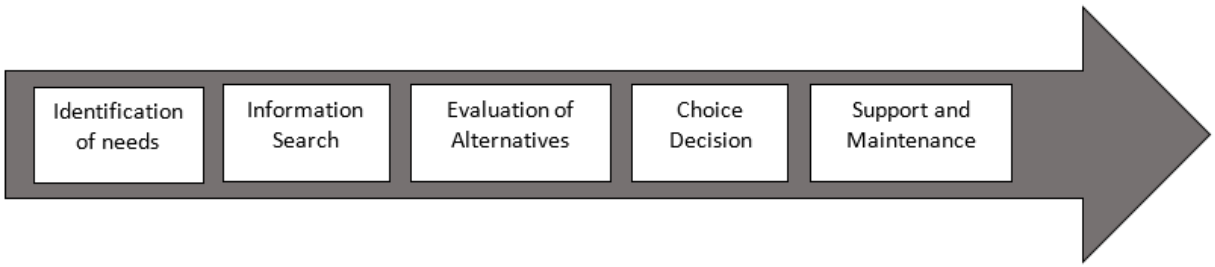

Figure 1. Online purchase process model by Turban et al.

This study includes the analysis of 51 case studies of companies that had successfully implemented changes at their company that utilized some AWS service. The case studies were reviewed for three broad categories that mirrored the three research questions: 1) "business challenges/issues that make organizations seek cloud services such as AWS", 2) "the common

tools that are being deployed from AWS to meet business requirements", and 3) "the benefits of using AWS to businesses migrating to cloud environment." As discussed earlier, these questions emerged from the general purchase process model. A thematic analysis was conducted on each of the three lists and two levels of refining /reducing to produce a final list of themes. Counts and percentages for each theme were then generated using the original case study data. The tolls that were utilized were also collated into groups based on their functionality.

The 51 case studies included companies from the Fortune 100 down to small startups and from local companies to the ones headquartered and conducting business around the world. The case studies were all self-reported and publically available from Amazon.

Findings

RQ 1. What are the business challenges/issues that make organizations seek cloud services such as AWS?

As shown in Table 1, many organizations faced lower than desired scalability, flexibility, and speed, high cost of support, insufficient data management capacity, lack of global reach, and many other challenges with their on premise IT architecture.

Table 1

Needs that Make Organization Look for New IT Solutions

Need for	Count	Percent
Increased speed or reduced latency	25	49%
Scaling/provisioning for changes	25	49%
More data capacity and processing	12	23.5%
Improved integration and consistency	11	21.6%
Reduced costs and resources	10	19.6%
Maintaining privacy and security	10	19.6%

Increased focus on customer service	9	17.6%
Improvement in a certain platform (BI, CRM, data storage, etc.)	8	15.7%
High availability	6	11.8%
Rapid development	6	11.8%

The number one challenge reported by the organizations was the lack of fast scalability. Most organizations reported the need to accommodate the planned or unplanned shifts in their traffic. For example, a retail company may experience high demands during the holiday seasons (such as Thanksgiving and Christmas). An Internet provider or a TV service provider may experience a much higher demand during certain hours; as such, the amount of traffic at 4 am is much lower than that at 6 pm. The most common on premise solution in such case is to provision for the maximum traffic, which means that during the slow days/times the provisioned resources are wasted. 49% of the organizations desired to achieve fast scalability, or the ability to instantly scale out adding more resources when the demand is high, and scale in when the demand decreases. The same number of respondents (49%) reported insufficient speed and higher latency in their on premise solutions.

In addition to wasted resources, the cost of maintenance of an on premise data center is very high. As reported by 23.5% of the organizations, moving their data centers would help them to substantially reduce the cost of maintenance and perform the same functions at a fraction of cost. The reported need of eliminating the on premise data centers often overlapped with the need to reduce other costs (reported by 19.6% of organizations), such as the cost of entry and the cost of research and development.

It is worth mentioning that 21.6% of organizations were in search for more consistent solutions, which included consistency between the US and the international markets and consistency among the various IT modules, such as document management and data analytics.

Discussion of Findings

There are several market challenges in current IT infrastructure models of organizations that are making agility in response to these situations difficult. Organizations are looking for cloud solutions in general and AWS in particular due to many reasons. Some of these are: lack of flexible IT architecture that could quickly scale spike in demands, need for robust IT infrastructure to reduce redundancy and maximize capacity utilization, lack of transparency for clients in terms of network connected devices, lack of solutions that lead to more data storage at reduced cost.

One of the cases that was analyzed for this study, RAMCO, needed to be able to provision servers quickly for its customers and meet the service-level agreements (SLAs) that the company offers its customers for backup and disaster recovery. RAMCO, as typical of many other organizations in the industry, ran its own data center and had to contend with the high cost of power, capital expenditures, and security. To be competitive in the market, RAMCO, started looking for a service provider that could offer a cost-effective environment and meet the company's need for high availability, resiliency and security (AWS, 2018).

Similarly, at SEACO the infrastructure in their data centers was old and slow, and outages were causing headaches for the business. It took the company four days to complete its monthly billing cycle, and the SAP systems remained unpatched for years due to the infrastructure's lack of agility to run such a project. The company was actively looking for a solution where these routine things could be handled more efficiently. SEACO needed lower latency and higher performance than what it received through its traditional on-premises data center facilities.

RQ 2. What are the common tools that are being deployed from AWS to meet business requirements?

Most organizations using AWS run Elastic Compute Cloud (EC2) instances (Table 2) and report that AWS EC2 allow great flexibility in instances operating systems and the configuration they run (73%). There are preconfigured Amazon Machine Images (AMI) that run IIS only, or IIS with MS SQL Server, or an Apache server with MySQL. If there is no specific machine image that an organization needs, it can look on the Amazon marketplace. There is a high number of

AMIs available there that were created, configured, and successfully deployed earlier by other organizations with the similar needs.

The second most common set of tools (56%) requested by the organizations are the scaling tools group; namely, the "big 3" – Auto Scaling, Elastic Load Balancing – and Cloud Front and other cloud support tools such as CloudWatch. These tools are needed to organize and manage the cloud. For example, if an organization runs EC2 instances and needs to scale the network when the demand increases or decreases, this can be achieved with AutoScaling used to add or remove instances depending on demand, Elastic Load Balancing used to distribute the load among the instances, and CloudFront used to deliver content through the network.

The third most common AWS tool used by the organization is the Simple Storage Solution (S3), although there is a demand for other storage solutions, such as Elastic Block Storage (22%).

A substantial number of organizations (26%) reported the need for networking tools, such as Virtual Private Network (VPC) and Route 53.

Table 2

Commonly Required AWS Tools

Tool or Category	Count	Percent
EC2	37	73%
Scaling tools (Auto Scaling, ELB, CloudWatch, CloudFront, ElastiCache, CloudFormation, ECR)	28	56%
S3	22	43%
Networking (VPC, Route 53, DirectConnect)	13	26%
Data warehouses, data analytics (RedShift, Hadoop, Elastic Map Reduce, Glacier, Kinesis)	12	24%
Security (IAM, CloudTrail, Certificate Manager, Cognito, Cloud HSM)	12	24%
Development tools (CodePipe, Lambda, BeanStalk, CodeCommit, CodeDeploy,)	11	22%
EBS	11	22%
Relational DB Solutions	10	20%

Messaging services (Simple Notifications, Simple Queue, Simple Email)	9	18%
Non-relational DB (DynamoDB)	6	12%
Government Cloud	1	2%

Discussion of Findings

The above mentioned four categories of AWS tools (EC2, S3, cloud organization tools and networking tools) can be applicable to any business, which is likely the reason they are in higher demand than other tools. Some tools listed in the table can be combined in, or separated from other tool groups, which means that the categories in Table 2 are somewhat conditional.

Cloud support tools such as AutoScaling and ELB are almost never used as standalone tools; therefore, they were combined in one category. At the same time, an organization does not have to adopt all of them at once; e. g, it can use AutoScaling, ELB, and CloudFront, but not ElastiCache.

We outlined S3 as a separate category; however, different types of storage solutions can be combined in one category. AWS offer multiple types of non-database data storage, such as S3, EBS, and the AWS file storage system.

The use of Virtual Private Cloud (VPC) was reported only by 26% of organizations; however, these data may be inaccurate. VPC is used in virtually any cloud architecture where EC2 instances are involved. In the current AWS architecture, an EC2 instance should be placed in a subnet inside of a VPC upon its creation.

RQ 3. What are the benefits of using AWS to businesses migrating to cloud environment?

In analyzing the organizations that chose AWS as their cloud service provider, we attempted to determine what makes them decide in favor of AWS. There is no connection between the numbers in Table 1 and Table 3. For example, an organization may report that it needs to improve its data storage solutions. Scenario 1 – it may adopt AWS solutions because they are better than the ones offered by other cloud providers. Scenario 2 – the organization may find the

AWS solutions similar to the ones offered by other cloud providers, but there is another reason that tips the scale in favor of AWS – for example, a better scalability of the data connections or higher availability of data. Shown in Table 3 are the reported reasons for the organizational decisions to adopt AWS technologies.

We made and interesting discovery that many companies reported certain needs on the first step of their cloud migration (searching for a cloud provider) and further reported even more needs that they were able to fulfill with AWS. As such, a company that was looking for reducing its IT maintenance cost and dedicating more time to customer support, reports that implementing an AWS solution fulfilled all these demands and in addition helped to reduce the latency in communicating with its customers. Similar to that, a company that reported increasing speed and flexibility as its primary goal, may also report to have found a better security solution.

Table 3

Reasons for Choosing AWS

Business Reason for Using AWS	Count	Percent
Fast Scalability	24	47%
Get Rid of larger Data Centers	18	35%
Faster development and deployment	15	29%
Technology advantage	14	27%
Global Consistency	8	15.6%
Analytics	7	13.7%
Share Data/Documents easily	6	11.7%
Security/Compliance	6	11.7%
Reduced Costs	3	6%
Better System Information	2	4%
Low Cost of Entry	2	4%
The large number of AWS Partners	1	2%

Discussion of Findings

The cloud services provide incentives for usage to businesses that are dealing with a fluid demand from customers and competitive bottom lines to infuse into IT infrastructure. In our review of AWS cases studies, we identified several benefits of using cloud services such as: fast deployment of products and services, pay-for-use model of use, lower costs of deploying solutions, and instant scalability. In case of Amazon Prime using AWS, the organization required an architecture that can quickly scale and handle spikes in demand based on what was being streamed (AWS, 2018). The organization also wanted to ensure that it provides seamless experience to user while inserting ads in videos and collecting analytics for the ads. AWS was able to deliver this through using AWS Elemental that combines deep video expertise with the power and scale of the cloud, enabling the media companies to deliver premium video experiences. It also uses AWS Elemental MediaTailor that allows to monetize video content through the insertion of targeted advertising. Amazon Prime was able to accomplish its goals by using Amazon Dynamo DB, the key value store for the streaming platform. It provides the capability to quickly write to and read from a highly scalable back-end database (AWS, 2018).

Our data analysis suggests other benefits of using cloud services to meet customer demands as quickly as possible. Some of these include improved capacity utilization and, just as importantly, a possibility to extend and deliver services to customers much more rapidly. Organizations can leverage the infrastructure created by AWS to easily avoid the need to buy expensive hardware and are able to decrease time to market with flexibility of adding data as required.

One of the cases reviewed for this study, *Impossible Solution*, required a business solution to address the need for very low latency between the server and the client and scalability in real-time while providing consistency in international market. The organization started using Amazon Simple Notification Service (Amazon SNS) and Amazon Simple Queue Service (Amazon SQS) for small parts of their rendering infrastructure. This allowed requests to be analyzed and routed to a server running on Amazon EC2. In such model the video is rendered in real time and is returned to the user or uploaded to Amazon S3, YouTube, Facebook, or another destination. Amazon DynamoDB is used for fast lookups in this case. Impossible Solution's use of AWS resulted in multiple benefits on the operational front. Some of these include immediate improvements to its infrastructure's elasticity since moving to AWS – the load patterns vary

greatly, sometimes increasing by 20 times within an hour. Using AWS, the system scales to the exact number of servers required for a given load. The estimate cost savings with AWS was about 40 percent to 50 percent. Impossible Solution also realized that its security is much enhanced with features like dedicated instances and separated infrastructure.

Some other reported benefits of using cloud services include rapid elasticity offered by the network, ubiquitous network access from all geographical regions, low-cost disaster recovery and data storage solutions, on-demand security controls features available, real time detection of system tampering, and rapid re-constitution of services creating flexibility (Subashini and Kavitha, 2010). Mahindra Satyam (AWS, 2018) approached Amazon for a client's need to develop a way to share documents with its partners. The business need was to develop the capability to search and download documents, integrate with Enterprise Systems, to retrieve documents and metadata for upload, and authenticate all users against the Enterprise Active Directory (AWS, 2018). AS a part of the solution, Amazon Elastic Compute Cloud (Amazon EC2) instances were launched in the public domain with Elastic IP and Domain Name Service (DNS). Microsoft SharePoint Portal was used as the document management portal and Security Assertion Markup Language (SAML) to authenticate claims against the Active Directory. Amazon Elastic Block Storage (Amazon EBS) was proposed to be added as needed for database storage and to meet growing data demand. The AWS solution had manifold benefits for the organization. First, it enhanced the ability to scale in or out depending on traffic and the pay-per-use model proved to be useful as these features reduce expenses by eliminating the cost of maintaining an infrastructure of physical servers. Second, Amazon's role in managing the services was helpful since it reduced the responsibilities (and headaches) as well as the costs of administering an infrastructure. Mahindra was satisfied with the solution and its pharmaceutical client has saved up to 40 percent in infrastructure and maintenance costs using AWS. There was also a significant reduction in up-front costs as well as the potential for reduced lifetime costs.

Amazon is very service oriented organization. Several organizations that were studied suggest that proactive service of AWS team has been a major factor in choosing these cloud services over others.

Pixels, one the cases in this study, had a specific business need. The organization serves up to 7 million advertising impressions per month for its customers. In order to deliver these impressions

and measure its advertising campaign performance, Pixels had collocated five servers in a company-owned Malaysian data center and leased 18 servers across two data centers in Hong Kong (AWS, 2018). One of the major problems it faced was IT administrative overhead. The IT team spent considerable time in managing processors and memory resources, tracking warranty information and ordering new hardware to support existing operations. The main challenge was estimating impressions and provisioning traffic for the month. Due to changing demands, the IT team had to request additional bandwidth and the company was charged higher for these last minute requests.

Pixel approached Amazon for potential solutions to their business needs. Amazon provisioned a range of Amazon EC2 instances, installed the required services, and completed configuration work to get its new infrastructure up and running. Previously, the Pixels advertisement serving and analytics platform was manual but it became fully automated in AWS. The Amazon CloudFront content delivery network (CDN) now distributes the images to end users via up to 53 edge locations worldwide. The CDN ensures the ad images are served to users over local bandwidth, minimizing latency that could otherwise slow ad load times and compromise the user experience (AWS, 2018). The solutions have worked well for the organization. Pixels has improved its availability to 99.8 percent and its system response times have decreased from 100 milliseconds to 40–60 milliseconds, depending on network performance (AWS, 2018). AWS tools and technologies have helped Pixels with scalability, allowing new products to market faster and at a reduced cost; they have also improved the availability of its products. To deliver its analytics platform on a physical infrastructure, Pixels would need to calculate the storage, compute, and database resources required to process anticipated data and traffic volumes. In AWS environment, they are able to do this easily.

The benefits accruing from using cloud services are increasing. However, there are issues with using cloud services in organizations. Security of information has been cited as one of the major issues with migration to cloud platform (Viega, 2009; Subashini and Kavitha, 2010). Some of the potential security issues involve access vulnerabilities, virtualization vulnerabilities, regular web application vulnerabilities such as SQL injection, privacy and control issues with third party storing the data, integrity and confidentiality issues, and data loss/theft issues, to name a few

(Wang et al., 2009). Virtualization takes the processing load off the client side, but security risks are worth considering (Subashini and Kavitha, 2010).

There are several advantages in using a cloud-based environment for enhancing efficiency, but there are concerns of using these solutions as well. Cloud computing is a technology that has proven to be disruptive to the ways of IT industry, and its adoption and usage has exponentially grown over last decade or so. Still, several outstanding issues exist, particularly related to service-level agreements (SLA), security and privacy, and power efficiency (Subashini and Kavitha, 2010).

Limitations and Future Research

This study was done on a small number of organizations. Our goal was to set the platform for the next stage of this research and to outline a comprehensive set of reasons for an organization to choose a cloud provider. We included only the organizations that decided to adopt AWS. In the future studies we intend to look at the organizations that adopted other cloud providers. We did not run a direct correlation test between the reasons for the organizations to move their IT resources to the cloud and the reasons for their choosing AWS as their cloud provider – this is another goal for our future research.

Conclusion

There is a variety of reasons that make organizations search for a cloud solution. Some of them are more general, such as increased flexibility/scalability, reduced resources and lower maintenance costs. Some reasons, such as improving a BI or a CRM system, or creating an agile development platform, are more specific to the businesses. We found that the top three reasons the organizations report in moving their IT infrastructure to the cloud are speed, flexibility, and reduced resources for maintenance. The most required cloud resources are virtual machines, the data solutions, and the cloud infrastructure that allows rapid scaling of the cloud resources according to the demands. As reported by the organizations, the reasons they decide to go with AWS and not the other cloud providers include flexibility, scalability, universality (multiple platforms with mostly any configuration), and the number of available web services. Many organizations mentioned high quality customer support as a key to their decision to choose AWS.

While some of these conclusion were predictable, we did make some interesting observations that were not related to the research questions. Many organizations turn to the cloud technologies to solve certain challenges with their on premise IT, but find many additional improvements on their way. No matter what IT resources are moved to the cloud, most organizations are determined to not stop the process and continue with the migration and other innovative strategies.

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AN EXAMINATION OF CUSTOMER BEHAVIOR REGARDING THE UTILIZATION OF MOBILE APPLICATIONS IN THE MICE INDUSTRY

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ABSTRACT

The purpose of this study is to open the black box of consumers' decision-making processes regarding the utilization of mobile applications in the meetings, incentives, conferences, and exhibitions (MICE) industry. Although the MICE industry has steady markets with positive trends and forecasts, the competition is becoming fiercer. Furthermore, stakeholder tastes have become increasingly demanding, impulsive, and diverse. In this study, we intend to examine consumers' decision-making processes with regard to utilizing mobile applications in an event called "The Taiwan Agriculture Week." An empirical study was adopted to incorporate cognitive and attitudinal variables into the technology acceptance model (TAM) as a mediating variable as related to mobile applications. An effective sample of 398 (examination 1 and examination 2) was collected, and SPSS and PLS were used to analyze the data.

The results of this study have both theoretical and practical implications. In particular, the contributions of this study to the technology acceptance literature, as well as the consumer behavior and MICE literatures, are outlined. This research also provides insights for decision makers working in the MICE industry.

Key Words: *Consumer behavior; Decision making; MICE; Mobile applications*

INTRODUCTION

Background

Due to the rapid development of information and communication technology, the use of mobile applications has become more popular and important for modern business practices. In the meetings, incentives, conferences, and exhibitions (MICE) industry, people have been increasingly connected before the event begins to arrange pre-meetings as well as to stay closely connected for post-event activities. Although the MICE industry has steady markets with optimistic trends and forecasts (Rogers, 2013), the competition is becoming fiercer.

Furthermore, stakeholder tastes have become increasingly demanding, impulsive, and diverse. To remain competitive, and possibly even to survive the ruthlessness of this new high competition era, organizations should provide goods, such as services and technology, which can meet consumers' demands (Maital &Seshadri, 2007). Recently, the MICE sector has become more tech heavy (Incentives, Business, Travel, & Meetings Park & Gretzel, 2007). Recent investigations of business presses show strong evidence that event technologies are substantially changing the way MICE experiences are shaped. Event technology is a complex product, consisting of goods and services regarding different activities, and as such, the exhibitor is affected by "the quality of services provided" presenting "a positive relationship between buyer satisfaction and a desire to use it,"

If a service is well designed and turns out to be a pleasant experience, then it may act as a critical point of differentiation from competitors; it is more likely to bring favorable service quality and brand image evaluations and, thus, to affect customer loyalty.

The purpose of this study is to open the black box of consumers' decision-making processes regarding the utilization of mobile applications in the MICE industry. Some studies have suggested that one key driving factor in adopting applications is the pursuit of a particular goal. It is widely accepted that mobile technology and its relevant services provide a distinct advantage for tourism organizations and perform multiple functions in tourism practices (Kim & Preis, 2015; Morosan, 2014). Simply launching these mobile applications does not guarantee success (Bouwman, de Vos, & Haaker, 20008; Kim & Preis, 2015). The dramatically growing number of mobile applications makes it difficult for an event organizer to motivate consumers to utilize their mobile applications.

As a result, being aware of and mitigating the risks of the launch mistakes of these applications will lead to applications that can effectively build and retain customers well after an application has been launched.

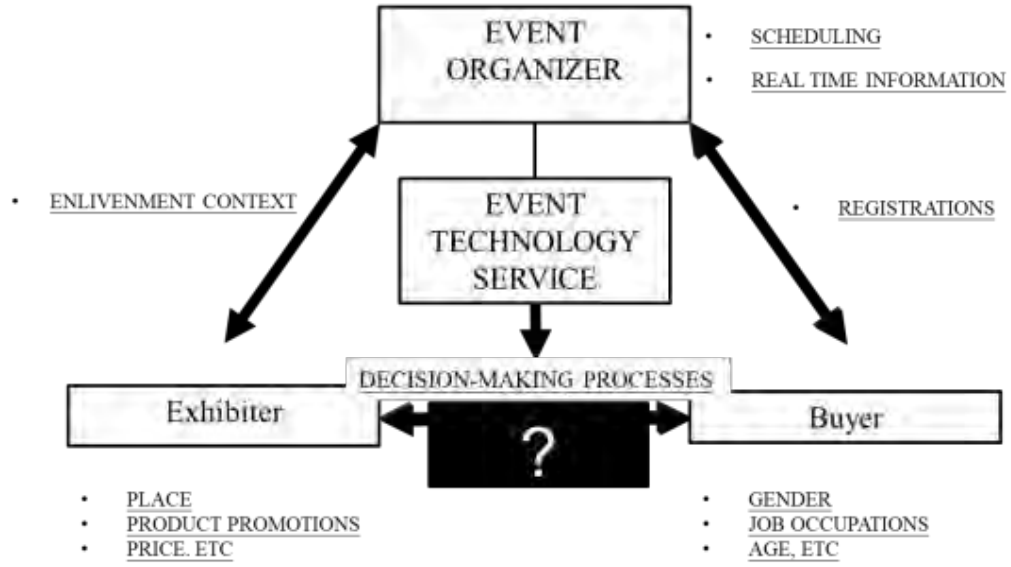

Figure 1 A positive relationship between buyer satisfaction and a desire to use it, of utilization of mobile applications in the mice industry

Research questions

We have found several critical questions regarding the decision-making processes for adopting mobile technologies that have not been answered. Comprehensively understanding the decision-making processes of event participants in regard to mobile technology adoption is imperative to successfully implement and build technology utilization strategies for the sustainable growth of the MICE industry. Thus, the overarching research question that is raised is as follows: "what are the psychological decision-making processes of event participants who would like to utilize mobile technology?"

How do individual characteristics (i.e., habit) influence the decision-making process? What are the affective and motivational factors in the decision-making process? How do environmental factors, such as subjective norms and perceived behavioral control, influence the decision-making process? However, previous studies might not provide convincing answers to the concerns above and the questions regarding affective, motivational, and emotional processes. Without understanding the affective, motivational, and emotional processes (Taylor, 2007), a discussion of the decision-making processes for adopting mobile technology is impartial and unreliable at best. To draw a clearer picture that depicts the decision-making processes of the adoption process for mobile technology, it is imperative to understand not only cognitive and attitudinal factors but also emotional and motivational factors (Venkatesh, 2000).

Purpose of the study

The primary purpose of this study is to examine the behavior processes regarding applications and the application use decisions of MICE buyers in the exhibition industry. By adapting the technology acceptance model (TAM), it is intended to provide a comprehensive understanding of the goal-oriented behavior of users in the conference and exhibition while considering the factors that affect their acceptance of exhibition applications. The users' cognitive and attitudinal variables (attitudinal variables) structure model is then introduced, including habits, motivations, and decision variables (motivational and decision variables in the model). Previous research has shown that mobile applications have penetrated every decision-making process of consumers' behaviors (Kim & Preis, 2015; Morosan, 2014), from messaging and assessment to the procurement process. (Riebeck, Stark, Modsching, & Kawalek, 2008). This study also considers that exhibition applications can perform a variety of services in the exhibition, such as registration and the exchange of business cards. Therefore, understanding and reducing the risk of launch errors with these applications will result in the applications being able to effectively build and retain customers after the application is launched. In this study, we intend to study the decision-making process of consumers using mobile applications in an event called "Taiwan Agriculture Week." This study will focus on (1) the current application use in the exhibition industry; (2) the expected variables in TAM (perceived ease of use and perceived usefulness), how to control attitudes, and how perceived variables (attitude and perceived behavior control) interact with each other; and (3) a determination of the impact on the intent to understand the use of customary behavior. Empirical research is used to incorporate cognitive and attitudinal variables into the TAM as mediator variables and to associate habitual, motivational, and emotional variables in goal-directed behavior with mobile applications.

LITERATURE REVIEW AND RESEARCH HYPOTHESES

Theoretical background

Taking into consideration the importance of MICE mobile applications, this study focuses on gaining insight into MICE consumers' decision-making processes regarding the utilization of mobile applications to achieve personal goals. To provide a solid theoretical basis for examining how people act and react to applications, the present study will evaluate the theories underpinning the investigation of event consumers' behavioral intentions for mobile technology adoption by proposing a comprehensive model that incorporates two primary research streams: (1) the technology acceptance literature and (2) the consumer

behavior literature. The study also provides conceptual clarity and preliminary evidence regarding how these two different theoretical frameworks can and should be integrated. This integration helps build a bridge from cognitive technology adoption processes to habitual, motivational, and emotional processes in an individual's decision making.

The convenience of mobile application use in MICE

MICE is an industry with high utilization value for the analysis of big data under the current trend of B2BC. The advantages of the UI (user interface) and UX (user experience) of mobile applications are convenient, fast, easy to use and space free of constraints. In the future, this new service is expected to bring about a new model of trade show business for consumer business to provide a new sense of the use of technology. Gehrt and Yale (2001) have pointed out that convenience occurs in the process of service consumption, and it will be able to retain more exhibition buyers. Therefore, based on the literature and research framework of "attitude perception-perceptual usability-perceptual usefulness," this study proposes the following hypothesis:

Hypothesis 1: Perceived ease of use is positively related to customers' perceived usefulness of applications in the MICE industry.

Users' attitudes towards applications In order to understand the user's attitudes towards the use of new technology and their intention to use it, Davis (1986) proposed the first edition of the technology acceptance model (TAM I) and established the pre-variables that influence the user's attitude towards the use of information technology - perceptual usefulness and perceptual ease of use. Davis et al. (1989) then proposed a revised technology acceptance model (TAM II). The major arguments of these two models are that "perceived usefulness" and " perceived ease of use" will affect the user's "use attitude" towards the technology, and then "use intention" and "actual user behavior." Davis thought that behavior attitude is influenced by external variables, which are majorly personal thoughts and evaluations of a specific behavior, which is called "Belief. " On the other hand, user attitudes will affect behavior intentions. In this study, the user attitude refers to whether buyers or consumers are willing to use applications when facing the exhibition. Therefore, this study proposes the following research hypotheses:

Hypothesis 2: Perceived ease of use is positively related to customers' attitudes toward applications in the MICE industry.

Hypothesis 3: Perceived usefulness is positively related to customers' attitudes toward applications in the MICE industry.

Hypothesis 4: Perceived behavioral controls have a positive effect on behavioral intentions of utilizing MICE applications.

Davis's "Perceived usefulness perceived ease of use and user acceptance of information technology" research results show "compatibility," "perceived usefulness" and "ease of use" are most influential in the use decisions. Relevant research literature points out that "perceived usefulness" and "ease of use" are important and decisive in the study of use behaviours (Adams et al., 1992; Davis, 1989, 1993; Davis et Al., 1989; Mathieson, 1991; Taylor and Todd, 1995).

In addition, the research results of Kara Hanna, Straub, and chervany (1991) and Moore and Benbasat all show that " attitudes towards the use of information systems" include " perceived usefulness", "usefulness of social interactions", "compatibility of the system with work" and " ease of use", etc. will affect the use behaviours. Therefore, according to the research purposes and research framework of "user attitude-behavior control," the following research hypothesis is proposed:

Hypothesis 5: Perceived ease of use is positively related to customers' perceived behavioral controls of applications in the MICE industry.

People's attitude towards things is one of the variables that affect related behaviors. According to Karahanna, Straub, and Chervany (1999), the standardized social belief in the use of information system behavior is significantly influenced by the related groups, such as supervisors, managers or colleagues, who are close to the person. The reason is that with the encouragement and influences of, perceived risk and uncertainty tend to be significantly reduced, which are also the assurance to the use of the exhibition applications. Therefore, according to the research purposes and research framework of "social standardized-use expectation," this research puts forward the following research hypotheses:

Hypothesis 6: Subjective norms have a positive influence on desires toward applications in the MICE industry.

Behavior intention of users

In TAM mode, the effects of individual differences (perceived usefulness) are explored, while in TRA mode, the influence of social norms (such as friends) is majorly discussed. Fishbein and Ajzen (1975) define "the behavioral intentions" as a measure of the intensity of intentions of a particular behavior. In the TRA model, the user behavior of the

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MICE applications can be predicted by the "intention," and the "intention" is determined by the "individual attitude" and "social standards." Research by relevant scholars also supports "behavioral intent" as a factor to the intensity of people's intention to behave towards a particular behavior (Davis, Baggozzi, and Warshaw1989; Jackson, Chow, and Leitch, 1997; Karahanna, Straub, and Chervany, 1999; Hartwick and Barki, 1994). Davis, Baggozzi, and Warshaw (1989) point out that the attitude is formed by the belief and feeling of the object of the attitude, and the attitude can affect the behavioral intention, which is, the strength of the attitude determines the behavioral intention.

Therefore, the user behavior of MICE applications should be measured by behavioral intention, which can accurately predict the user's future user behavior. “Attitudes" are affected by feelings such as "easy to use" and "perceived usefulness," and "attitude" can affect the user's "behavior intention." "Behavioral intention" can also affect the user's use of information system behavior, so this study based on "user behavior intention" related to the literature and research purposes and research framework, and the following research hypotheses are presented:

Hypothesis 7: Perceived behavioral controls have a positive effect on behavioral intentions to utilize MICE applications.

Hypothesis 8: behavioral intentions toward applications in the MICE industry have a positive influence on behavior decision

METHOD

Test field background

The Taiwan Agriculture Week(TAW) 2017 was attracted more than 14,117 visits from 34 countries, the exhibition brought a successful launch, It is an exclusive trade show, representing Taiwan’s premier, international and professional B2B trading platform that focuses on state-of-the-art technologies for the field of agriculture in Asia. The annual TAW is concurrently held with the “Livestock & Aquaculture Taiwan Expo & Forum” (LAT), which is expecting 300 exhibitors from 20 countries and regions and over 20,000 visitors from 40 countries and regions. This three-day trade show contains a series of conference and business matchmaking programs and will reveal the strength and competitiveness of Taiwan’s supply chain. This conference is a perfect platform to expect the chance to see the world in Taiwan and Taiwan in the world.

Research framework

Based on a comprehensive literature review, the study adopted previously developed and validated measurement items with slight modifications to better fit the current study (Ajzen & Fishbein, 1980; Churchill, 1979; Davis, 1989; Goodhue & Thomson, 1995; Kline, 2005; Schrier, 2009). All the constructs in this study were measured with multiple items (Straub, Boudreau, & Gefen, 2004). By using multiple indicators to measure theoretical constructs, this study can increase its validity by covering various facets of the construct (Kline, 2005). An extensive literature review on consumers' behaviors, technology acceptance behaviors, and psychosocial theories was conducted to elicit a preliminary list of measurement items for this study (Ajzen & Fishbein, 1980; Ajzen & Madden, 1986; Bagozzi et al., 1998; Carrus et al., 2008; Davis, 1989; Goodhue & Thomson, 1995; Perugini & Bagozzi, 2001, 2004). The theoretical, conceptual model is shown in Figure 2 below:

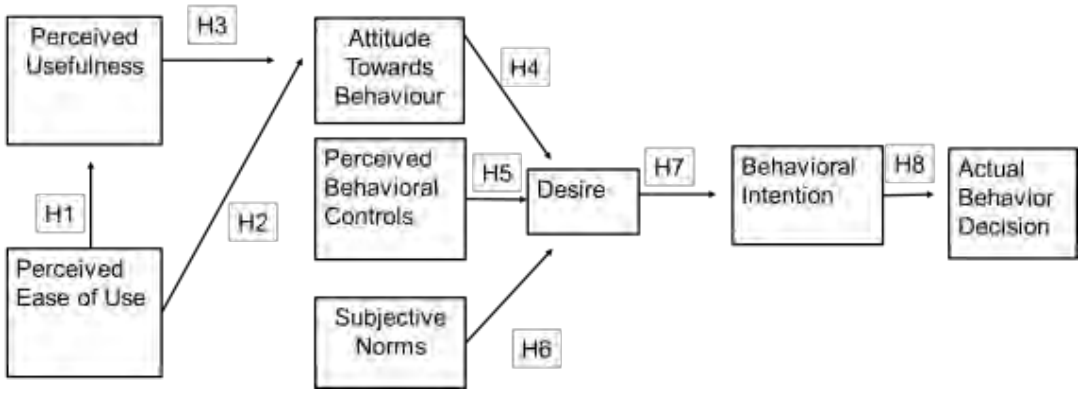

Figure 2: Theoretical Conceptual Model

Therefore, this study combines the two into the cognitive convenience of the construction surface as an external variable of the mode of acceptance of science and technology. Furthermore, the paper puts forward an expanded TAM with the direction of user attitude and purchase intention as the guidelines for scientific acceptance and explores the cognitive convenience, cognitive usefulness and relationship between attitudes towards use and intention to purchase.

Definition of the Variables

Construct	Definition	Adapted from
Perceived Usefulness	The extent to which a consumer believes using MICE mobile applications would enhance him or her effectiveness in the overall MICE experience.	Davis (1989)
Perceived Ease of Use	The extent to which a consumer believes using MICE mobile applications would be effortless.	Davis (1989)
Attitude	A consumer's evaluation of the desirability of using MICE mobile applications.	Perugini & Bagozzi (2001)
Subjective Norm	A consumer's perceptions of the expectations of others about the adoption of MICE mobile applications, which result from perceiving others want one to utilize MICE mobile applications.	Ajzen (1991, p. 183)
Anticipated Emotions	Positive emotional responses formed when individuals pre-factually consider goal achievement. Negative emotional responses formed when individuals pre-factually consider goal failure.	Perugini & Bagozzi (2001)
Perceived Behavioral Control	A consumer's self-perception of their own capabilities to utilize MICE mobile applications can reinforce the consumer's desire, and behavioral intention to adopt MICE mobile applications.	Ajzen (1991)
Desire	A state of mind whereby a customer has a personal motivation to utilize MICE mobile applications.	Richetin et al. (2008)
Habit	Habit represents a variable that measures the frequency of past behaviors. Habit is developed through frequent usage in a stable context and this acts as an automatic link between a desire to act and a specific behavioral intention.	Perugini & Bagozzi (2001)
Intention to Use	The user's judgment about the likeliness to engage in online transactions via MICE mobile applications.	Gillenson & Sherrell (2002)

Table 1: Definition of the TAM variables

Furthermore, this study adopts the "questionnaire survey method." Additionally, this research explores cognitive convenience, cognitive usefulness, and the relationship between attitudes towards use and intention to use. Based on the relevant theories and related studies from the literature review, this study presents a framework for the decision process of the user; we investigate behavioral intention using MICE applications and use TAM to explain the cognitive and attitude determinants of this behavior (Davis et al. 1989). This study has three key steps. First, the user's attitude towards the exhibition service technology is determined. Second, the intention of the exhibition buyer's behavior is evaluated. Finally, the methods for assessing the effect of measurement techniques are studied.

Measurement of the Technology Acceptance Model (TAM) constructs

Items for TAM constructs (i.e., perceived usefulness (PU) and perceived ease of use (PEU)) were adapted from the previous literature

(Davis, 1989; Kim et al., 2008). The items for these two constructs were modified within the context of the MICE technology environment (Table 2). Four items were used to measure perceived ease of use (Davis, 1989; Kim et al., 2008), and five items were used to measure perceived usefulness (Davis, 1989; Kim et al., 2008).

Measurement of the Technology Acceptance Model (TAM) constructs

Construct	Scale Item
Perceived Ease of Use	(T1_1) Learning to operate event mobile applications is easy for me. (T1_2) It is easy for me to become skillful at using event mobile applications. (T1_3) I find the use of event mobile applications is easy. (T1_4) My interactions with event mobile applications are clear and understandable.
Perceived Usefulness	(T1_5) Mobile applications are useful in my event experiences. (T1_6) Mobile applications enhance the quality of my event experiences. (T1_7) Mobile applications enable me to have more convenient event experiences. (T1_8) Using mobile applications increase my event productivity. (T1_9) Using mobile applications enhance the effectiveness on my event trips.

Table 2: Measurement of the TAM

Measurement of attitudes, subjective norms, & perceived behavioral controls

The survey asked respondents to rate their attitudes towards utilizing applications while attending an event. To measure attitudes, instruments were adopted from Ajzen (1991), Ajzen and Fishbein (1973), and Venkatesh et al. (2003), with modifications to reflect the adoption of applications within the context of the MICE technology environment. Additionally, the survey was designed to gather social norms and perceived behavioral controls related to utilizing MICE applications, which were measured by four items (Nysveen, Pedersen, & Thorbjørnsen, 2005a; Rivers & Sheeran, 2003).

Measurement of Attitudes, Subjective Norms, & Perceived Behavioral Controls	
Construct	**Scale Item**
Attitudes	(M1_1) Using mobile event applications is a good idea. (M1_2) I like the idea of using event mobile applications. (M1_3) Event mobile applications make my trip more interesting. (M1_4) I like traveling to events that have mobile applications created for the specific event.
Subjective Norms	(M1_5) I want to use event mobile applications because my colleagues do so. (M1_6) My peers think I should use event mobile applications. (M1_7) I think there is social pressure regarding event mobile applications.
Perceived Behavioral Control	(M2_1) I am confident that if I want, I can use event mobile applications. (M2_2) I am capable of using event mobile applications. (M2_3) I have enough time to use event mobile applications. (M2_4) There are factors preventing me from using event mobile applications.

Table 3: Measurement of Attitudes, Subjective Norms, & Perceived Behavioral Controls

Measurement of desire

This study assumes desires, emanating from appraisals of the target behavior and its anticipated emotions, lead to the intention to utilize MICE mobile applications. As shown in table 4, desire was measured using four items, with modifications to reflect the adoption of MICE mobile applications (Perugini & Bagozzi, 2001, 2004; Perugini & Conner, 2000).

Measurement of Desires	
Construct	**Scale Item**
Desires	(M2_5) I would like to use event mobile applications. (M2_6) I wish to use event mobile applications. (M2_7) I crave to use event mobile applications. (M2_8) I have an urge to use event mobile applications.

Table 4: Measurement of Desires

Measurement of intention to use

Respondents were asked about their intention to use MICE mobile applications. Three questions were included in this part of the survey (Perugini & Bagozzi, 2004).

Measurement of Intentions to Use	
Construct	**Scale Item**
Intentions to Use	(M5_1) I intend to use event mobile applications in the future. (M5_2) I recommend others use event mobile applications. (M5_3) It is likely I will use mobile applications created for specific events on a business trip in which I attend an event.

Table 5: Measurement of Intentions to Use

Measurement of Demographic Variables

Variables	***Options***
Gender	□ Men □ Women
Age	□ 20 years old (including) the following □ 21 - 30 years old □ 31 - 40 years old □ 41 - 50 years old □ 51 years old
Nationality (Measure II)	□ Australia □China □ Europe □ Hong Kong and Macao □ India □ Indonesia □ Japan □ Korea □ Malaysia □ Philippines □ Singapore □ Taiwan □ Thailand □ United States
Degree of education	□ Primary school or below □ Middle school □ High School (POST) □ Colleges & universities □ Master or above
How many hours per day you use the APP	□ 1 hour (incl.) below □ 2 - 3 hours □ 4 - 5 hours □ More than 6 hours
Usage of the APP (check)	□ Business word processing □ Entertainment (for example online games)

SAMPLING AND DATA COLLECTION

Data were collected both in Chinese and English using a questionnaire distributed to the Taiwan External Trade Development Council (TAITRA). The sample frame was drawn from members of the Taiwan Convention & Exhibition Association (TCEA). The sample of firms were provided by the TCEA and the Taiwan Chamber of Commerce. To enhance the generalizability of the results, we included samples of both consumer-exhibitor relationships. We thus enhanced the generalizability of the findings across two types of buying situations (B2B2C) while also providing increased variance on the geographic closeness measure. In examination one, potential respondents were first contacted by telephone. Qualified and willing respondents were emailed a personalized letter and questionnaire. In examination two, the sample frame was drawn from the “The Taiwan Agriculture Week 2017” exhibition hall exit in the Kaohsiung Exhibition Center directory. Altogether, 500 completed questionnaires were returned; in total there were 148 responses to examination one (33% response rate) and 250 responses to examination two (50% response rate) buyer- exhibitor relationship. Twelve respondents reported a low level of confidence in their responses and were dropped. An additional 39 responses were discarded because of excessive missing data, leaving a final usable sample of 398.

RESULT ANALYSIS

The examination One: the questionnaire was sent by email it, has 146 questionnaires were collected, including 130 valid surveys. Basic demographic analysis and descriptive statistics are as follows; detailed data shown on table 6:

The examination Two: questionnaire were collected in the "The Taiwan Agriculture Week 2017"exhibition hall exit in Kaohsiung Exhibition Centre directory. it has 250 questionnaires were collected, including250 valid questionnaires. Basic demographic analysis and descriptive statistics are as follows,. Detailed data is shown in table 7.

This questionnaire was sent by email and network questionnaire, and 146 questionnaires were collected, including 130 valid questionnaires. Basic demographic analysis and descriptive statistics follow, and detailed data are shown in table 4-1.

Feature variables	Category	Number	Percentage (%)
Gender	Men	74	56.9%
	Women	56	43.1%
Age	20 years old	8	6.1%
	(including) the	51	39.2%
	following	30	23.1%
	30 years old	37	28.5%
	31 - 40 years old	4	3.1%
	41 - 50 years old		
	Over 51 years of		
	age		
Education level	Primary school or	0	0.0%
	below	1	0.8%
	Middle school	5	3.8%
	High School	87	66.9%
		37	28.5%
	colleges&		
	universities		
	Master or above		
How many hours	1 hours (incl.)	11	8.5%
per day you use	below	43	33.0%
the applications	2-3 hours	60	46.2%
	4-5 hours	16	12.3%
	More than 6		
	hours		
Experience using	Within 1 years	6	4.6%
the applications	(inclusive)	37	28.5%
	2 - 3 years	55	42.2%
	4 - 5 years	24	18.5%
	6 - 7 years	8	6.2%
	Over 8 years		
Number of	Have never	73	56.2%
participations in	1 - 3 times	27	20.8%
the Convention			
and exhibition			
procurement in			
the past three			
years			

Table 6one

Feature variables	Category	Number	Percentage (%)
Gender	Male	119	47.6%
	Female	131	52.4%
Age	20 years (and below)	0	0%
	21-30 years	54	21.6%
	31 - 40 years	82	32.8%
	41 - 50 years	50	20%
	Over 51 years	64	25.6%
Nationality	Australia	1	0.4%
	China	7	2.8%
	Europe	2	0.8%
	Hong Kong and Macao	4	1.6%
	India	0	0%
	Indonesia	2	0.8%
	Japan	**3**	**1.2%**
	Korea	**2**	**0.8%**
	Malaysia Philippines	**3**	**1.2%**
	Singapore	**1**	**0.4%**
	Taiwan	**0**	**0%**
	Thailand	**216**	**86.4%**
	United States	**4**	**1.6%**
	Other	**1**	**0.4%**
		4	**1.6%**
Degree of education	Primary school or	3	1.2%
	below	6	2.4%
	Middle school	35	14%
	High school	143	57.2%
	colleges& universities	63	25.2%
	Master or above		
How many hours per day you use the applications	1 hours (incl.) or	49	19.6%
	below	72	28.8%
	2-3 hours	69	27.6%
	4-5 hours	60	24%
	More than 6 hours		
Experience using the applications	Within 1 years	36	14.4%
	(inclusive)	49	19.6%
	2 - 3 years	82	32.8%
	4 - 5 years	54	21.6%
	6 - 7 years	29	11.6%
	Over 8 years		
Number of user in the MICE procurement in the past three years	Have never	60	24%
	1 - 3 times	104	41.6%
	4 - 6 times	55	22%
	More than 7 times	31	12.4%

Table 7: Examination Two

Analysis of the reliability and validity of questionnaires (Smart PLS)

In this paper, the parameters of each measurement model are estimated, and the reliability and validity of each variable are verified. Hair et al. (1998) proposed that it is necessary to consider three aspects, such as the reliability of individual items, the reliability of latent variable composition and the average mutation extraction of the potential variable. If all three aspects are met, the reliability and validity of the study can be assumed.

Individual item reliability, IR

Individual item reliability represents the extent to which a potential variable can interpret each dominant variable. Hair et al. (1998) suggested that the influence factor of each variable should be greater than 0.5; otherwise, it will affect the explanatory power of the variable. Therefore, the PE1 and PE2 of the deletion factors are too low, and after the deletions, the detailed construction of the reliability and the validity of the increase is in line with the condition that the influence factor be greater than 0.5.

Composite reliability, CR

Composite reliability (CR) partly reflects the internal consistency of the structure; the higher the CR value of the potential variable is, i.e., the higher the correlation of the measured variable is, the more accurately the potential variable can be reflected. Generally, the value must be greater than 0.7; therefore, as the reliability of the potential variable is 0.9, it indicates that the structure of this study has good internal consistency.

Another indicator for measuring the reliability of potential variables is Cronbach's α. According to Nunnally (1978), the threshold value of Cronbach's α is 0.7, and the Cronbach's α value of this study is greater than 0.8, which also shows that the study has sufficient internal consistency, and the observation variables are sufficient to reflect the potential variables. The potential variable composition reliability of this study exceeded the standard, showing that the multidimensional characteristics of the deconstructive plan behavior theory worked well in this study and did not affect the research results because of the conflict between positive belief and negative belief.

Average variance extracted, AVE

The average variance extracted (AVE) represents the value of the percentage potential variable that can be measured by the observed variable, and the AVE can be divided into two terms: convergent validity and difference validity.

Convergence validity: Fornell & Larcker (1981) suggested a critical criterion of 0.5. Above 0.5, there is convergence validity. The AVE value of this study is between 0.706 and 7.2, which has sufficient convergence validity.

The difference of validity: The square root of the AVE value should be greater than the correlation coefficient between the different constructions, and the square root of the AVE value of perceptual usefulness is slightly less than the correlation coefficient of the attitude, and the remainder of the project has enough difference validity. Through the high reliability and validity analysis, it is confirmed that this research model has a considerable degree of reference value, and the detailed data are recorded in table 8 and table 9.

Variable	Cronbachα	CR	AVE
Perceived ease of	0.820→0.894	0.861→0.927	0.543→0.706
Perceived	0.925	0.941	0.729
Attitude	0.867	0.918	0.790
Perceptual	0.911	0.957	0.918
Specification	0.957	0.972	0.920
Use expectations	0.833	0.901	0.753
Behavioral	0.945	0.961	0.859
Actual decision	0.830	0.921	0.853

Table 8 Comparison of the reliability and validity of different constructs

Variable	**PE**	**PU**	**ATB**	**BC**	**SN**	**DE**	**BI**	**ADB**
PE	0.872							
PU	0.751	0.854						
ATB	0.876	0.921	0.889					
PBC	0.738	0.654	0.669	0.958				
SN	0.785	0.798	0.847	0.651	0.959			
DE	0.826	0.805	0.844	0.847	0.859	0.868		
BI	0.823	0.808	0.874	0.683	0.844	0.874	0.927	
ADB	0.480	0.518	0.518	0.497	0.433	0.467	0.874	0.924

Table 9 Comparison of reliability and validity of the different constructs

As we know from the above picture, under the verification of the bootstrap repeated sampling method, hypotheses 1, 2, 3, 4, 5, 6, 7 and 8 are all statistically significant; therefore, perceptual usability has the most considerable influence on perceptual usefulness, and the path coefficient is 0.751. Attitude has less influence on the expectation of use, and the path coefficient is 0.223. The direct and indirect effects of the whole structure are shown in tables 4-5. The higher the number is in the table, the higher the influence of the structure. Due to a large number of research definitions, the table cannot

adequately present the content, so the table content is represented by the abbreviation with each definition word; DI means direct influence (Direct), and IND means indirect influence (Indirect). Since some digits are all zero, we need to omit the single precision of the number, for example, .751 is 0.751. The comparison table of research hypotheses is shown in table 10.

Table 10: Influence tables of the various construction thoughts

	PE		PU		ATB		PBC		SN		DE		BI		ADB	
	DI	IN	DI	IN	DI	IN	DI	IN	DI	IN	DI	IN	DI	IND	DI	IND
PE	-	-	.751	-	.423	-	-	-	-	-	-	.196	-	.171	-	.080
PU	-	-	-	-	.602	-	-	-	-	-	-	.135	-	.118	-	.055
AT	-	-	-	-	-	-	-	-	-	-	.223	-	-	.195	-	.223
PB	-	-	-	-	-	-	-	-	-	-	.454	-	-	.397	-	.185
SN	-	-	-	-	-	-	-	-	-	-	.374	-	-	.327	-	.152
DE	-	-	-	-	-	-	-	-	-	-	-	-	.874	-	-	.406
BI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.465	-
AB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Hypothesis 1: The ease of use and the user's attitude towards the exhibition APP is significantly related to the usefulness of the conference and exhibition services technologies. At 95% confidence level, the T value is 15.912, and the accuracy is above 0.001, so the null hypothesis can be discarded. Therefore, this study speculates that the perceived ease of use of the exhibition APP is significantly related to the perceived usefulness. The proposed TAM architecture is consistent.

Hypothesis 2: Under the 95% confidence level, the T value is 14.051, and the significant level is over 0.001, so we can discard the null hypothesis. This study suggests that the perceived usefulness of the APP is significantly correlated with the attitude of using the conference and exhibition service technology APP, and this result is also related to the T of Davis' (1989) architecture matches (AM).

Hypothesis, 3: The user's perception of the APP is significantly related to the user's attitude to the application of the conference and exhibition service technology APP in the exhibition. Under the 95% confidence level, the T value is 9.959, and the significance level is above 0.001, so we can discard the null hypothesis. This study suggests that the perceptual practicality of the exhibition APP is significantly related to the attitude of the application of the conference and exhibition service technology APP, and this result also correlates with the TAM Schema match.

Hypothesis 4: Under the 95% confidence level of , the T value is 3.823, and the significance level is above 0.001, so we can discard the null hypothesis. This study suggests that the attitude of using the conference and exhibition service Technology APP has a significant correlation with the expectation of use.

Hypothesis 5: The user's perceptual behavior control regarding the MICE APP has a significant correlation with the use of the conference and exhibition services APP. Under the 95% confidence level, the T value is 11.498, and the significance level is over 0.001, so we can discard the null hypothesis; therefore, this study speculates that the user's perception of the MICE APP has a significant correlation with the expectation of the application of the conference and exhibition service technology..

Hypothesis 6: The exhibition APP's social standards and the expectation of the use of exhibition services technology APP have a significant correlation. Under the 95% confidence level, the T value is 5.856, and the significance level is more than 0.001, so we can discard the null hypothesis. This study speculates that the social standards of the exhibition APP have a significant correlation with the expectation of use of the conference and exhibition service technology APP, and it is correlated with the TPB Schema model proposed by Taylor & Tod (1995).

Hypothesis 7: The user expectation of the exhibition APP is significantly related to the use intention of the conference and exhibition service technology APP. Under the 95% confidence level, the T value is 29.250, and the significance level is above 0.001, so we can reject the null hypothesis. This study speculates that the usage expectation of the MICE APP was significantly correlated with the usage intention of the conference and exhibition service technology, and it is matched with the model of goal-directed behavior (MGB) architecture proposed by Perugini & Bagozzi (2001).

Hypothesis 8: The behavioral intentions of using the conference and exhibition services APP are significantly related to actual behavioral decisions. At the 95% confidence level, the T value is 4.301, and the significant level is above 0.001, so the null hypothesis can be discarded. Therefore, this study speculates that the behavioral intention of using the exhibition APP is significantly related to actual decision-making behavior, which is consistent with Perugini & Bagozzi (2001). The proposed MGB architecture is consistent.

CONCLUSIONS

The present study has both theoretical and practical implications. In particular, the contributions of this study to the technology acceptance literature, as well as the consumer behavior and MICE literatures, are outlined. This research also provides insights for decision makers working in the area of the MICE industry. These findings represent a significant advancement in research on both technology and consumer behaviors.

On the other hand, this study contributes to the technology acceptance literature by providing evidence of the most influential psychological factors (i.e., perceived usefulness and perceived ease of use) in users' motivations to utilize mobile applications in the MICE industry. As previous studies in technology acceptance have asserted, the criticality of individuals' perceived usefulness and perceived ease of use form a decision to engage in technology adoption behaviors. This study's results empirically demonstrated the importance of these concepts in determining MICE participants' mobile application usage intentions. Specifically, perceived ease of use not only affects customers' perceived usefulness of mobile applications but also affects attitudes towards mobile applications and the perceived behavioral control of mobile applications in the MICE industry.

These findings show that the anticipated variables in the TAM (e.g., PU and PEU) exert a positive effect on constructs in the MGB. The theoretical importance and value of the proposed conceptual framework can be reinforced by the fact it was precisely developed and met Ajzen's (1991) and Ajzen and Fishbein's (1980) requisites for theory extension, specifically applications appropriate for mobile application acceptance in the MICE industry.

LIMITATION AND RECOMMENDATIONS FOR FUTURE RESEARCH DIRECTIONS

The findings from this study have potential implications for academic researchers and practitioners. The present study contains several limitations, which call for key directions for forthcoming studies.

The first limitation concerns generalizability of the exploratory findings represented in this study. Since this study was conducted within Taiwan, which has a relatively high penetration rate for mobile technologies, these findings may not apply to countries less technologically-advanced. In addition, this study investigated only one type of technology (i.e., mobile applications). To make these findings more generalizable, future research should be conducted across different countries, difference cultural contexts, and different technologies to account for potential differences in the results as well as the findings (Zhang, Zhu, & Liu, 2012). For example, future research can include national and/or

cultural realms rooted in different philosophical perspectives as moderators. This may provide richer insights on consumer adoption around the world.

The second limitation is related to measurement issues. This study used self administrated questionnaires to assess consumers' decision-making processes for utilization of a technology because of the scope of this dissertation in terms of time and cost. However, potential limitations come from the nature of self-reported responses. it is widely assumed a common method bias inflates relationships among variables measured by self reports (Straub, Limayem, & Karahanna-Evaristo, 1995). Therefore, future researchers could use a richer research methodology by combining quantitative and qualitative methods to remedy some of the shortcomings of using self-administered data.

The final limitation is the sample of this study is not free from bias, due to convenience sampling. Because this study focused on a specific customer segment of the MICE participants. The present study used a convenience sample recruited from event social network. While it is considered an easily obtained, efficient, and cost effective sampling method, the findings from this study might have been biased by the fact that respondents are able to access online and have an account; therefore, this study is unable to account for those who are not current users. Future studies should consider using random samples and could provide a clearer comprehension of the emotional reactions by comparing emotions of business event participants and leisure event participants.

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BLOCKCHAIN APPLICATIONS TO ENGINEERING MODEL MANAGEMENT

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Abstract

Highly sophisticated products such as aircraft and robots are created from the engineering and analysis of the various parts and subassemblies that, when constructed and fully assembled, make up the whole product. These models and analysis are the product of very highly trained engineers and analysts and represent a significant investment by the firm. From time to time, and for various reasons, these models are revised. It is imperative that the proper version of the model be utilized in the appropriate application. However, it is sometimes difficult to maintain version control when configurations can change rapidly and advanced versions of engineering data are sometimes made available for use in order to expedite schedules. The potential dangers inherent in the use of the incorrect version of an engineering model are the creation of improper parts or tools and the costs associated with that. However, a release control system using blockchain technology will improve the firm's ability to control the version being provided for both internal and external use. This paper uses a design science methodology to define a blockchain based system that provides an accurate, and efficient, version control approach.
Keywords: blockchain, distributed ledger, manufacturing, engineering change order, design science.

Introduction

Economists have stressed the importance of manufacturing to a nation's ability to create wealth for centuries (Smith, 1776). However, the discussion of manufactured goods' contribution to national wealth often overlooks one of the primary sources of that wealth, that is, the engineering behind the products that are produced. However, to be the source of this value, certain organizational processes must be observed with reference to the artifacts created during the engineering process, such as engineering drawings, models, and analyses. Without careful control of these products in terms of quality, applicability, and currency, the potential exists to not just miss an opportunity to create value but also to create serious problems. In light of these

concerns, this paper proposes a method to ensure that the organizational processes that allow these engineering tools to spur the creation of so many amazing products are supported by the information systems they exist on.

The specific focus of this paper is the method by which engineering models and drawings are initially made available, how they are revised in an orderly fashion, and how they are protected from unauthorized changes and use. The technology selected to provide these services is blockchain, the same technology underlying various cryptocurrencies. The paper provides a design for an engineering drawing and model management tool that will ensure the orderly management of digital engineering information as well as the coordination of the instructions that provide for their revision and updating, which are commonly known as Engineering Change Orders (ECO).

The paper is organized as follows: The next section provides some background on the processes that make up the engineering model management process as well as an overview of blockchain technology and its characteristics that make it an attractive tool for this environment. Following that, the paper reviews the literature surrounding both the engineering model management process and the relevant applications of blockchain, after which it presents the research questions and the methodology to be used, a description of the requirements as derived from the two case study sites as well as the system design, and details of the system evaluation process. The paper concludes with a summation, contributions, and directions for future research.

Foundational Concepts

Engineering process

The process of engineering products, ranging from aircraft to medical instruments to washing machines, typically follows a similar pathway. The process can be characterized as iterative and often recursive (Paulo 2018). The iterative nature of the engineering process stems from the fact that despite the best efforts of all concerned, the initial version of the engineering product might not be completely correct or complete. This is the nature of creating complex products that purport to satisfy complex requirements. Therefore, there are very often revisions that must take place in order to eventually arrive at the correct solution. These iterations are a normal part of the engineering process and are often considered evidence of a rigorous engineering effort. With each iteration, the design team usually learns something about their

product and this enhanced understanding is often incorporated, when possible, into the revised design, thus allowing the finished product to reflect a progression of domain knowledge. This is a normal and desirable characteristic of the engineering process and usually results in a better final product as well as a deeper understanding of the product by the team. It can, however, result in a more difficult project management task. Because of the interconnected nature of the engineering process, there is a great deal of recursion built into it. Once the need for a modification on one component is identified, many or all of its interconnected components must be modified accordingly. Sometimes these modifications are significant, dealing with shapes and materials. In other cases, the modifications are simply the change of a notation for an adjoining part that has changed its revision level. In either case, the revision of one component causes a cascade of changes throughout the product, leading to its recursive nature.

Because these changes across product engineering might happen in different locations, with different personnel, and in varying sequences, there must be a mechanism to keep track of which versions of parts go with which other versions. It could easily happen that as the product matures there are many different combinations of parts and revision levels thereof that go into a bona fide version of the finished product. And, with many thousands or even millions of parts to keep track of, the model release and version control system becomes the key to proper usage of parts and assemblies. Each engineering model details the creation of one or more parts, or the creation of a subassembly. As the current design changes to reflect changes in requirements or to correct oversights, the revision level of these models must be changed to reflect the current version. Along with this, a mechanism must be put in place to ensure that a) engineers and manufacturing personnel are using the current version, b) any changes made to the current version (e.g. a revision to the revision) are communicated to the pertinent organizational functions quickly and accurately along with any instructions involving retrofitting, and c) that no changes are made to the current version of the design without proper analysis or approval.

The importance of these controlling mechanisms cannot be overstated. Without adequate version control, products can be made incorrectly, to outdated standards, or with reduced performance. Moreover, when manufacturing and quality control are not working to the same specifications, products that are correctly made might not pass quality tests or, in the worst case, products that should not pass are accepted. There is also the problem of traceability. Without a precise understanding of which design versions were used to produce and assemble the

components of the final product, it is very difficult to understand the root of problems that occur after the product is sold and placed into service. Regulatory agencies such as the Federal Aviation Administration, U.S. Food and Drug Administration, and the National Highway Traffic Safety Administration will, during an initial certification program or while investigating accidents or malfunctions require that the full sequence of revisions and improvements incorporated into the product be produced and documented to insure that the proper versions were installed.

To compound the complexity caused by multiple versions of parts being used in a product, it is often the case that the final product is produced in a facility that is the endpoint of multiple supply chains coming from remote locations within the firm, from domestic vendors outside the firm, and from international sources on different continents. In each situation, the geographic and organizational distances involved tend to complicate not just the physical supply chain but the informational supply chain as well (Cho, Ryoo & Kim, 2017). Therefore, the dispersal of information regarding the proper version of parts to use is complicated by the logistical issues surrounding the movement of parts between facilities.

The system that most manufacturers use to manage this process starts with design review procedures in which initial designs are analyzed for compliance with stated requirements (Figure 1). Revisions to these designs are also approved after they are deemed to comply with the organization's policies for approving ECOs. After approval, designs are stored in a "release" file that is read-only to most organizational members, with only members with the authority to release new and revised designs having write permission. There are some pitfalls evident in this process. First, the number of people with write permission in the release file is not always well-controlled, leaving the possibility of changes being made to the released models that have not been through the approval process and are not universally known about. Second, models that have been developed but not fully released can be made available to the rest of the organization on an unofficial basis to help make a schedule milestone, with the intention of substituting the official version when it is released. However, the time pressures of product development and production can cause these advances to be neglected, thus leaving open the possibility of changes being made downstream in the engineering process that are never incorporated into the released model or the finished product. In the first case, the unauthorized change might be caught if the

log files for the release file are analyzed in a timely fashion, but there might be no process for identifying the second potential pitfall.

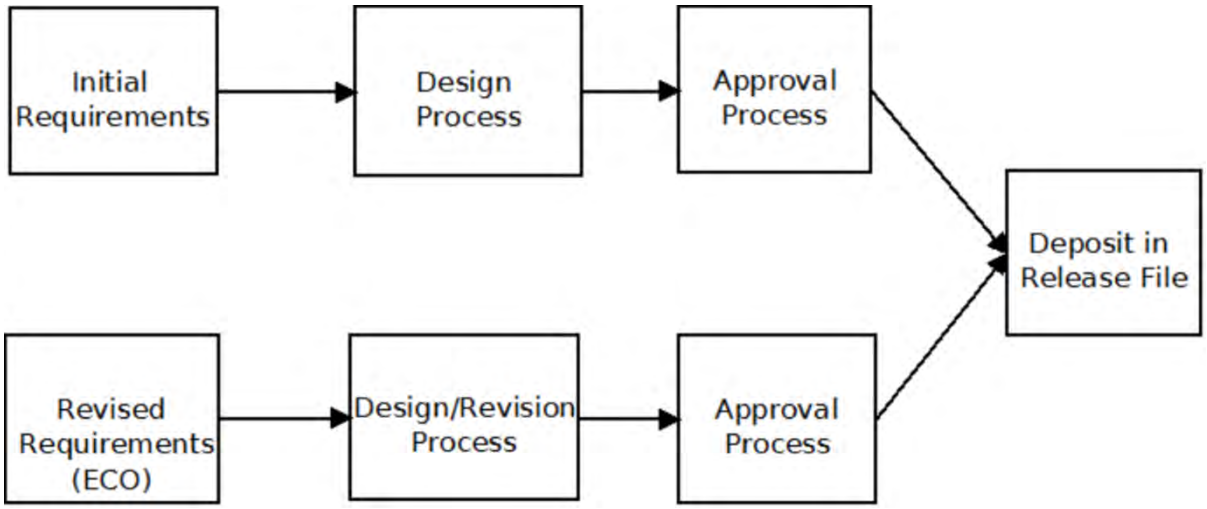

Figure 1: Typical Engineering Model Management Process

Blockchain

Blockchain was first introduced as the technology underlying cryptocurrencies like Bitcoin (Nakamoto, 2008). When introduced it promised three capabilities: data security, data immutability, and data redundancy. The security is provided through the use of cryptographic hash algorithms that will provide secure hash values for the material to be secured. Cryptographic hash algorithms have the following useful properties (Drescher, 2017):

1. Deterministic hash values such that the same input, if run through the algorithm twice, will result in the same hash value.
2. Efficient of computing resources.
3. It is infeasible that knowing the hash value will result in being able to determine the initial input.
4. Small changes in the input will result in significant changes in the hash value.
5. It is infeasible for two inputs to create the same hash value.

The immutability of the data stored on a blockchain is ensured by the requirement that before a block of data can be added to the chain, it must be encrypted one more time and include the data from the previous block in the final encryption. By doing so, any change to the data in

the preceding block, whether authorized or not, will immediately invalidate the encryption in all subsequent blocks added to the chain. As long as all of the hash values in all blocks match their neighbors on the chain, there have been no changes. Once the hash values are different, the change in value will be immediately noticeable. To make it difficult for an actor with write privileges to change the values on a certain block and then adjust the hash values on all subsequent blocks to match, there is a requirement that before a block can be added to the chain a set of cryptographic calculations must be undertaken to solve a "hash puzzle." This puzzle can be made very easy or very difficult depending on the level of protection sought, but it applies a penalty such that data cannot be changed easily.

Bitcoin was meant to exist outside the realm of the financial regulatory environment (Böhme, Christin, Edelman & Moore 2015) and to be resident on a global peer-to-peer (p2p) network of computers, none of which are considered to be trusted. This redundancy was managed by a simple p2p protocol that allowed the data to be included on the chain to be passed from peer to peer and each one had a chance to perform the calculations that would allow the data to be added. When a peer solved the puzzle, it was rewarded with bitcoin currency. As the chain grew, the current status was also passed across the network such that each peer had a current copy, thus further reducing the ability for one bad actor to take advantage of the data on the chain. The point of this paper is to apply the blockchain methodology, suitably modified, to the task of ensuring that each product is built with the proper version of the engineering, and thus the proper version of the parts.

Literature Review

The current project brings together two previously unrelated streams of research. The first is the area of inquiry surrounding the processes of releasing, changing, and managing the changes to, engineering models. Because of the significance of engineering changes in terms of product quality and resource use, the impacts of engineering changes have been an important topic of research in the engineering management literature. This research is reviewed in the first subsection. The second subsection contains an overview of the state of the art in the area of blockchain technologies and applications. Though this paper appears to be the first application of blockchain in the product engineering space, there are many areas of application that help to illuminate the present research.

Engineering Change Order Research

The research surrounding the proper evaluation, execution, and management of ECOs has a number of different facets. The first centers on a general approach to dealing with ECOs in a complex and dynamic environment. Schuh, Gartzen, Soucy-Bouchard & Basse (2017) stress the need for agility in the ECO process rather than an approach that stresses compliance with strict, and sometimes wasteful, change processes. Han, Lee & Nyamsuren (2014) provide a framework for an ECO system that optimizes engineering change management in a Make-to-Stock (MTS) and Make-to-Order (MTO) environment. In each of these studies, the importance of the accuracy and alignment of the ECO process is stressed as an important success factor to both the ECO process and the engineering function of the firm.

The optimization of the ECO process is the subject of a number of papers. Mehta, Patil & Dutta (2012) provide an information-based approach to computing the similarity between engineering changes. Taylor, Uddin, Goodrum, McCoy and Shan (2012) take a statistical approach to understanding the relationship between the amount and frequency of change orders and the type of activity being revised. Their results suggest that different types of tasks tend to create an identifiable pattern of change orders. An object-oriented discrete event simulation (DES) model is developed by Du, El-Gafy & Zhao (2016) in order to optimize the change order management process and reduce the costs associated with it. Lastly, Loch and Terwiesch (1999) investigate the effect of capacity and congestion on the ECO process and suggest methods to accelerate the process within these constraints.

Many of the challenges faced in managing ECOs can be addressed using various software tools. For instance, Chinn & Madey (2000) introduce an expert system that includes a temporal component and can help integrate the ECO process into a standard workflow control tool. Likewise, Habhouba, Desrochers & Cherkaoui (2006) propose an agent-based tool that helps to control the ECO approval process and automates certain checks for inconsistencies, thus speeding the process.

It is well understood that ECOs do not come about without cost and while they are often considered to be a “cost of doing business” (Schuh et al 2017) they should instead be considered an opportunity to improve the product or the production process. Nevertheless, the costs associated with ECOs must be considered and controlled. Efforts have been made to understand the impact of ECOs on total project cost (Hanna, Camlic, Peterson & Nordheim, 2002; Serag,

Oloufa, Malone & Radwan, 2010) and labor productivity (Moselhi, Assem & El-Rayes 2005; Ibbs 2005). There have also been models created that seek to predict the frequency of change orders (Anastasopoulos, Labi, Bhargava, Bordat & Mannering 2010) as well as the causes for those ECOs (Wu, Hsieh & Cheng 2004).

The last task in this subsection is to review the literature that relates the concept of concurrent engineering to the ECO process. Concurrent engineering is a term applied to the reality that the engineering process is not always (in fact, hardly ever) a linear process. Parts that must eventually fit together in an assembly are sometimes designed out of order or with imperfect information about the mating parts. This usually occurs because of schedule or resource constraints and always results in ECOs being issued to finally bring all of the parts into compliance with the others in the assembly. Thus, ECOs move from an occasional occurrence to a planned requirement. This puts additional pressure on the ECO process to perform in accordance with the needs of the organization. Lee, Pena-Mora & Park (2005) propose a model to help in the identification of iterative cycles inherent in the concurrent design process. Terwiesch & Loch (1999) identify the many coordination difficulties brought about by concurrent design principles and relate the cost of ECOs to their timing. Loch, Mihm & Huchzermeier (2003) discuss how concurrent engineering complicates the interactions between components and stress that it is very useful to make all component information, even if it is preliminary in nature, available to all actors in the process. Lastly, Roemer, Ahmadi & Wang (2000) point out that concurrent engineering requires different and more effective means of communication among the entities in the design and manufacturing process.

The challenge of dealing with engineering change orders goes back to the beginning of engineering itself. The literature reviewed here demonstrates its importance and the level of effort expended to understand and optimize the process. A constant theme, however, is that the changes made to the engineering must be accurate, immutable, and transparent for the process to be efficient and effective, especially in an environment characterized by concurrent engineering, outsourcing, and global supply chains.

Blockchain

Because of its relatively short existence, there is little in the way of empirical research having to do with blockchain technologies or applications. There are, however, a number of papers that explore the various applications and characteristics of blockchain. While Firica

(2017) points out the potential performance issues with the application of blockchain in high volume transaction environments, a number of authors provide guidance for the architecture of blockchain-based systems. For instance, Xu et al (2017) provide a comprehensive list of design considerations for blockchain-based systems and also provide insight into how multiple chains might be merged effectively. Xu et al (2016) discuss the concept of off-chain storage and the performance differences between public (such as Bitcoin) chains and private chains.

The second largest stream of blockchain application research, behind financial transactions, is that of supply chain management. This is a much more closely related area to the current project. For instance, Kim & Laskowski (2018) describe an ontology-driven blockchain design for supply chain management. They focus their design on the problem of provenance determination, which is not greatly different than keeping track of the changes to an engineering model. Gao et al (2018) promote a hybrid blockchain supply chain model that attempts to overcome the performance issues associated with a public chain by putting in place a two-step block creation process. Finally, O'Leary (2017) investigates the application of a blockchain system to a consortium-based private chain environment in which only those firms involved in the supply chain have access to the chain, thus reducing the performance challenges as well as providing improved safety for the data.

Some authors focus their efforts on the use of a blockchain-based system to control physical objects. This approach is meant to bridge the gap between the initial research efforts aimed at managing financial transactions (virtual objects) with those managing more tangible objects (e.g. products in a supply chain or engineering models). Wu et al (2017) and Lu & Wu (2017) introduce an independent, crowd-validated shipment tracking framework that ties into the movement of physical shipments. Glover & Hermans (2017) take a similar approach in improving the traceability of clinical trial supply chains in order to maintain their HIPAA compliance. Notheisen, Cholewa & Shanmugam (2017) attempt to do the same within the vehicle manufacturing space.

Research Questions and Methodology

With potential shortcomings described in the Introduction as inspiration, the two research questions addressed by this paper are:

1. Can blockchain technology be applied to the managing of released engineering models and their associated ECOs?

2. How does the use of blockchain technology provide relief to the shortcomings mentioned above?

To address the first research question, an engineering model management system using a blockchain approach is designed. In doing so, the requirements and processes used in two actual organizations provide a basis upon which to design this system. To address the second research question, representatives of both organizations evaluate these designs in terms of how the processes embedded in this system will support and improve the current engineering model management approach.

Methodology

To answer these research questions, this study utilizes a Design Science Research (DSR) approach. This approach is chosen because it provides a framework for the creation of an IT artifact that solves an identified organizational need. The use of DSR has become well accepted by the IT community and appears in an increasing number of journal articles (Indulska & Recker 2010) The DSR guidelines followed by this study are shown in Table 1 (Hevner, March & Park 2004).

The process of building the artifact begins with gathering requirements from two engineering organizations. One of these organizations is a major aircraft engineering and manufacturing firm that performs its own engineering services internally and manufactures airframe components both internally and through the use of vendors. The customers of the firm are both domestic and international and encompass commercial, private, and governmental organizations. In such an environment as this, the engineering release process has a number of steps and each engineering model could have a rather complicated applicability profile. Moreover, the use of vendors to build certain aircraft components such as wing flaps and engines generates a requirement to share certain design data with external entities.

The second organization involved in this study designs and manufactures automated manufacturing machinery for a wide variety of industries. They exist in a largely Make-to-Order environment in which they design and manufacture machines specifically for the individual customer. While most of their manufacturing is performed internally, they also utilize vendors for certain highly specialized or rarely needed processes. As a firm that specializes in custom developed and produced products, they have little trouble with maintaining version control and ECO management, but it is still important for them to maintain the same level of discipline as

other manufacturers. Many of the components used in one product can be common to other products (e.g. servos, motors, even software) and as these components are updated and improved, they must have a reliable way to determine which versions were incorporated in which products.

System Design

System Requirements

The system requirements for the aircraft manufacturer and the machine manufacturer are relatively straightforward and have a great deal in common. They perform all of their engineering and design processes in a 3D Computer Aided Design (CAD) system, though they use different systems. For the aircraft manufacturer this includes all contour definitions, structural design, kinematics (e.g. landing gear, wing flaps, etc.), electromechanical lines (e.g. fuel, hydraulics, etc.), and many types of analyses (e.g. finite element analysis, aerodynamics, weight and balance, etc.). For the machinery manufacturer, these are typically solid model representations of the machines they have designed. Each of these models have associated with them various analyses, documentation, and bills of material (BoM) that occur in various formats including word processing, spreadsheet, and other office productivity tools.

Both organizations are located at a single geographic location, so all engineering and manufacturing is performed in a single building (machinery manufacturer) or campus (aircraft manufacturer). Both firms store their engineering data in onsite storage facilities rather than cloud storage. Both use a form of client/server architecture to facilitate the movement of data throughout the organization. Both firms make the engineering data available to all other internal departments, but only certain personnel have the ability to change or delete previously released engineering information. Both firms use a read-only file (called either a release file (aircraft) or the “vault” (machinery)) that contains the current and previous versions of the approved designs. Neither firm is required to share engineering data with their customers or the government. Both, however, share limited engineering with vendors who are contracted to build parts for their final products. There is currently no method, other than an accompanying memo or verbal confirmation that ensures the data sent to the vendor reflects the current design iteration.

In terms of engineering change processes, both firms follow a traditional ECO mechanism in which revisions are suggested or requested based upon customer requirement

1. Design as an Artifact	This study provides a set of models that describe the system's basic architecture as well as its functionality.
2. Problem Relevance	The relevance of this problem is discussed in both the Foundational Concepts section as well as the Literature Review
3. Design Evaluation	The design developed is evaluated within the two organizations in terms of its ability to address the shortcomings in their current engineering model management processes.
4. Research Contributions	This research contributes in its novel application of an emerging technology (blockchain) and by providing a basis upon which the buyer/vendor relationship can be further understood.
5. Research Rigor	The rigor of this DSR study stems from its grounding in the engineering model management processes of two engineering organizations and from the evaluative processes applied within these organizations to understand the improvement made in their respective organizations.
6. Design as a Search Process	The system design that results from this study is the result of weighing the requirements of the organizations, the broader concepts of engineering model management, and the various regulatory, competitive, and legal issues that impact these processes.
7. Communication of Research	The results of this research are to be communicated to the broad IS and engineering community through publication in an apprpriate journal as well as being discussed at the two firms taking part in the study.

Table 1: Design-Science Research Guidelines (Hevner, March & Park 2004)

changes, product improvement programs, or to correct engineering oversights. The changes are discussed and analyzed by a team of engineers and analysts that determines the applicability, cost and schedule impacts, and contractual ramifications. The larger of the two companies (aircraft manufacturer) has a more formal process in place than the other firm, but they both accomplish the same result. The changes are then made to the affected model(s) and the revised models (with their associated documents) are placed in the release file after being checked and evaluated as per the firm's normal processes. The ECOs that brought about the model changes are typically not stored with the revised models but are placed in another file. Engineers from both firms expressed that they would like to have those ECOs available to them as they use the revised models, but they can be difficult to find.

System Design

The process of designing a blockchain-based system, just as with any IT design project, starts with an understanding of the objective of the system. In this case, the objective is to create a tool that ensures that only current, approved, released engineering information is used in the

engineering of related parts and assemblies and in the manufacture of parts and tools. This applies to both internal operations as well as vendor activities. A simple peer-to-peer transmission of information, as discussed earlier in the paper, can result in the use of information that is not current or that has not been through the official checking and releasing process. Blockchain technology is chosen as the foundational technology because of its ability to guarantee that the proper model is being used (or sent to a vendor) without complex and time consuming checking and verification on the part of either the sender or receiver. A blockchain based system improves upon the current approach in which verification is left solely in the hands of the sender. This system allows independent verification without dependence on a third party to provide assurance that the proper version of the information is being utilized. For internal use of engineering data, no viable third party verifier exists and to use one for external information transmission (e.g. to a vendor) would be outside the typical industry process as well as incur additional costs and delays.

A more traditional SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis of the current process provides the following insights:

- Strengths: Simplicity of the transfer system, efficient of computing resources, little to no management participation, low cost.
- Weaknesses: Lack of verification of currency of information being used, easy to circumvent when immediate information is needed, increases probability that improper information is used to create subsequent engineering or parts/tools.
- Opportunities: Because virtually all engineering information is stored, transmitted, and consumed in an electronic format, the opportunity to impose additional controls and requirements, without the need for additional human effort or cost, exists in this case. This can provide increased validity, traceability, and ultimately effectiveness of the engineering information created.
- Threats: Because virtually all engineering information is stored, transmitted, and consumed electronically, the opportunity for improper use and distribution is substantial. Without a proper method to control the manner in which information is distributed, and a method to ensure the immutability of transmission and version control data, the organization has little control, except for employee procedures, over the utilization of very costly engineering information.

To guide the design process, Xu et al's (2016) guidelines for blockchain systems design is used (Table 2).

The first design decision is to define what information will be held on the chain. In the original conception of blockchain, the data on the chain represented the actual Bitcoin transactions. However, to store all of the engineering data on the chain would require that the block size of the chain be much larger than the original blockchain specifications, require a great deal of processing power, and risk that other parties can access these proprietary data. Instead, this system stores its data in an off-chain storage facility (Design Decision 1). The architecture of the engineering storage facility is not important to this discussion, so in the interest of ease of use the data can be kept in much the same manner as it is currently. However, all of the information associated with a specific engineering model, as well as the model itself, is stored in an encrypted manner and fashioned into a Merkle Tree format (Drescher 2017). In a Merkle Tree, the various documents are encrypted together using an appropriate cryptographic hash function such that the root of the Merkle Tree is the hash value after all documents have been hashed together, usually in a binary fashion (Figure 2).

Blockchain Design Decision 1	Mechansims of improving transaction processing rate
Blockchain Design Decision 2	Mechansims of selecting the next block added to the blockchain
Application Design Decision 1	Scope: On-chain vs. off-chain
Application Design Decision 2	Public chain vs. private chain
Application Design Decision 3	Single chain vs. multiple chains
Application Design Decision 4	External validation vs. internal validation
Application Design Decision 5	Permissionless vs. permissioned blockchain

Table 2: Design Decision Tradeoffs (Xu et al 2016)

In Figure 2, each document, regardless of format, is run through the hash algorithm and the result is a hash reference (HR) value specific to each document. Then, the HR for each document is hashed again, this time with its neighbor, to create a HR for the combination. This

can be done across as many layers and branches as necessary. Also, the data to be hashed can include the hash value of data from another source (or another chain) in this case the hash of an ECO that is applicable to this engineering model. When all documents or models are finally hashed into one HR, this is known as the root of the Merkle Tree (Drescher 2017). This is the value to be stored on the blockchain. It should be noted that if even a small change is made to any of the documents or models that have been hashed into the Merkle Root, the Merkle Root hash value will change, thereby providing proof that at least one of the values in the tree has been changed. By systematically decrypting the values in the tree and comparing the HR values to a value known to be correct, the changed document can be identified and the revisions made clear.

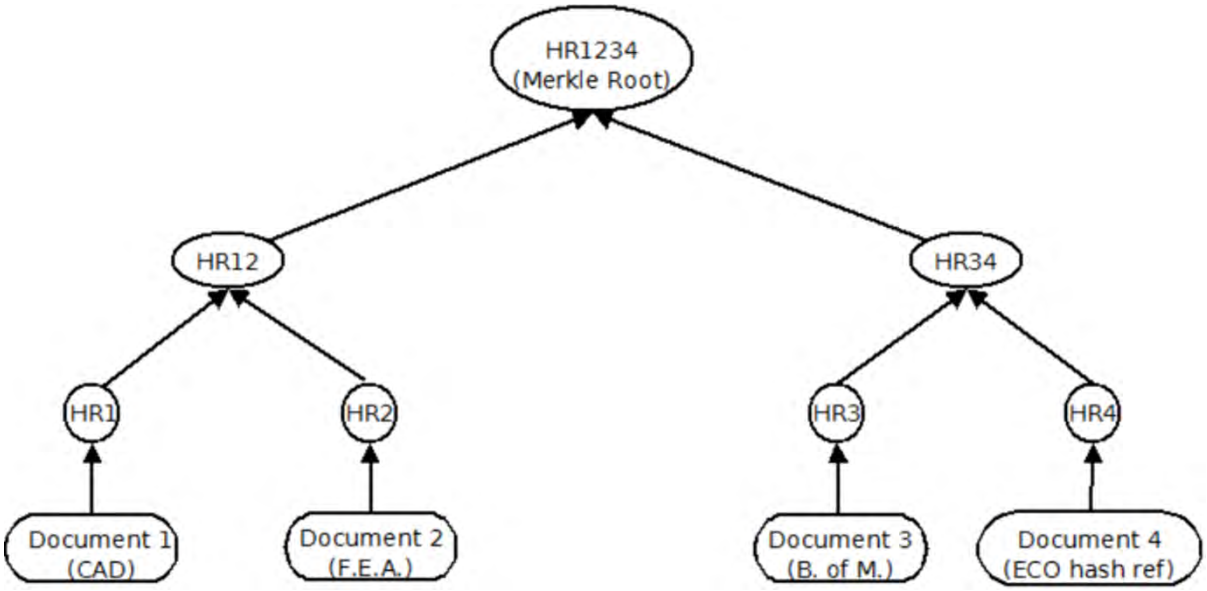

Figure 2: Engineering Information Stored in Merkle Tree Format

When engineering information is accessed in the release file, it is accompanied by the hash value of the Merkle Tree it has been processed into. This value will be the same as the HR stored on the blockchain that refers to that model and its associated documents. If the information retrieved has been changed in even a small way, the hash values will not match and the differences between the files must be investigated. If the blockchain is then shared with the major stakeholders of the firm, which in these cases is the major vendors, then it provides an

error-proof check that the data sent to the vendor is the same that is currently residing in the firm's release file. Having parallel chains in multiple organizations is an example of a private blockchain (Application Design Decision 2). While a single, internal chain prevents internal operations from using incomplete or non-current information, the multiple location private chain described here means that all data sent to vendors can be verified, independently, as being the same as the data in the release file.

The requirement of maintaining a duplicate chain is not onerous nor is it without precedent. Vendors are often compelled to comply with requirements from the buyer that impose far greater burdens than this. These can range from the use of a specific IT system, to adjustments in delivery and batch sizes, to significant quality requirements, to the monitoring of the buyer's stock level. In the present case, the vendor would be asked to dedicate a relatively small amount of computing resources to maintain the blockchain data and to compute the hash puzzle required to add data to the chain. These could be done in a cloud environment if that fits into the vendor's IT architecture more comfortably. It should be noted that having a copy of the chain in their possession does not give the vendor access to all of the underlying engineering information, only the Merkle Root hash value, which is useless without the decryption key. It is also important to note that the vendors, or whatever stakeholders end up holding the chain, will not have permission to change or erase data on the chain, only to read the hash values so they may compare them with the data sent from the buyer. This is known as a permissioned blockchain in which each participant has a certain level of access that is controlled by a third party or, in this case, the buying firm in their role as the owner of the data on the chain (Application Design Decision 5).

At this point, it is appropriate to consider Blockchain Design Decisions 1 & 2. Decision 1 centers on mechanisms to improve the transaction processing rate, or the rate at which blocks can be added to the chain. This is considered a major obstacle to scaling blockchain into a large-scale transactional system (Gilbert 2016). However, in the present system, the speed at which blocks are added is of less importance according to the engineers and managers involved in providing the requirements of the system. In most cases, transaction times measured in hours are sufficient to provide the service intended. The transaction rate is a function of a) the amount of data being added in a block and b) the difficulty of the hash puzzle that must be solved. In a closed, well protected environment such as this, the puzzle requirements can be reduced to ease the Proof-of-

Work requirement for adding blocks to the chain (Drescher 2017). It will also serve to reduce the resource requirements for the parties helping to maintain the chain.

During the search process to identify the proper manner in which to include blockchain in the problem solution a number of concepts were discussed with members of both case study firms. The feasibility of using vendors or other stakeholders as chain repositories was thoroughly explored from an organizational, security, and inter-organizational influence perspective. These are explored in the next section. The decision of how to store ECOs effectively is another important design decision. At first, the creation of a second chain to store only ECO data was considered, resulting in a multiple chain environment (Application Design Decision 3). However, the increased effort to maintain that chain, coupled with the ability to include the hash value from the ECO in the definition of the engineering model hash, points the design toward a single-chain architecture.

The last decision to consider is whether the system requires a "validation oracle," and if so, should that be within the system or external. A validation oracle is a service that validates the transactions that occur on the chain in the form of smart contracts (Drescher 2017). These are important when the chain is designed to store financial transactions or other state-changing activities such as the change of ownership of real estate. However, the current system stores only the current state of data, not the transactions that create or modify it, so the use of a validation oracle is unnecessary.

Figure 3 displays the design of the system as discussed. The Engineering Information Database contains all released CAD models and documents that pertain to a specific part or assembly and their hash reference values (only HR values are shown for clarity). When released, the hash reference at the root of the Merkle Tree for the initial release is used to create a block on the blockchain (Block 1). Once added successfully to at least one of the chains, this block is then copied to all other chains. It does not matter which chain successfully solves the hash puzzle first. When an ECO is created that affects that part, the CAD model and other documents are revised accordingly and labeled as Revision A. These are re-encrypted along with the HR value of the ECO that drove the changes (Model 1A HR). As with the initial release, the root of the Merkle Tree is added as a block to the chain (Block N), which is again copied to all of the other chains.

System Evaluation and Discussion

Hevner, March & Park (2004) suggest a number of options to evaluate the artifact built during a design science project. Of those, the descriptive method is the most appropriate for a design at this stage of maturity. The design was presented to the engineers and engineering managers at the two case study firms and they evaluated it from three perspectives: performance, organizational processes, and cost.

The performance of the system is based not upon its processing speed but rather its ability to handle the situations that the firms face when it comes to the management of engineering information and provide the safeguards desired. The research participants presented five scenarios for analysis:

1. Initial model release
2. Model revision based on ECO
3. Model revision due to error
4. Model cancelation
5. Applicability of model to multiple products

The first two scenarios, initial release of model and model revision based on ECO, are standard operations and the ability to handle those scenarios has been described previously. The revision of a model due to error (calculation error, misspelling, etc.) does not usually require an ECO and so would not include the HR value of the ECO in the revised block. The aircraft engineering manager mentioned that in a military aircraft environment these would require an ECO, and they would be dealt with accordingly. In most cases, a change of this nature would simply be listed in the notes included on the model, but in this case the participants suggested that a memo explaining the reason for the change should be included in the collection of documents supporting the model, and hence in the Merkle Root HR as well.

Model cancelation occurs when a product redesign renders a part unnecessary for a product. In the past, a model that has been deemed unnecessary, and has not been used in any product, was simply deleted from the database. However, blockchain does not have a mechanism to remove a block. In this case, the engineering managers elected to add a document to the part definition file explaining why the part was made unnecessary and make the revision designation "canceled." The block is created with the hashed data as before, but the engineering data that created the hash reference for the block can be deleted or archived.

It is not uncommon for a part to be applicable to multiple aircraft or machines, such as a servo motor. In these cases, it is highly inefficient to duplicate the engineering models and documents for each application. Rather, the models are cross-referenced for each type of machine or vehicle they are used on and an applicability document is produced. The difficulty presents itself when different applications of the same part are tied to different revision levels. Thus, it is possible that one revision level, the "A" revision, is applicable to products 1-5 while the "B" revision belongs on products 6-10. In a traditional model management system, it is possible that through an oversight, the wrong revision level can be distributed to a vendor for manufacture. However, the blockchain method described here eliminates that possibility by allowing the vendor to compare the HR sent with the engineering data to the hash value on the blockchain, thus ensuring that the proper revision level is sent. When multiple revisions are active simultaneously, having the blockchain to provide a final check will eliminate many costly errors.

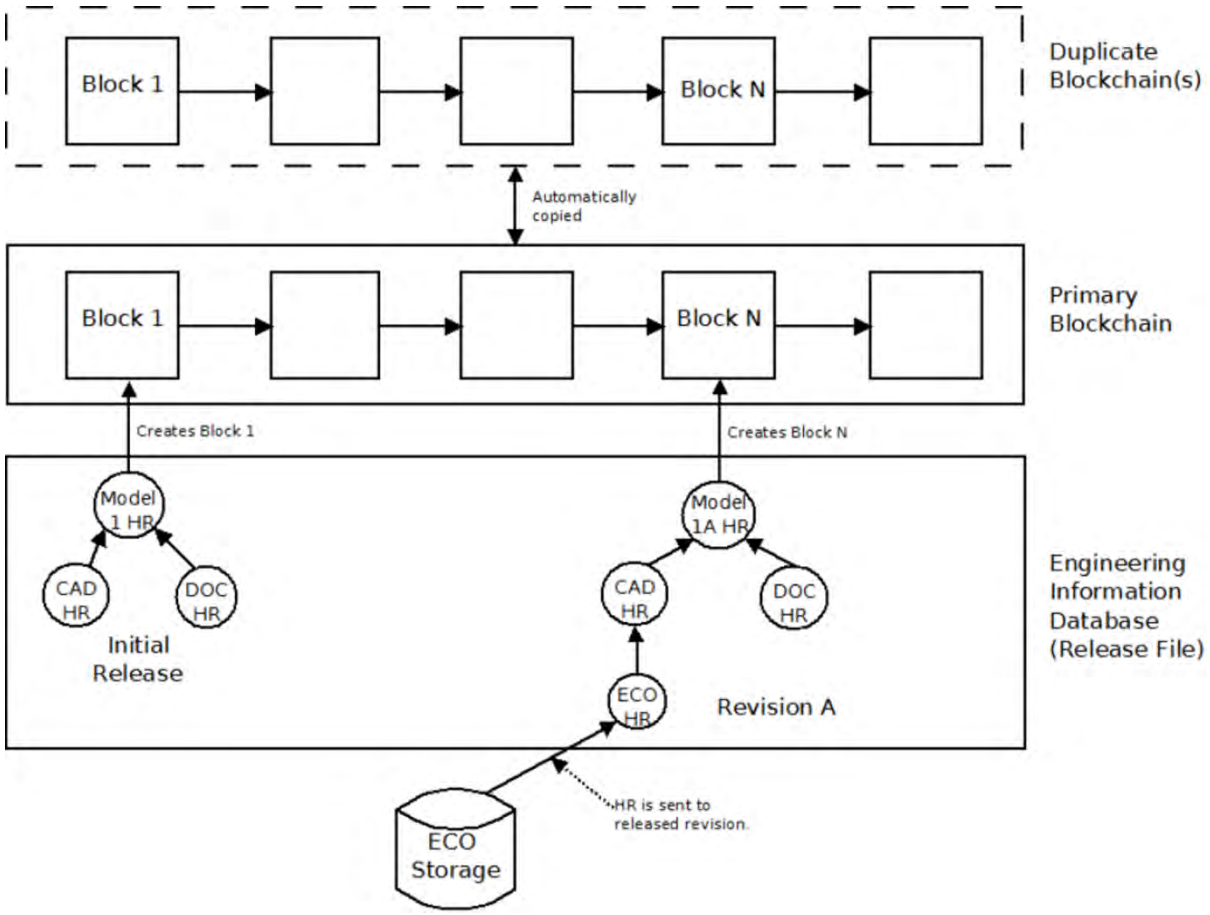

Figure 3: Engineering Information System Blockchain Design

From an organizational perspective, the system design is evaluated in terms of the internal organizational processes as well as the inter-organizational processes when dealing with vendors. Internally, the process of extracting needed information from the release file to begin work will require one additional step, that is, to compare the HR value on the accessed information with the HR value on the blockchain to ensure that the proper version has been accessed. This will eliminate the risks associated with providing an "advance copy" of the engineering information so that downstream activities can commence while the release process takes place. While this is an unofficial activity, it is relatively common in many engineering and manufacturing environments. Even in cases in which an unofficial copy is passed between colleagues, the hash values must be checked prior to releasing the engineering being created from the advance copy or the creation of parts or tools.

Inter-organizational issues center on whether the vendor, or any other stakeholder, would be willing to involve itself in the computations and storage of a blockchain. The consensus among the research participants is that there is a reason for them to invest in the necessary infrastructure as well as to take responsibility for its maintenance. As mentioned earlier, when data is passed to a vendor that turns out to be incorrect, the vendor sometimes wastes significant capital and time scrapping incorrect parts and tools and rebuilding them with the correct information. Even when the mistake is on the part of the buying firm, there is a period during which the vendor will have to spend its own funds to correct the problem and wait for repayment from the buyer. As pointed out by the aircraft engineering manager, often the responsibility for the mistake is never successfully determined, causing significant disruption in the buyer/vendor relationship. According to one engineering manager, this type of situation has ended otherwise successful outsourcing relationships. With the ability to host these processes in the cloud (O'Leary 2017), the cost and risk to be borne by the vendor to prevent these types of disruptions is minimal.

This level of cooperation from the vendor extends the concepts originally set forth in the Social Exchange Theory (SET) (Lambe, Wittman & Speckman 2001). SET suggests that buyers and vendors will cooperate with each other and try to solve supply-chain problems as long as the results are beneficial to both parties. There is a long history of firms having fewer but closer vendors (Seydel 2005) and of vendors being asked to provide feedback on the buyer's operations

in order to improve their functionality (Cunningham et al 2016). Buyers also recognize that vendors often have knowledge and expertise that will allow them to improve their operations (Wong, Tjosvold & Zhang 2005). This system asks that the vendor do more than provide feedback. It requires that the vendor take advantage of a mechanism to independently verify that the data being transferred has been properly selected and sent. This is a further sharing of the responsibility for a successful interaction. Future research will determine vendors' level of acceptance for this responsibility-sharing arrangement.

It is also useful to view this arrangement through the lens of Deutsch's theory of cooperation and competition (Deutsch 1973, 1980) in which he posits that the manner in which goals are structured will determine how people, and organizations, interact. These interactions can be classified as cooperation, competition, and independence. This arrangement of parallel blockchain custody will only work in relationships that are cooperative in nature. In these types of relationships, according to Deutsch (1980), the two partner firms will act in concert and share those resources that will eventually result in a stronger, and therefore a more successful, product. In the present case, the firms will share information and responsibility, and each firm will contribute to the success of the venture by using resources (computing, electricity, capital) to embody these contributions. Turk and Klinc (2017) suggest that the use of blockchain can increase, or even replace, the trust between partners in an information-intensive environment such as engineering and manufacturing.

Last, the topic of cost is explored. The additional storage and computation capability necessary to execute these processes is relatively modest because only the root hash references are stored on the chain. The large CAD and analysis files would be stored in any case and pose no additional resource requirements. The computation necessary to solve the hash puzzles to add blocks to the chain will not be as onerous as if they were taking place on the open Internet and there will be only a handful a day to compute rather than the thousands of daily transactions on the Bitcoin system (Gilbert 2016).

Conclusion

This paper describes the use of blockchain technology in the management of engineering information, and the ECOs that cause their revision, in the manufacturing industry. Using the Design Science Research methodology, an artifact has been created (a system design) that addresses a problem relevant to almost every manufacturing and engineering organization in the

world. The evaluation of the artifact by the two engineering firms that participated in the study provide confidence that the design approach is sound and that the system built based on the design artifact will indeed provide relief from the problem of maintaining control over the information used to build expensive tools and parts. It also provides a mechanism by which the ECO process can be more readily analyzed by the management team to better understand why changes are made and how effectively the change mechanism is performing.

The contributions of this paper are two-fold. First, it demonstrates that blockchain, while developed for a very different purpose, can improve upon the current system used used to control the release, modification, and use of engineering information, even in a multi-organizational, multi-national, multi-platform environment by adding a method to ensure the validity of the information being transmitted or accessed. Because no information can be used without confirming its proper revision level, and that the ability to confirm this is automatic and beyond the control of any of the parties once the system is implemented, all participants in the process can have confidence in the process. The use of cloud providers to perform these activities limits the costs and risks involved and removes any technological incompatibilities.

The second contribution is in the area of buyer/vendor relations. With a system such as this in place, the ability of the vendor to ensure the data it receives is of a proper revision level puts the vendor in a better position to control its own operations. It will no longer be vulnerable to rapid and unexpected changes in engineering information without proper notice or having to work with preliminary data and then perform expensive and time-consuming rework when the official data arrives. The relationship between buyer and vendor is a small part of the overall supply chain, but it is a controlled by a rather unique and somewhat special set of circumstances. The buyer is doing far more than simply purchasing a commodity. This relationship results in the creation of a product that fills a specific, and sometimes crucial, role in the buyer's final product and must be built to often exacting specifications. This requires that the information passed between the two parties is highly accurate, precise, and readily useable. Since part definitions such as these are often the result of other processes and analyses, they are subject to change without a warning or in a certain pattern. This requires a tighter, more intimate buyer/vendor relationship. This is an extension of Deutsch's (1980) theory of cooperation and competition as well as the SET. In both theoretical frameworks, the type of relationship between the two parties has a direct effect on the success of the venture. It remains for future research to determine if this

extended relationship will be feasible and bring the benefits possible with the blockchain approach.

Future research tasks are to build a prototype system that performs the operations described herein and test the manner in which these processes perform in terms of the organizations' processes. Another interesting line of research will be to extend the organizational theories described herein to better understand the boundaries of the buyer/vendor relationship.

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BLOCKCHAIN TECHNOLOGY OPPORTUNITIES IN THE HEALTHCARE INDUSTRY

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ABSTRACT

Blockchain technology represents a significant step forward in how people can make online transactions. A blockchain is a digital ledger with improved security, increased speed and much lower transaction costs. Blockchain technology has emerged in response to the growing need of society to offer these three values.

The paper covers the key features of a blockchain and demonstrates how each of these features is designed to answer the values required by society. The paper discusses multiple potential applications for this technology and then dives deeper its potential within the healthcare industry. One noteworthy conclusion is how the Drug Supply Chain Security Action (DSCSA) mandate passed in 2013 almost dictates the use of blockchain technology within the pharmaceutical supply chain. To prevent fraudulent medication from reaching patients, the mandate requires product identification, tracing, storing and verification as well as a mechanism to detect and respond to suspect medication – all on an online shared network. This could provide the first tangible path to market for blockchain in a well-established industry.

Finally, the paper concludes that many of the intended benefits of blockchain technology paradoxically act as potential limitations. For example, the immutable nature of blockchain appears to be in direct conflict with the European Union's recently passed General Data Protection Regulation which states that individuals have the right to fully and completely erase all personal data.

Blockchain presents itself as a technological advancement in how society store and handles online information. Managers need to understand the benefits and challenges of adopting blockchain in their businesses as many industries begin to explore the applications.

Key words

Blockchain, distributed network, hash, digital ledger, smart contracts

DO RECOMMENDATIONS FROM FRIENDS MATTER? EVIDENCE FROM VIDEO GAME PLATFORMS

Abstract

We investigate how peer influence affects customers' product adoption behaviors in emerging video game platforms. Understanding peer influence is critical to motivating users' willingness to purchase and improving marketing performance for game publishers. While similarities between socially linked users can be viewed as a consequence of social influence, homophily may also contribute to such phenomenon, causing identification difficulties in observational studies. Using data from the world's largest digital distribution platform for video games, we leverage the state-of-the-art recommender system algorithms and propose an innovative framework to identify social influence in the adoption of video games when a confounding homophily effect is present. The results show that peer influence has a positive impact on the adoption behaviors of platform users (i.e., a user tends to adopt a video game that has been purchased by his peer). We also find that the peer influence would have been overestimated by approximately 24% if homophily was not properly accounted for.

Keywords: video game, recommender system, side information, peer influence

1. Introduction

Video gaming is a large industry that keeps growing over the past few years. In 2017, the US video game industry generated a record of $36 billion in revenue, up 18% from 2016.[1] Comparatively, the US film industry has a total box office revenue of $11 billion in the same year.[2] It is apparent that the burgeoning video game industry is becoming relevant to consumers, companies, and researchers. Unlike the traditional brick-and-mortar store retailing business, online video gaming allows interactions between consumers through platforms, which would potentially change consumers' buying behaviors. Specifically, an online game platform can be considered as a community of friends with shared interests. A user can view his friends' purchased games, gameplay statistics and game screenshots. He can also send and/or receive personalized messages, and get notifications about the games when his friends are playing. These interactions make social influence even more salient in consumers' decision-making process. In

[1] Entertainment Software Association http://www.theesa.com/article/us-video-game-industry-revenue-reaches-36-billion-2017/

[2] Box Office Mojo https://www.boxofficemojo.com/

this study, we aim to quantify the role of peer influence in the adoption of video games. Although the effect of social influence has been widely discussed, the identification of peer influence is still challenging for empirical studies using observational data (Bapna & Umyarov 2015, Manski 1993). The main difficulty is that product adoption can also be explained by homophily, in which dyadic similarities between users create correlated outcome patterns among friends that merely mimic viral contagions without direct causal influence (McPherson et al. 2001). Therefore, when a user purchases a new game, it is important to know if the game adoption is driven by peer influence or similarity between the user and his friends. If peer influence can be identified in the adoption of games, then game publishers can generate more revenue by targeting influential users or building product features that facilitate peer influence. Alternatively, if homophily dominates consumer purchase behavior similarity, then game publishers should focus more on analyzing the shared taste of users who purchased the same game. Our study bridges two streams of research on video game industry and product adoption. On one hand, there is scant empirical research investigating the video game industry which mainly focuses on various factors that determine game sales (Zhu & Zhang 2010, Cox 2014). On the other hand, although previous literature has examined the effect of peer influence on product adoption in various domains including technology adoption (Brown & Venkatesh 2005), service adoption (Bapna & Umyarov 2015), and application adoption (Aral & Walker 2011, Davin et al. 2014), none of these has ever examined the effect of social influence in video game platforms. To the best of our knowledge, this is the first study to investigate the effect of social influence in video game platforms. It's worth mentioning that video game platforms differ from ordinary social network websites. Unlike social media such as Facebook or Twitter, online game platforms do not require pre-established interpersonal relationships between users. As a result, these platforms generally do not consider social factors such as relationships and trust among the users. Therefore, the power of social influence remains to be exploited (Li et al. 2013) in video gaming platforms, which motivates our empirical study.

This paper examines the effect of peer influence on the adoption of video games using data from the largest video game retailing platform in the world. In particular, we propose an innovative framework that integrates propensity score matching (PSM, Rosenbaum & Rubin

1983) and recommender system to identify social influence in the adoption of video games when a confounding homophily effect is present. The basic idea is to reveal users' gaming preferences that drive the formation of friendships among similar users as hypothesized by homophily assumption. Homophily is then controlled by matching users into control/treatment group with similar taste as measured by latent features. By examining the purchasing behavior of users with friends who adopted the game (treatment group) and those without friends who adopted the game (control group), we can estimate the direction and magnitude of social influence in video game adoptions. Instead of representing users as the games they have purchased, we make use of the state-of-the-art matrix factorization algorithm and propose Similarity-Enhanced Matrix Factorization (SEMF), in an attempt to capture users' preferences due to its various advantages. First, as a dimension reduction technique, matrix factorization can effectively alleviate the sparsity problem (Chen et al. 2011) which arises when each user only interacts with a small portion of available items. Referring to video game platforms, a user considers a few tens of games, while the platform contains thousands of them. This sparsity may lead to zero values in similarity calculations between users, which would, in turn, make Boolean feature vector of purchased games less effective in identifying users' tastes. Therefore, we represent users by low-rank features derived from matrix factorization. Second, interactions between users and items may lead to data that is missing not at random (MNAR) (Little & Rubin 2014). For example, users typically purchase and play games they like, and rarely purchase games they do not like. Selection biases would thus be introduced when measuring users' gaming performance if we ignore the mechanism of missing values. We address this issue by assigning a weighting matrix, based on features that are less affected by selection bias, in our formulation of matrix factorization. Last, there exists very rich side information that describes games in detail. To improve the accuracy of our measure of users' tastes, we solve a regularized optimization problem that incorporates side information of games.

The rest of this paper is organized as follows. In Section 2, we review the related work. In Section 3, we show the details of the proposed framework that integrates recommender system and PSM for peer influence identification. We then describe the data in Section 4. The

performance of recommender system and the effect of peer influence are presented in Section 5. We conclude and discuss our work in Section 6.

2. Related Work

In this section, we briefly review the main works in peer influence identification and recommender system. In his seminal paper, Manski (1993) analyzes the problem of identifying endogenous social effects based on observed behavior. Since then, various approaches have been proposed to make use of observational data for peer influence identification. The basic idea is to control homophily, exogenous factors, or any other factors other than influence (Ma et al. 2015). Nair et al. (2010) quantify peer influence in physician prescription behavior. They utilize a fix effect model to control for the possible homophily. Ma et al. (2015) separate homophily from influence in the context of the purchase of caller ring-back tones by considering the dynamic purchase pattern in a choice model. Our work is most related to the studies that identify peer influence by incorporating user-level covariates in regression and matching. For example, Aral et al. (2009) develop a dynamic matched sample estimation framework to distinguish influence and homophily effects. To accurately proxy individual's tastes and preferences, they use a set of 46 covariates including data on users' demographics, mobile device usage, and page views in matching. They find strong evidence of social influence in the adoption of a mobile application. Nitzan & Libai (2011) investigate the role of social influence in customer retention of a mobile service provider. They include several demographic variables and usage characteristics to account for similarities in customers' tastes. However, user-level demographics are usually difficult to get in online platforms due to privacy policies. In this regard, researchers have to make the best use of the available data on user-item interaction in the analysis.

The most widely used approach for mining user-item interactions is Collaborative Filtering (CF) (Goldberg et al. 1992), which predicts the ratings an individual would give to items by analyzing preference similarity across individuals. In the context of product adoption, explicit ratings on products are hard to collect, and user-item interactions are implicitly expressed by users' adoption decisions. To address the implicit feedback, Hu et al. (2008) propose to use a weighting matrix that measures the confidence in observing positive and negative examples. We

extend their work and improve the prediction performance by incorporating a rich set of item information in matrix factorization. In this way, users' tastes can be accurately measured by the low-rank user vectors. To the best of our knowledge, there is no prior work on incorporating user-item interactions when identifying peer influence in a principled manner.

3. Research Methodology

We begin our analysis by capturing users' tastes. Intuitively, a user's preference for video games can be measured by the games he had purchased. We can thus use a vector of zeros and ones indicating un-purchased games and purchased games, respectively, to proxy a user's taste. This approach, however, is problematic in practice due to the following reasons. First, the fact that there are more than thousands of games in our dataset will lead to long user vectors with large dimensions, making PSM based on these vectors less efficient (Hill et al. 2011). As a result, some dimension reduction techniques are necessary to derive low-rank user vectors. Second, the measurement of taste might be biased if we only look at the purchased games of a user. For example, not buying a game can stem from many other reasons beyond not liking it. The user might be unaware of the existence of the game, or simply unable to afford it. Besides, a user may have different levels of preference for the purchased games. He may like some purchased games more than others. In other words, there is a lack of active rating on products as compared to movie rating websites, resulting in the problem of implicit feedback. This problem requires a weighting scheme on different games to get a more accurate measure of users' tastes. Moreover, the simple vectorization of purchased games ignores the very rich side information about video games. We argue that the game genres provide evidence for user's gaming preferences. In the context of video gaming, the most reliable and content-rich descriptors of a game lie in its genres voted by users. Meanwhile, video game platforms recommend products to their users based on a rich collection of predefined genres that describe gameplay including action, strategy, casual, and so on. These facts show that the information embedded in game genres play an important role in customer buying behavior. Therefore, the performance of the measure on users' tastes can be improved by taking into account this information. To address these concerns related to simple vectorization, we develop a collaborative filtering model for

implicit feedback with rich item information, whereby the derived low-rank vectors are used to measure users' tastes. We use the following notations throughout this paper:

m : number of users;

n : number of items (games);

k : number of latent factors;

$U = \{u_1, u_2, ..., u_m\}$: a group of users;

$I = \{i_1, i_2, ..., i_n\}$: a set of items (games);

x_u : k-dimension low-rank vector representing a user's preference over latent factors;

y_i : k-dimension low-rank vector representing an item (game);

$X = (x_1, ..., x_u, ..., x_m)^T$: $m \times k$ low-rank user matrix, where T is matrix transpose;

$Y = (y_1, ..., y_i, ..., y_n)^T$: $n \times k$ low-rank item (game) matrix;

$R = \{r_{ui}\}_{m \times n}$: user-item preference matrix, where $r_{ui} = 1$ if the user u purchased item i, and $r_{ui} = 0$ otherwise;

$P = (p_1, ..., p_i, ...)^T$: game information matrix;

$Q = (q_1, ..., q_u, ...)^T$: user information matrix;

$S = \{s_{ij}\}_{n \times n}$: item-item similarity matrix, where s_{ij} is the similarity between item i and item j;

$T = \{t_{ui}\}_{m \times n}$: user-item similarity matrix, where t_{ui} is the similarity between item u and item i;

$W = \{w_{ui}\}_{m \times n}$: weight matrix;

$\| \bullet \|_F$: Frobenius norm of a matrix;

Matrix factorization models have been widely used for recommendations (Koren et al. 2009). In cases of explicit rating where users actively evaluate items by giving both positive (likes) and negative (dislikes) examples as measured by numeric ratings in a score matrix R, we can approximate R by decomposing it into two low-rank matrices X and Y that represents users and items respectively. However, with implicit user feedback, the dataset usually only consists of binary values reflecting a user's action or inaction. Take our study for example. The dataset only indicates if a user has purchased a game or not without explicit ratings. A naive approach to this problem is to simply treat purchased games as positive examples with value 1 in R, and treat un-purchased games as negative examples with value 0 (i.e., AMAN). A better strategy is to

assign a weight matrix (i.e., wAMAN) to control the relative contribution of quadratic terms to the loss function :

$$J(X,Y) = \sum_{u,i} w_{ui}(r_{ui} - x_u^T y_i)^2 + \lambda(\sum_u \|x_u\|_F^2 + \sum_i \|y_i\|_F^2) \tag{1}$$

where λ is a regularization parameter that prevents overfitting. The weight w_{ui} can be considered as the confidence level that represents how confident we are about the value of r_{iu}. We give large values to w_{ui} if user u tends to like item i, and vice versa.

To improve the performance of matrix factorization and determine the weight matrix, we explore rich information embedded in games. We use genres as the source of information for a specific video game because they play an important role in game marketing effectiveness (Hofacker et al. 2016) through platforms and user experience (Quax et al. 2013).

3.1 Formulating Game Information Vectors

In our dataset, each user, no matter whether owns the game or not, can vote for genres that he thinks most relevant to the game from a collection of candidates. By taking advantage of the wisdom of the crowd, the assembling of user-generated genre tags will accurately characterize a video game in terms of gameplay. In this regard, a game can be represented by a collection of genre tags just as a document can be represented by a bag of words. We denote by

$$G_i = \{z_{i1}, z_{i2}, ..., z_{ig}, ...\}$$

the collection of genre tags of game i with z_{ig} as words. Tf-idf weightings can then be used to build the item information matrix. In particular, we promote words that are descriptive and unique to a game. For a given word z_{ig} we let

$$idf(z_{ig}) = log(|I|/|z_{ig} \in V_j|) \tag{2}$$

where $|I|$ is the total number of games and $|z_{ig} \in V_j|$ is the number of games whose vocabularies V_j contain z_{ig}. We then let

$$p_{ig} = idf(z_{ig}) \times tf(z_{ig}) \tag{3}$$

where $tf(z_{ig}) = |z_{ig} \in G_i|/|G_i|$ is the term frequency of word z_{ig} in game i. By taking into account game genres, we formally formulate the vector representation of games as

$$p_i = (p_{i1}, p_{i2}, ..., p_{ig}, ...) \tag{4}$$

We further develop a similarity measure between games using cosine similarity:

$$s_{ij} = cos(p_i, p_j) \tag{5}$$

where s_{ij} is the similarity between game i and game j.

3.2 Formulating User Information Vectors

Similar to game information vectors, user information vector can be defined using a collection of genre tags of purchased games. We let

$$q_u = \sum_{i \in I_u} p_i \tag{6}$$

where q_u is the aggregation of game information vectors owned by user u. This allows us to make a comparison between users and games. We can thus define a similarity measure between users and games as follows

$$t_{ui} = cos(q_u, p_i) \tag{7}$$

where t_{uj} is the cosine similarity between user u and game i. The weighting scheme can be determined in such a way that more weights will be given to cases where users are similar to games in terms of genres.

3.3 Similarity-Enhanced Matrix Factorization (SEMF)

We can now show how to incorporate rich item information into the factorization model. Motivated by the assumption that similarity between items should be consistent regardless of the representation method, we constrain latent features as factorized matrices of the item similarity matrix. In other words, if two items are similar as measured by genre information, they should also be similar to each other when we calculate their similarity using latent features. Mathematically, we then aim to find a solution by minimizing the following loss function:

$$J(X, Y) = \sum_{u,i} w_{ui}(r_{ui} - x_u^T y_i)^2 + \sum_{j>i} (s_{ij} - y_i^T y_j)^2 + \lambda(\sum_u \|x_u\|_F^2 + \sum_i \|y_i\|_F^2) \tag{8}$$

We assign weights to negative examples by looking at the similarity between the user and the game. The more similar they are, the less weights should be assigned to that negative example. Hence for negative examples:

$$w_{ui} = 1 - cos(q_u, p_i) = 1 - t_{ui} \tag{9}$$

For positive examples, we determine weights by considering the interaction between the user and the game. We denote by f_{ui} the time user u has spent on game i. The more time a user has spent on a game, the more he is interested in the game. As a result, we define weights for positive examples as:

$$w_{ui} = 1 + \alpha f_{ui} \tag{10}$$

where α is a positive number that controls the increase rate of confidence.

The low-ranked matrices can be solved by Alternative Least Square (ALS). To solve X, we first fix Y and take derivatives of loss function with respect to x_u:

$$\partial J/\partial x_u = -2\sum_i w_{ui} y_i (r_{ui} - x_u^T y_i) + 2\lambda x_u \tag{11}$$

Let the partial derivative $\partial J/\partial x_u = 0$, we get

$$x_u = (\lambda I_d + \sum_i w_{ui} y_i y_i^T)^{-1} (\sum_i w_{ui} r_{ui} y_i) \tag{12}$$

where I_d is an identity matrix of rank d. Similarly, let $\partial J/\partial y_i = 0$, we get

$$y_i = (\sum_u w_{ui} x_u x_u^T + \sum_j y_j y_j^T + \lambda I_d)^{-1} (\sum_u w_{ui} r_{ui} x_u + \sum_j s_{ij} y_i) \tag{13}$$

The update is then repeated until convergence. We summarize the algorithm as follows:

1. **Initialize** x_u and y_i with random numbers
2. **If** $r_{ui} = 0$ then
3. $\quad w_{ui} = 1 - t_{ui}$
4. **Else**
5. $\quad w_{ui} = 1 + \alpha f_{ui}$
6. **End if**
7. **Repeat**
8. $\quad x_u = (\lambda I_d + \sum_i w_{ui} y_i y_i^T)^{-1} (\sum_i w_{ui} r_{ui} y_i)$
9. $\quad y_i = (\sum_u w_{ui} x_u x_u^T + \sum_j y_j y_j^T + \lambda I_d)^{-1} (\sum_u w_{ui} r_{ui} x_u + \sum_j s_{ij} y_i)$
10. **Until** x_u, y_i converge

11. **Return** x_u , y_i

3.4 Identifying Peer Influence

Once we have derived low-rank latent features x_u that capture users' tastes in phase 1, we can estimate the effect of peer influence (i.e., if a user has friends who had purchased a specific game) by matching users who have adopter friends to users who have no adopter friends based on their tastes. As discussed in previous literature (Ara et al. 2009), the main difficulty in delivering an unbiased estimate of contagion effect is that we would never observe the buying behavior of a user who has adopter friends had he not has adopter friends. This is also called the counterfactual problem. We address this issue by assuming unconfoundedness (Rubin 1978), which states that the outcome is conditionally independent of treatment after controlling for a rich set of observable characteristics. To this end, we define the treatment as having at least one friend who has purchased a game in Phase 1. We match treated examples with users that were likely to be treated, conditional on latent features x_u, but who had not been treated. We use logistic regression to estimate the propensity of being treated as follows:

$$P(treat_u = 1|x_u) = exp(\alpha_u + \beta_u^T x_u + \varepsilon_u)/[1 + exp(\alpha_u + \beta_u^T x_u + \varepsilon_u)] \quad (14)$$

where $treat_u$ is a binary variable that equals one if the user receives treatment associated with the game and zero otherwise. α_u and β_u are intercepts and coefficients. ε_u are idiosyncratic errors. Nearest neighbor matching is then employed to get the treatment and the control group. Therefore, for a single game, we can estimate the effect of social influence using the following specification:

$$logit\, D_u = \delta \times treat_u + C_u + \varepsilon_u \quad (15)$$

Where D_u is a binary variable that indicates if user u eventually buys the game in phase 2, C_u are the control variables including the number of games owned by the user, the number of friends of the user, and the age of the account. ε_u are idiosyncratic errors. Our estimate of the treatment effect associated with the game is δ .

4. Data

We use data from Steam, the world's largest digital distribution platform for video games owned and operated by the Valve Corporation. Users need to install a local client, available from

Steam's official website, to enjoy services from the platform. Due to the Digital Rights Management (DRM) system of Steam that restricts unauthorized distribution of games, users have to log into the client to download and play the purchased games that are associated with their accounts. In additions to its digital store that sells a wide variety of video games from different publishers, Steam provides networking features such as friends, groups, and messaging services. After a user has launched a game, the Steam client continues to run alongside the current game and send notifications on his friends' game playing activities. The existence of these notifications is the main drive that promotes peer influence among friends. In this study, we use both user-level data that contains user's purchase history and friends' information and game-level data that includes game features such as genre, price, publisher/developer, and release date. For user-level data, we use the dataset obtained from a previous study (O'Neill et al. 2016).[3] In their original study, O'Neill et al. crawled the Steam website to collect data on 108.7 million user accounts, 196.37 million bidirectional friendships, and 384.3 million owned games with 2,814 distinct game titles. The collection of this user-level data was conducted twice, once in the year 2013 as initial crawl (phase 1) and once in the year 2014 as follow-up crawl (phase 2). This dynamic network setting allows us to examine the effect of various factors in phase 1 on customers' purchasing behavior in phase 2. We investigate the peer influence on the adoption of the game Dota2, the most popular online video game that is released in 2013. We tailor our sample to include 50,000 randomly selected users and examine the peer influence on their adoption of the game. For game-level data, we use the API provided by SteamSpy, a third-party website that provides statistics of games on Steam, to crawl the features of the games in our sample.[4] We consider game genres as the source of rich information that describes games in terms of gameplay. With the emergence of contemporary video games that incorporates more technologies and more aspects of gameplay, traditional game classification based on simple genre labels (eg., Action, Strategy, Simulation, Role-playing, etc.) fail to capture the novel complexity inherent in these games (Clarke et al. 2017). To solve this problem, Steam leverages

[3] The full dataset is available at https://steam.internet.byu.edu/.
[4] SteamSpy is available at https://steamspy.com/.

the wisdom of the crowd by allowing users to vote for genres of a game from a collection of 247 pre-defined sub-genre tags. We thus collect the user-generated tags for the games in our sample.

5. Results

The identification of peer influence depends on the ability of our model in capturing users' gaming preferences. We use mean percentage ranking (MPR) to evaluate the performance of proposed SEMF. We denote by $rank_{ui}$ the percentile ranking of game i within the ordered list of all games for user u. $rank_{ui} = 0\%$ means that the game is most preferred by the user while $rank_{ui} = 100\%$ means that it is least preferred. We calculate $rank_{ui}$ for users in the test set by tracking the actual adopted game in the list of all items ordered by predicted ratings from our model. The quality measure is then defined as the expected percentage ranking for all users and items.

$$MPR = \frac{\Sigma_{ui} I_{ui} rank_{ui}}{\Sigma_{ui} I_{ui}} \tag{16}$$

Where I_{ui} is a binary variable indicating whether user u purchases game i. Lower values of MPR are desirable, as they indicate the recommendation lists would capture users' preference by prioritizing actually purchased games. It is expected that a randomly recommended list would have a MPR around 50%.

We test our model with the different number of latent factors k, ranging from 5 to 50. Figure 1 shows the results. In general, MPR is improved as k increases. The figure shows a drastic decrease in the value of MPR when k increases from 5 to 20. The MPR can achieve 8%, which is much lower than 50% that would be achieved by a random predictor. The improvement of our model is limited if we further increase k to larger numbers. Thus, we choose $k = 20$ in our study. We also compare the performance of the proposed SEMF to the widely used wAMAN. We can see that MPR gains 2% by incorporating the rich collection of user-defined tags. In sum, the proposed SEMF can capture users' tastes in a precise manner.

Having derived the low-rank features x_u that accurately proxy users' gaming preference, we then conduct PSM and match users who don't have adopter friends (i.e., control units) to users who have adopter friends (i.e., treated units) based on x_u. The matched sample consists of 6,682 treated units and 26,728 control units. Figure 2 shows the histograms after matching. We can see

that the histograms for the treated and control groups are very similar, indicating that the matching is successful.

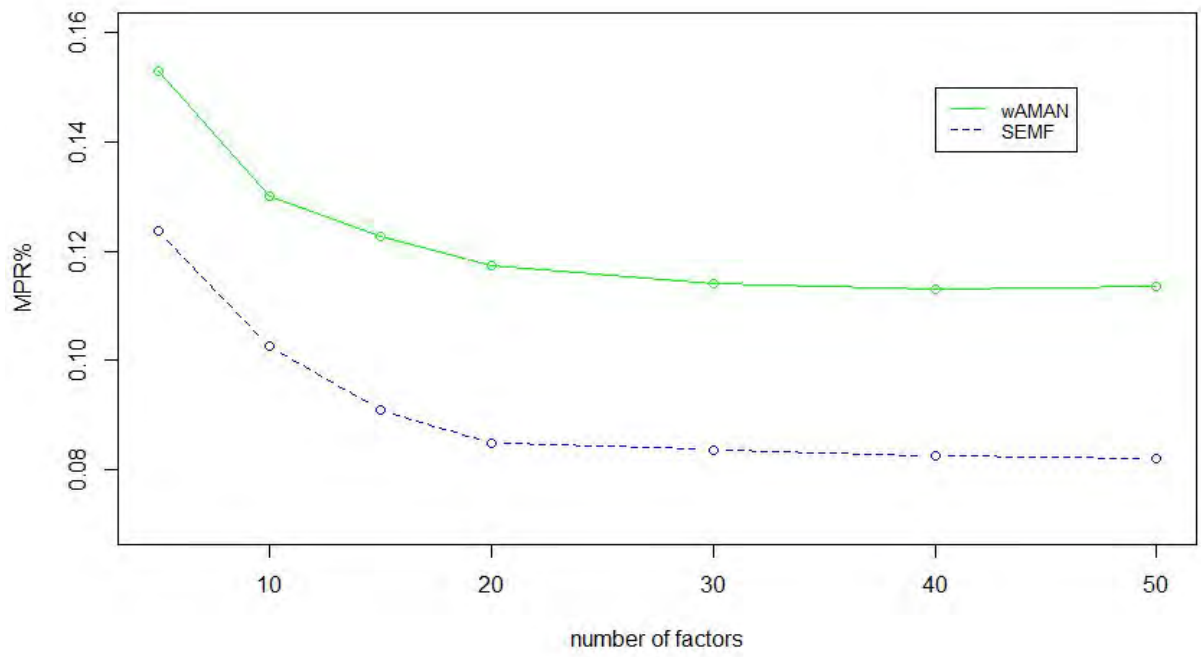

Figure 1: impact of varying the number of latent factors

We present our main result of the effect of peer influence in Table 1. We can see in column 1 that the effect of having adopter friends on users' purchase decision is significantly positive, with value 0.21. That is, the odds of purchasing the game for users with adopter friends over the odds of purchasing the game for users without adopter friends is $exp(0.21) = 1.23$. In column 2, we conducted logistic regression on the raw data without matching. The estimated effect of peer influence is 0.26. As illustrated in the previous studies (Tucker 2008, Hartman 2010), ignoring the homophily would give rise to an upward bias of the effect of social influence. In our sample, the bias results in a 24% inflation in the estimate.

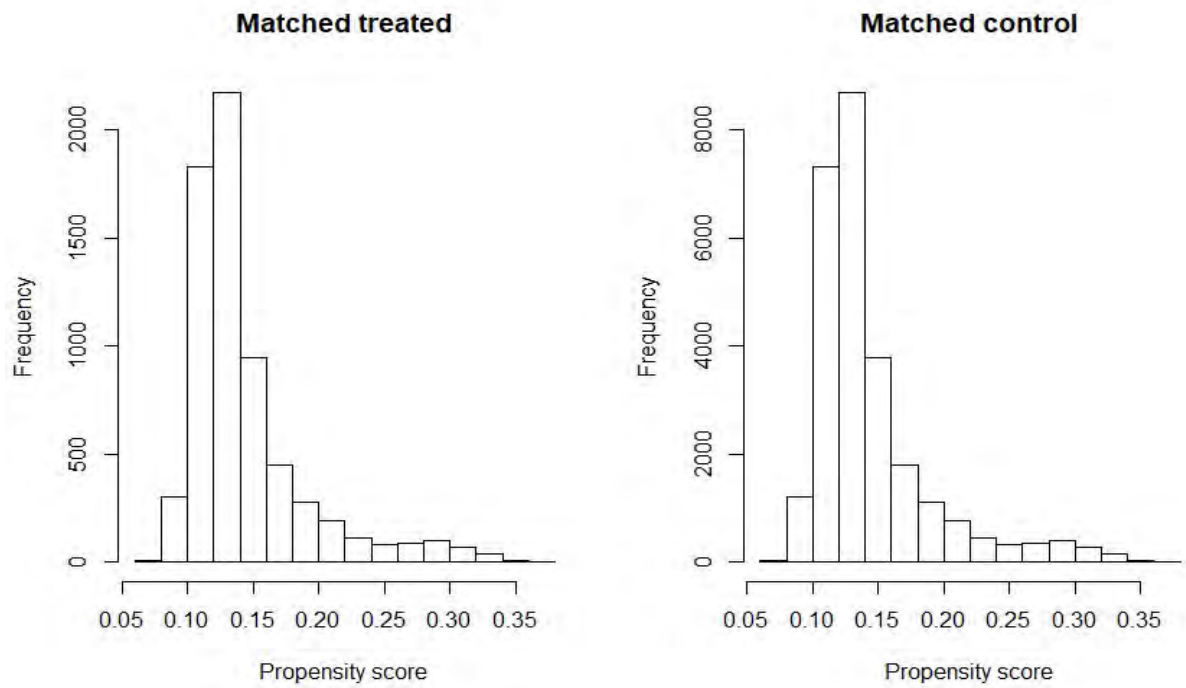

Figure 2: histograms of propensity scores after matching

Table 1: Main effects of peer influence

Logit regression	(1) Matched sample	(2) Raw sample
Effect of peer influence	0.213*** (0.04446)	0.257*** (0.04313)
Number of purchased games	-0.00217*** (0.0003923)	-0.00123*** (0.000391)
Number of friends	0.00269*** (0.000607)	0.00324*** (0.000590)
Age of account	-0.000137 (0.0000552)	-0.00000390 (0.0000458)
Intercept	-1.431*** (0.0497)	-1.667*** (0.0402)
# Observations	33,410	50,000
$P > \chi^2$	0.0000	0.0000

Standard errors in parentheses

*** $p < 0.01$ ** $p < 0.05$ * $p < 0.1$

6. Conclusions and Discussion

In this paper, we study the peer influence in the adoption of video games. Utilizing the state-of-the-art recommender system algorithm, we are able to control for homophily and identify the potential causal effect of peer influence on video game adoption among users of emerging online game platforms. The proposed SEMF achieved a good performance in capturing users' preference on games as indicated by low MPR. Peer influence is then identified by matching users with similar taste as measured by low-rank features. We have found a positive effect of peer influence. Our results also confirm that the magnitude of peer influence would be overestimated if homophily is not accounted for.

The contribution of this paper is twofold: First, our research adds to the growing body of research on video game industry regarding the identification of peer influence on game adoption behaviors. As opposed to previous studies that investigate factors influencing game sales on an aggregated game level, we examine the consumer purchase behavior on a more fine-grained user level. Our results could help researchers better understand the decision-making process in online game platforms. Moreover, stakeholders of video games such as game developers, game publishers, and game platforms would generate more revenue from games by employing strategies that promote peer influence among friends. Second, we contribute to the literature on product adoption by proposing an innovative yet simple framework that disentangles homophily from social influence between linked users. Our method can be applied to different online social network contexts that exhibit user-item interactions. Another merit of our approach is the use of observational data in the identification strategy, which does not require experimental manipulation and can be applied to more scenarios where experimental data is difficult to get.

The potential caveat of this research could be due to the use of a focal game DOTA2 in our analysis of peer influence, which limits the capacity of our study to investigate the role of item-related features in the consumer decision-making process. In particular, since purchase price is a non-negligible factor in consumer decision-making in the sense that users are more inclined to adopt a game if the cost is low, we would expect that the effect of social influence is heterogeneous with respect to price. To this end, we will explore the moderating effect of price on social influence in our future study. Another limitation is the small sample size. Among 108

million users on Steam, we randomly select 50,000 users due to the time complexity of our algorithm in solving the optimization problem. We will develop a parallel algorithm for large-scale datasets in follow-up studies so that the effect of peer influence can be fully explored.

There are several gaps for future research. One can extend our current research to a couple of different directions. First, the moderating effect of user-specific characteristics on peer influence would be interesting to investigate. For example, since the user-level social network data is available, researchers can further study if users' network properties (e.g., centrality, structural hole) would affect peer influence in the adoption of games. Second, we only examine the peer influence in the adoption of the most popular game in 2013 in our paper. Researchers can also include more games in their studies so that item-related heterogeneity (e.g., game publisher, game genre) in peer influence can be studied.

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Exploring consumer concerns regarding acceptance and use of smart robots

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Abstract

Background: In recent years, many research and development of smart robots are focus on technology development and application, or clinical applications. However, the actual social needs of consumers has been ignored. Furthermore, while facing the problem of robotics, both European countries and American are committed to find out the unsatisfied needs of users to create greater value, whether in pursuing technology solutions or service-oriented business models.

Purpose: This study argued that whether the smart robot service model meet or help consumers to improve their quality of life or work efficiency? This study expects to use technology acceptance model research and explore the investigation and analysis of the technology acceptance and willingness of smart robots in Taiwan, and thus to provide researcher to implement the development and demand of smart robots in future.

Methods: First, we compare the research findings of intelligent robots in Europe and America. Consequently, we apply the quantitative and qualitative research methods to collect 1,540 samples, including 599 people (40%) and online responses. 941 questionnaires (60%) were further validated to analyze relevant research hypothesis models.

Conclusion：This study highlights the relationship between the consumption behavior of smart robots and various factors, such as Hedonic Motivation, Performance Expectancy and Social Influence, which play an important role in explain to adopt the intention for used smart robots.

Management implications: Due to the cultural backgrounds, we realized that the difference views of public on the attitudes between East and West in terms of technological inventions. Taiwanese are more likely to accept new technologies intervene to routine life. Thus, the development of smart robots should according to the market and consumer demand, and the Chinese market should be on top priority to establish word of mouth and confidence.

Suggestion: Social and technological factors are essential to explain the intentions of smart robots. The finding of this study enable to serve smart robot service provider and robotic researcher , in order to provide a good reference for how to successfully improve the application of robotics.

Keywords: Smart Robot, UTAUT 2, Behavioral Intention.

1. RESEARCH BACKGROUND AND PURPOSE

1.1 Research Background

Taiwan has entered an advanced society and estimates the elderly population will reach 20% of the total population in 2025, therefore the needs of manpower care is obvious. However, the society are unbearable the cost of manpower require for either home care type or institutional type in future. The experience of long-term care implementation in Japan shown that the country needs to develop artificial model at the same time, in order to extend the health of the people, and shorten the period of disability to be taken care, as well to create the opportunity and the critical point of long-term care of the robot and intelligent automation industries(Li & Chen, 2018). The aging society will increase the proportion of elderly people living alone or in the health-care community. Thus, the development and introduction of accompanying robots will play the role of care support.

The previous service robots were only used in a single function, such as restaurant a la carte robots, sweeping robots or handling robots. However, the development of artificial intelligence broadens the field used by traditional service robots, and the learning and identification of companion robots, people can learn to talk with the caregiver, and then generate communication, this will help the elderly or the patient to carry the work at home and communicate with the intelligent robot without any burden. On top of it, the companion robot can also communicate with family member's smart phone and link with the regional hospital care system. When the elderly has an accident at home, the medical

institution can be notified immediately, and the family members also have the function of emergency rescue contact. Moreover, the invention of pets accompanying intelligent robots can simulate the interactive feedback of animals and people through machine learning. In turn, the elderly can add fun to life without worrying about the care of pets (Huang, 2018).

According to the International Federation of Robotics (Tsuda, 2016), the average annual compound growth rate of service robots will reach 16% from 2017 to 2021. Moreover, the output value of service robots will surpass that of industrial robots by 2021. The commercialization capability of robots still have a big room ahead. Although many manufacturers in Taiwan have continuously invested in the development of service-oriented robots, but most of them have not really been introduced to the market after the completion of development, this is due to some technical problem have not meet the expectations of majority customers. The technology of artificial intelligence and natural speech processing is not mature. Customers expect robots to have instant and multi-lingual dialogue capabilities, but these need to be pending in the cloud process, customers in turn feel that the response is a bit slow.

Moreover, IFR applied the International Organization for Standardization (ISO), the definition of robot is a multi-functional multi-axis structure that can be reprogrammed and automatically controlled. Service-oriented robots are defined as "automatic or semi-automatic machines that provide services other than manufacturing processes to promote human well-being", including assisting cleaning, navigation, and physiological assistance to entertaining and educational robots (TAIROA, 2018).

On the other hand, China divides robots into two categories: industrial robots and service robots. Service robots are subdivided into personal/home robots and professional service robots. Personal/home robots include: homework robots, recreational robots, handicapped assisted robots, home security and surveillance robots, and other professional robots: field robots, professional cleaning robots, medical robots, logistics robots, inspections and maintenance robots, construction robots, underwater robots, defense, rescue and safety application robots(TAIROA, 2018).

The academic community generally believes that robots must have two qualities: mobility and autonomy. "Autonomy is not the same as artificial intelligence. Autonomy covers wisdom. It means that machines can sense the environment, detect external changes, and react." Dr.Yang explains that smart but not moving machines (For example, a desktop computer) is not a robot. Similarly, a mobile but lacking autonomy machine (such as a car) is also not a robot(Yang, 2016). The definition of "smart robot" in this study is that smart

robots can perform relative and appropriate reactions and actions by sensing different external environments and commands, and use the above-mentioned service robots in general market services or home care (Wang, Xuan, & Lin, 2016).

On the whole, this study cites the example of Pepper Smart Robot and ASUS Zenbo Smart Robot(Bai et al., 2018), which allows respondents to fill-in the questionnaire.

In 2015, Japanese software banking company began selling humanoid robot "Pepper", mainly targeted in the field of education and leisure. It has artificial intelligence AI technology, which can distinguish between voice and instant dialogue. It also has a tactile, acoustic and emotional system that can recognize(Aaltonen, Arvola, Heikkilä, & Lammi, 2017; De Gauquier et al., 2018; Hirschmanner et al., 2018; Pepper & Pepper, 2013; Tanaka et al., 2015). The emotional state of the other party makes an emotional expression interaction with people. It makes people feel that Pepper is not a smart robot. In contrast, it is like a good friend in home life, and even more like a family. This is a good helper for the elder's family. In addition to daily behavioral interactions, it can also help the elder people to express language or communicate roles.

This research mainly aimed at the smart robot of the daily life care of the people as the analytical spindle, and analyzes and compares the functions of the robots that have been developed. In this study, ASUS Zenbo and Pepper are more suitable for the needs of the elder people and the Taiwanese acceptable and consume. Under this condition, the technological acceptance model is used to study the acceptance and willingness of the people in Taiwan regarding the smart robot.

1.2 Research purposes

Smart robots have begun designed and used by various home appliances or electronics manufacturers. Smart robots can be integrated into family life through the functions of the internet. Smart robots are new technology for the elders group, but what is the attitude of the elders' acceptance? Many reports on research robots shown that how to increase the acceptance of people and the willingness to interact are currently the greatest challenge (Alaiad & Zhou, 2014; de Graaf, Ben Allouch, & van Dijk, 2019; IROS, 2018; Smith & Anderson, 2014; Wang et al., 2016; Yang, 2016).

However, the research and development of smart robots has been innovated, the consequences of influence to the new technology of smart robots, it is increasingly needs to research on relevant issues. This study explores the ideas from Taiwanese about smart robots under different preferences, first to compares the development and research findings of smart robots in the social influence of European and American scholars, and collects relevant theories on TAM technology application. This study is aimed at Taiwanese home care and single elder, further deepen research needs and explore service

gaps for smart robots of the services for the majority of dementia or disabled elders in future.

Alongside the above motivations, this study uses TAM Technology Acceptance Model(Davis, 1989) and UTAUT2 Extended Integration Technology Acceptance Model (V. Venkatesh, Thong, & Xu, 2012)to study the understanding of the service-oriented smart robots to the elders family. And behavioral intentions in the perceptual usefulness, perceptibility and ease of use, the attitude of use and the frequency of re-use will be related research, and explore the causal relationship between the consumers' consumption behavior and various factors of smart robots.

2. LITERATURE REVIEW

2.1 Smart Robots service

The study draw attention to possible risks from the development of robotics, including such aspects as employment, privacy protection, safety and civil liability. In January 2017, the JURI Committee adopted its report with recommendations to the Commission, on "*Civil law rules on robotics"*. The report calls on the Commission to propose EU legislation defined "smart robot" as one which has autonomy through the use of sensors and/or interconnectivity with the environment, which has at least a minor physical support, which adapts its behavior and actions to the environment and which cannot be defined as having 'life' in the biological sense (Nevejans, 2017).

Home healthcare robots (HHRs) provide clinical information at the right time and place, reducing the mistake made by human, improving safety and quality. In the past few years, HHR has helped nurses, doctors, therapists and other professionals to provide family health care and services for elders in various ways, such as monitoring personal health and safety, providing medication treatment scheduling, and detecting people lying on the ground. To assist with physical, cognitive and occupational therapy as well as nursing tasks (e.g. monitoring blood pressure and bedridden). There have been many studies on the acceptance of models for information systems applications, especially in the use of ICTs and smart devices(Berg, Aarts, van, & J, 2013; Zhou, 2012).

Many of the research on robotics are generally focused on technology implementation and technology development and clinical applications, which ignores the social needs of consumers. In 2014, an American scholar found that the most predictive indicator of HHRs' family medical robots' willingness to use is social influence, which can provide information for service providers or technical design developers (Alaiad & Zhou, 2014; Liu, 2017).

The European Parliament adopted the "Robot Law" resolution in February 2017, the proposer, Luxembourg politician Mady Delvaux, pointed out that human life will be influenced by robots more and more. Therefore, in order to ensure the meaning of its existence, it can always serve humanity now or in the future, and it is a new and clear definition of what is meant by "smart robots". A clear classification standard was developed to incorporate and operate more intelligent robots into the registration system for monitoring and control(Nevejans, 2017). The smart robot, can be designed functional to meet the needs of elders. According to the needs of the elders, they can be more gracious while designing products, and at the same time not only to enhance the functions, but also need to considerate the price (Maartje & Somaya, 2013).

2.2 Technology Acceptance Theories

Technology Acceptance Model (TAM), a theoretical validation model developed by Davis in 1989, Davis (1989) based on the rational behavior theory proposed by Ajzen and Fishbein (M. Fishbein & Ajzen, 1977).

The theory of program behavior develops a technology acceptance model that provides general explanations for the determinants of technology acceptance by the average user, interprets the user's behavior, and at the same time takes into account the most simplified theoretical basis (Davis, 1989). Technology acceptance is defined as “an individual’s psychological state with regard to his or her voluntary or intended use of a particular technology”(Gattiker, 1984).

The most recent model to emerge from this long line of study is known as the Unified Theory of Acceptance and Use of Technology (UTAUT) (V. Venkatesh, Morris, M. G., Davis, G. B., & Davis, F. D., 2003). UTAUT advances on the basis of integrating the dominant constructs of eight prior prevailing models that range from human behavior, to computer science. According to Venkatesh et al. (2003), UTAUT proposed four main factors that influence intention and usage of information technology. First is performance expectancy. It is the degree to which an individual believes that using the system will help him or her to attain gains in job performance. Second is effort expectancy. It is the degree of ease associated with the use of the system. Third is facilitating conditions. It is the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system. Fourth is social influence. It is the degree to which an individual perceives that others believe that he or she should use the new system.

Despites the wide acceptance of UTAUT, Venkatesh et.al. incorporated three other constructs into UTAUT: hedonic motivation, price value, and experience habit, extending

UTAUT into UTAUT 2. Compared to UTAUT, the extensions proposed in UTAUT2 produced a substantial improvement in the variance explained in behavioral intention (56 percent to 74 percent) and technology use (40 percent to 52 percent).

3. RESEARCH MODEL AND HYPOTHESES

The UTAUT2 attempts to explain usage intention, as well as subsequent usage behavior. The theory suggests that seven key constructs: performance expectancy, effort expectancy, social influence, facilitating conditions , Hedonic Motivation, Price Value and Experience & Habit, are direct determinants of behavioral intention and behavior.

The comprehensiveness, suitability, validity, reliability and a accuracy of the model have been demonstrated in different contexts (AlAwadhi & Morris, 2008). This study refers to other literatures and finds that other four constructs such as Trust(Gaudiello, **2016**), Privacy(Miller & Blackler, 2017; Parker, 2017), Legal security and Ethics (A.Godfrey et al., 2007; Lin, Abney, & Bekey, 2011)will affect the behavioral Intention，Thus, our research model for determinants of behavioral intention is shown in figure 1.

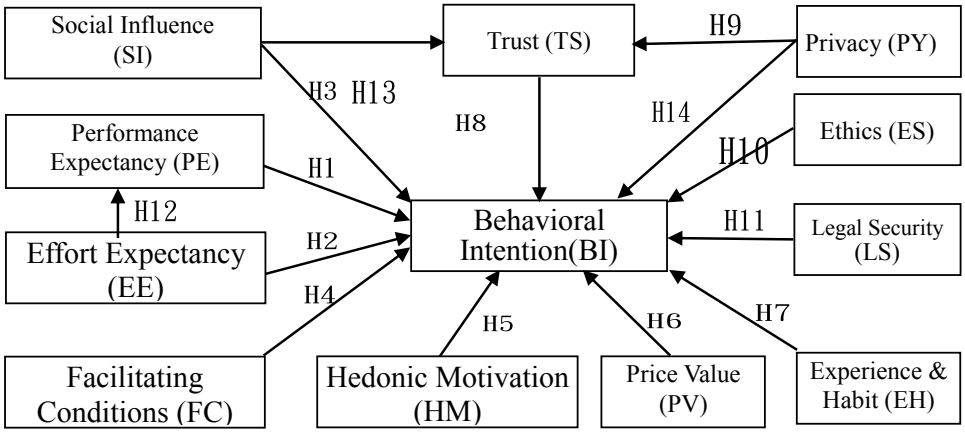

Figure 1. The Research Model

Behavioral intention is the dependent variable, which relates to the way(s) stakeholders intend to use smart robots. Behavioral intention is a predictor of actual use, which is in turn influenced by Performance Expectancy, Effort expectancy, Social influence, and Facilitating condition, Hedonic Motivation, Price Value, Experience & Habit, Trust, Privacy, Legal security and Ethics.

Performance Expectancy (PE)

Performance expectancy is defined as the degree to which an individual believes that using the system will help him or her to attain gains in a job (Davis, 1989). Adapting

performance expectancy to smart robots suggests that stakeholders think smart robots are beneficial in that they can help them get better/ a raise, improve overall productivity and perform tasks quickly and flexibly , or access services effectively(Alaiad & Zhou, 2014).

Performance expectations are integrated by the constucts of previous relevant research models(V. Venkatesh, Morris, M. G., Davis, G. B., & Davis, F. D., 2003), including Perceived usefulness, extrinsic motivation , job-fit , relative advantage , and outcome expectations five major constructs. Furthermore, this study pointed out that performance expectations will lead to the occurrence of network behavior, increase willingness to use and satisfaction (AlAwadhi & Morris, 2008; Compeau, 1995), which positive impact on behavioral intentions. Thus, we put forward the following hypothesis:
H1：*Performance expectancy has a positive effect Behavioral intention to use smart robots.*

Effort Expectancy (EE)
Alongside UTAUT, effort expectancy is defined as the degree of ease associated with the use of the system. According to Venkatesh et al. (2003), this factor was derived from the perceived ease of use factor as proposed in Technology Acceptance Model (TAM). Davis (1989) found that users predicts that prior preparation will not be required when using certain systems or technologies. Effort Expectancy includes the constructs of perceived ease of use, complexity and ease of use(V. Venkatesh, & Davis, F. D., 2000).
The characteristics of elderly consumers, to choose the products for convenience, practical, simple operation, which will increase the willingness to use, but strive to have a gap between performance and expected performance, and seriously affect the willingness to use and behavior(Zhang, 2009). Extensive empirical evidence has shown that effort expectancy has a direct effect on usage intention for technology adoption(Kijsanayotin, 2009). Therefore, we propose the following hypothesis:
H2：*Effort expectancy has a positive effect behavioral intention to use smart robots.*
H12：*Effort expectancy has a negative effect performance expectancy to use smart robots.*

Social Influence (SI)
Social influence is the degree to which a user perceives that significant persons believe technology use to be important. It is similar to the factor “subjective norm” as defined in Technology of Acceptance Model (TAM) 2, an extension of TAM. Moore and Benbasat (1991) defined image as the degree to which using a technology innovation is perceived to enhance individual‘s image or status in his or her social group.
Social Influence integrated the subjective norm (TRA, TAM2, TPB and C-TAM-TPB), social factors (MPCU), and image (IDT) (Venkatesh& Davis, 2000). Maldonado

et.al(Maldonado, 2011)found that learning motivation and social influence had a positive influence on behavioral intention, while facilitating condition had no effect on e-learning portal use. Middle Eastern auditors are more likely to use the technology if it is mandated by the higher authorities. Social influence is also affected the acceptance of IT(Kijsanayotin, 2009). Moreover, Social use of word-of-mouth will also increase consumer trust in technology use(Moore, 1991). Therefore, we propose the following hypothesis:

H3：*Social influence has a positive effect behavioral intention to use smart robots.*

H13：*Social influence has a positive effect trust to use smart robots.*

Facilitating Conditions (FC)

Facilitating conditions is defined as the degree to which an individual believes that organizational and technical infrastructure exists to support use of the system. Similar discussion can be found in model of personal computer utilization by Thompson et al(Thompson, 1991). Facilitating Conditions integrated perceived behavioral control, facilitating conditions, and compatibility. The underlying construct of facilitating condition is operated to include aspects of the technological and/or organizational environment that are designed to remove barriers to use(Keong, 2012). Therefore, we propose the following hypothesis:

H4：*Facilitating conditions have a positive effect behavioral intention to use smart robots.*

Hedonic Motivation (HM)

Hedonic motivation is defined as the fun or pleasure derived from using a technology, and it has been shown to play an important role in determining technology acceptance and use (S. A. Brown, Venkatesh, Viswanath, 2005).Hedonic motivation including the use of technology products enjoyment and attractiveness, will let consumers more willingness to use this feature. In consumer context, hedonic motivation has also been found to be an important determinant of technology acceptance and use(Bae & Chang, 2012). Thus, we add hedonic motivation as a predictor of consumer's behavioral intention to use a technology. Hence, we propose the following hypothesis:

H5：*Hedonic Motivation have a positive effect behavioral intention to use smart robots.*

Price Value (PV)

An important difference between a consumer use setting and the organizational use setting, where UTAUT was developed, is that consumers usually bear the monetary cost of such use whereas employees do not(V. Venkatesh et al., 2012). The cost and pricing structure may have a significant impact on consumers' technology use(Dodds, 1991). Therefore,

we propose the following hypothesis:
H6：*Price Value have a positive effect behavioral intention to use smart robots.*

Experience and Habit (EH)
The construct added to UTAUT is two related yet distinct constructs, namely experience and habit. Venkatesh et al.(V. Venkatesh, Morris, M. G., Davis, G. B., & Davis, F. D., 2003)operated experience as three levels based on passage of time: (1) post-training was when the system was initially available for use; (2) one month later; (3) three months later. Habit was defined by(Limayem, Hirt, & Cheung, 2007), as the extent to which people tend to perform behaviors automatically because of learning, while equated habit with automaticity(Kijsanayotin, 2009). Thus, we posit the following hypothesis:
H7：*Experience and habit have a positive effect behavioral intention to use smart robots.*

Behavioral intention (BI)
Behavioral intent refers to the subjective idea of an individual's plan to perform a particular behavior, as an individual's measure of the intensity of a particular behavioral intent, rather than the actual operation(Ajzen & Fishbein, 2005; M. Fishbein, & Ajzen, I, 1975). Therefore, this study defines the behavioral intention as "the frequency and use of the user in the use of smart Robots."

Trust (TS)
People believe that the robots have the ability and integrity to protect their personal information from potential problems, and thus people have good interaction with, and high confidence in, the robots' words and actions (Gaudiello, **2016**). Trust often involves three types of beliefs: ability, integrity and benevolence(Zhou, 2012), Accordingly, trust with smrte robots indicates that people believe that the robots have the ability and integrity to protect their personal information from potential problems, and thus people have good interaction with, and high confidence in, the robots' words and actions(Armida, 2008; J. Wu, Shen, Lin, Greenes, & Bates, 2008). Therefore, we propose the following hypothesis:
H8：*Trust have a positive effect behavioral intention to use smart robots.*

Privacy concerns(PY)
Privacy as the right to be left alone privacy concerns as the stakeholders' lack of control over the collection and use of their personal information after they have adopted the system. Four types of privacy – information privacy, bodily privacy, privacy of communications, and territorial privacy(Foon & Chan, 2013; Hossain & Prybutok, 2008). The presence of robotic devices in our environment gives rise to unique privacy problems unlike those in other domains. Despite rapid advancement in the perception,

movement, and learning capabilities of robots, issues in robot privacy remain without an effective research program, Accountability and audit mechanisms are discussed, as are trust and security models for mitigating secondary privacy harms(Kevin L. Miller, 2017). There is preliminary evidence that privacy concerns are one of the determinants of the usage intention(Hossain & Prybutok, 2008; Wu & Chen, 2005)and trust(Zhou, 2012). Therefore, we propose the following hypothesis:

H9：*The lever of Privacy concerns have a negative effect behavioral intention to use smart robots.*

H14：*The lever of Privacy concerns have a negative effect trust to use smart robots.*

Ethics (ES)

It can be explained in terms of agency, reliability, liability and Confidentiality(Booth, Whicker, Wyman, Pugh, & Thompson, 2009; Dickens & Cook, 2006), Concerns Ethics is considered a standard of behavior and a concept of right and wrong beyond what the legal consideration is in any given situation(Xu & Gupta, 2009). As with other emerging technologies, advanced robotics brings with it new ethical and policy challenges. Therefore, we propose the following hypothesis:

H10：*Ethics have a negative effect behavioral intention to use smart robots.*

Legal Security

Legal Security is described as a rule of conduct or action prescribed or formally recognized as binding or enforced by a controlling authority(I. Brown & Adams, 2007). It can be explained in terms of the law coverage for privacy, reliability and quality, and tort-liability(Booth et al., 2009). Users are concerned whether local law covers these components. Considering the governmental local law for protecting health information privacy (by giving individuals control over health data without severely restricting warranted communal uses) directly improves the quality and reliability of health data(Alaiad & Zhou, 2014). Therefore, we propose the following hypothesis:

H11：*Legal Security have a negative effect behavioral intention to use smart robots.*

4. METHOD DESIGN

The model proposed in this study consists of a total of 12 facets, and each structure is measured with multiple items. All construct items were adapted from Venkatesh(V. Venkatesh, Morris, M. G., Davis, G. B., & Davis, F. D., 2003) and other scholars'(Alaiad & Zhou, 2014)research questionnaires.

The questionnaire instrument collects additional information such as gender, education, age, and robot knowledge. All questionnaire items were measured using a 7-point Likert scale, ranging from “strongly disagree” to “strongly agree”. The sample of the study was targeted at the general adult population in Taiwan: the two methods were collected on-site and online questionnaires. Each questionnaire has four main parts: an introduction to

smart robots, demographic information, questions about using smart robots, and comparing EU perceptions and acceptances of robots. The questionnaire was distributed to participants who participated in the lectures from the northern, central, southern and other places of Taiwan and randomly selected online.

On-site respondents will watch 8 minutes of youtube video introduction "5 Best Smart Robots That You need To See", including five robots such as Moorebot, MIKO Robot, COSMO Robot Kuri Robot, OMATE, or direct actual experience. ASUS Zenbo fills in the questionnaire again.

A total of 2,105 questionnaires were collected, of which 1,684 were considered complete. This study only targets those who are over 50 years old, and then deletes the deviation. The final valid questionnaire is 1540 (73%) ，Total 599 online samples (39%) and 941 (61%) paper samples (Fill in the questionnaire on the spot).

5. RESULTS

5.1 Sample Profile

The majority of the participants is two age groups were analyzed, 917 (59.6%) females, 623 males (40.4%), including 51-64 years old 698 Persons (45.3%) and 65 years old 240 Persons (15.6%). Middle-aged and elderly people over 50 years old account for 60%, and young people under 50 years old account for 40%, which helps to understand the difference in technology acceptance of smart robots from different generations.(see table 1)

Expecting in 2025, Taiwan is about to enter the super-age generation, and smart robots are important consumer groups for the future development of assisting the elderly to take care of the elderly. Among the statisticians, there are 851 people (55.3%) living with elders over 65 years old, which makes this study more representative of the acceptance of smart robots by Taiwanese elderly people. 56.9% of these respondents are still working. The monthly income is NT$60,000 and 18.5%. Only 30.4% of the respondents are retired. Unemployed is a college student or housewife, accounting for 12.7%. There is no income at all. Accounted for 20.5%.

Taiwan’s education is popular and generally accepted higher education. In this study, the education level of college education was as high as 65.6%, except for the age of 65, which accounted for 15.6%. Among them, 8.3% of the elderly were not able to receive education at an early age. They only had middle school. So most people have a fairly common understanding of the technology information reception of robots. (**See** table 1)

Table 1: Statistics of demographic profile.

Variable		0n-line	Paper	Total	%
Gender	Man	*313*	*310*	*623*	*40.4*
	female	*286*	*631*	*917*	*59.6*
	Total	*599*	*941*	*1540*	*100*
AGE	19-30 yrs	*90*	*115*	*205*	*13.3*
	31-50 yrs	*209*	*188*	*397*	*25.8*
	51-64 yrs	*258*	*440*	*698*	*45.3*
	＞65yrs	*42*	*198*	*240*	*15.6*
	Total	*599*	*941*	*1540*	*100*
Number of elderly people at home	50-65yrs	*183*	*216*	*399*	*25.9*
	＞65yrs	*295*	*556*	*851*	*55.3*
	No.	*121*	*169*	*290*	*18.8*
	Total	*599*	*941*	*1540*	*100*
education level	＜Middle School	*11*	*117*	*128*	*8.3*
	High school	*99*	*303*	*402*	*26.1*
	＞College degree	*489*	*521*	*1010*	*65.6*
	Total	*599*	*941*	*1540*	*100*
Career background	Employment	*461*	*416*	*877*	*56.9*
	Retire	*68*	*400*	*468*	*30.4*
	Unemployed	*70*	*125*	*195*	*12.7*
	Total	*599*	*521*	*1540*	*100*
monthly income (NT.)	20,000-30,000	*78*	*211*	*289*	*18.8*
	30,000-60,000	*277*	*295*	*569*	*36.9*
	60,000＜	*188*	*97*	*285*	*18.5*
	No income	*59*	*338*	*397*	*28.5*
	Total	*599*	*941*	*1540*	*100*

5.2 Survey of attitudes toward robots and artificial intelligence

This section of the report deals with respondents' experiences with and perceptions about robots and artificial intelligence - including use of robots at home or at work, attitudes to

robots and artificial intelligence, and their potential impacts on jobs and society in general.

Summarizes the participants' knowledge levels on AI and robots. It is shown that most participants have heard about Artificial intelligence (87.5%), but few have actual experience of using them (31.2%). Have heard that 87.5% of people with artificial intelligence, which is more than 47% of the EU. In addition, the proportion of robots used has doubled in the EU (14%). (Table 2)

Table 2: Attitudes toward robots and AI (A)

Question	answer	Taiwan		EU%
		Total	%	
1. Have you used a robot?	Yes	*480*	*31.2*	***14***
	No	*1060*	*68.8*	***85***
2. Have you heard of AI?	yes	*1347*	*87.5*	***47***
	No	*193*	*12.5*	***53***
3.Opinions :	Positive	*863*	*56*	***61***
Views on robotics & AI?	Negative	*119*	*7.7*	***30***
	Don't know	*558*	*36.2*	***9***

Have you ever used a robot at home or at work/such as a robotic vacuum cleaner at home or an industrial robot at work? According to the statistics of this study, 68.8% of Taiwanese who never used robot at home or at work. However, most of the Taiwanese people are optimistic about robots and artificial intelligence, positive attitude is 56% and the negative attitude is only 7.7%，Another 36.2% of the people have no opinion. In contrast, up to 30% of the EU is very negative about robots. But more than six in ten have a positive view of robots and artificial intelligence (61%).More than eight in ten respondents agree robots are necessary as they can do jobs that are too hard or too dangerous for people (84%), and 68% agree robots and artificial intelligence are a good thing for society because they help people do their jobs or carry out daily tasks at home (Table3).

However, respondents express widespread concerns that the use of robots and artificial intelligence leads to job losses and consider that these technologies need careful management. Although more than six in ten respondents have a positive view of robots and artificial intelligence, an even higher proportion (EU: 72%＞TW59%) agree robots and artificial intelligence steal people's jobs. Almost one quarter disagrees (24%). Despite the different cultural backgrounds of things, the fear of facing robots is very similar to that of fear.

Table 3: Attitudes toward robots and AI (B)

Question	Area	Agree	Dis-agree	Don't know
4. More jobs will disappear	EU	74	20	6
	TW	68	14	18
5. Robot require careful management.	EU	88	7	5
	TW	88	2	10
6. Robot can do too hard or too dangerous work	EU	84	13	3
	TW	84	12	4
7. Robot ahead of other world regions	EU	41	33	26
	TW	59	15	26
8. Robots steal Peoples' jobs.	EU	72	24	4
	TW	59	16	25

5.3 Measurement Model Validation

The convergence validity is the most representative of Average Variance Extracted (AVE). AVE is the explanatory force for calculating the variation of potential variables to each measurement variable. It can be used to judge reliability and also represent convergence validity. Must be greater than 0.5 (Bagozzi & Yi, 1988). Table 3 summarizes the results for the items comprising the model.

Table 3: Item Loadings, AVE, Composite Reliabilities (CR) and Cronbachs Alpha

	Convergence validity >0.5	Composition reliability >0.8	Internal consistency >0.8
	AVE	C.R	Cronbachs Alpha
BI(Behavioralintention)	0.593	0.814	0.760
EE(EffortExpectancy)	0.679	0.894	0.844
ES(Ethics)	0.711	0.925	0.898
FC(Facilitating conditions)	0.603	0.859	0.783
HM(Hedonistic motivation)	0.746	0.921	0.885
EH(Experience&Habit)	0.503	0.799	0.665
PE(Performance Expectancy)	0.788	0.937	0.910
PV(Price Value)	0.640	0.871	0.792
PY(Privacy)	0.753	0.939	0.920
SI(Social Influence)	0.653	0.882	0.821
TS(Trust)	0.616	0.860	0.779
LS(Legal security)	0.777	0.946	0.928

The results show acceptable convergent validity to all the constructs except facilitating condition. All item loadings are significant. All AVEs are above 0.5, all CRs are above 0.8 and all alpha values are larger than 0.7, showing good reliability. Therefore, the results support the convergent validity of all the scales (Gefen & Straub, 2005). Discriminate validity is confirmed if the square root of AVE are significantly higher than correlations between constructs in the corresponding rows and columns. As shown in Table 4 the instrument demonstrates adequate discriminate validity as the AVE (bold) are greater with respect to the corresponding correlation values in the adjoining columns and rows.

The correlation analysis of all sample measurement models is mainly used to verify the degree of discrimination between different facets in the measurement questions, and the degree of correlation between the single question and other questions should be higher than the degree of correlation with the different facets. This study uses the Pearson correlation matrix to measure the degree of correlation of the facets. Table 4 all sample differential validity analysis, the square values of other facets are larger than other facets. The correlation coefficient, therefore, proves that the questionnaire designed by the Institute has sufficient discriminant validity.

Table 4: AVE Scores and Correlation of Latent Variables

item	AVE	**BI**	**EE**	**EH**	**ES**	**FC**	**HM**	**LS**	**PE**	**PV**	**PY**	**SI**	**TS**
BI	0.593	0.770											
EE	0.679	0.635	0.824										
EH	0.503	0.715	0.633	0.710									
ES	0.711	-0.196	-0.100	-0.275	0.843								
FC	0.603	0.649	0.596	0.691	-0.133	0.777							
HM	0.746	0.741	0.541	0.631	-0.150	0.578	0.864						
LS	0.777	-0.176	-0.119	-0.262	0.694	-0.108	-0.175	0.881					
PE	0.788	0.717	0.600	0.686	-0.183	0.556	0.535	-0.176	0.887				
PV	0.640	0.574	0.512	0.523	-0.121	0.588	0.528	-0.074	0.418	0.800			
PY	0.753	-0.183	-0.171	-0.290	0.626	-0.149	-0.203	0.723	-0.211	-0.110	0.868		
SI	0.653	0.675	0.568	0.581	-0.183	0.633	0.475	-0.106	0.562	0.512	-0.112	0.808	
TS	0.616	0.656	0.571	0.659	-0.154	0.591	0.595	-0.134	0.540	0.621	-0.186	0.563	0.785

5.3 Testing the Structural Model

The structural model gives information as to how well the theoretical model predicts the

hypothesized paths or relation-ships. It is estimated by the path coefficients and *R*2values,as shown in Fig. 2. *R*2 indicates the percentage of the variances in the corresponding construct that is explained by the structural paths leading to it. The path coefficients indicate the strengths of relationships between constructs. Table 5 depicts the structural model showing path coefficients and R2. The R2 value for the *behavioral* intention indicates that the model explained 76.3% of the variance. R2 for performance expectancy indicates that effort expectancy explained 33.8% of the variance. R2 for social Influence and privacy indicates that trust explained 36% of the variance. The bootstrap method was used in smart PLS to assess the statistical significance of the path coefficients.

As shown in Table 5, performance expectancy (PE) positively predicted behavioral intention (0.263, $p < 0.001$); therefore, H1 was supported. Second, effort expectancy (EE) significantly negative predicted performance expectancy (PE) (0.060, $p <0.001$); therefore, H12 was supported. Third, social influence (SI) positively predicted behavioral intention (0.212, $p<0.001$); social influence (SI) positively predicted trust (0.594, $p <0.001$); therefore, H3 and H13 was supported. Four, Hedonic motivation positively predicted behavioral intention (0.349, $p <0.001$); therefore, H5 was supported. *Price Value (PV)* positively predicted behavioral intention (0.058, $p <0.001$); therefore, H6 was supported. *Experience and habit (EH)* positively predicted behavioral intention (0.082, $p <0.001$); therefore, H6 was supported. *Privacy (PY)* negatively predicted trust (-0.124, $p <0.011$); therefore, H14 was supported.

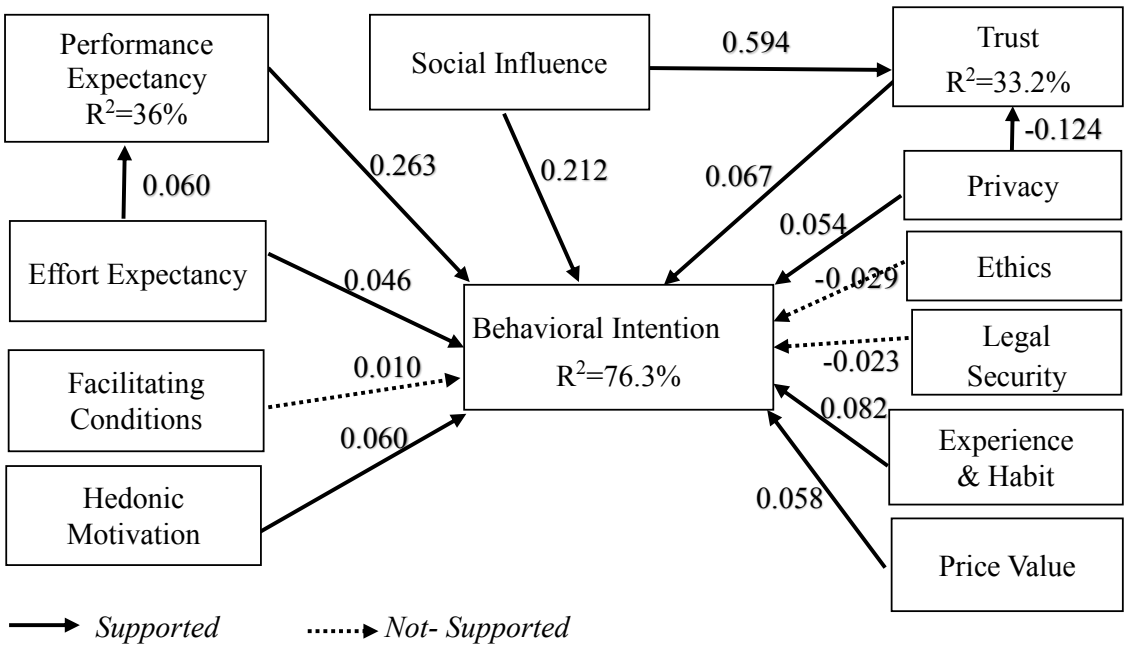

Figure 2. The Research structural model results

Table 5: Structural Model Results

variance	Original	Standard	T Statistics	p-value	R Square	HYPO
EE> BI	0.046	0.021	2.191	0.029	0.762	***Supported***
EE> PE	0.600	0.020	30.228	0.000	0.360	***Supported***
ES> BI	-0.029	0.023	1.258	0.209		***Not- Supported***
FC> BI	0.010	0.022	0.450	0.653		***Not- Supported***
HM> BI	0.349	0.024	14.596	0.000		***Supported***
EH> BI	0.082	0.025	3.216	0.001		***Supported***
PE> BI	0.263	0.025	10.369	0.000		***Supported***
PV> BI	0.058	0.018	3.197	0.001		***Supported***
PY> BI	0.054	0.023	2.366	0.018		***Supported***
PY> TS	-0.124	0.026	4.742	0.000		***Supported***
SI> BI	0.212	0.021	10.060	0.000		***Supported***
SI> TS	0.549	0.020	27.106	0.000	0.332	***Supported***
TS> BI	0.067	0.024	2.843	0.005		***Supported***
LS> BI	-0.023	0.023	1.019	0.308		***Not- Supported***

PE (Performance Expectancy, EE (Effort Expectancy, SI (Social Influence, FC (Facilitating conditions), HM (Hedonistic motivation), PV (Price Value), EH (Experience & Habit), TS (Trust), PY (Privacy), ES (Ethics), LS (Legal security), BI (Behavioral intention)

In summary, eleven hypotheses representing the relationship between performance expectancy, effort expectancy (indirectly), effort expectancy (EE), social influence, facilitating condition, privacy (PY), trust (TS) and behavioral intention were supported in this study. However, the proposed direct effect of Ethics (ES), Facilitating conditions (FC), Legal security (LS) etc. on behavioral intention was not supported. In other words, effort expectancy (EE) was not found to have a direct impact on behavioral intention of AI robots, but have an indirect effect through performance expectancy (0.020, $p < 0.001$).

Table 6: Hypothesis Results

	Hypothesis	Supported
H1	Performance expectancy has a positive effect on the Behavioral intention	yes
H2	Effort expectancy has a positive effect on the Behavioral intention	yes
H3	Social influence has a positive effect on the Behavioral intention	yes
H4	Facilitating conditions have a positive effect on the Behavioral intention	Not

H5	Hedonic Motivation have a positive effect on the Behavioral intention	yes
H6	Price Value have a positive effect on the Behavioral intention	yes
H7	Experience & Habit have a positive effect on the Behavioral intention	yes
H8	Trust has a positive effect on the Behavioral intention	yes
H9	Privacy concerns have a negative effect on the Behavioral intention	yes
H10	Ethical concerns have a negative effect on the Behavioral intention	Not
H11	Legal concerns have a negative effect on the Behavioral intention	Not
H12	Effort expectancy has a negative effect on performance expectancy	yes
H13	Social influence has a positive effect on trust	yes
H14	Privacy concerns have a negative effect on trust	yes

6. DISCUSSION & CONCLUSION

This study sought to identify factors that predict the consumers' behavior intention of smart robots by applying the UTAUT2 model. The results to explore the reasons affecting the willingness of consumers to use smart robots, and the influence of the actual purchase behavior. From the study, we can find that the differences in the cultural background between the East and the West lead to different intentions for the use of smart Robots. It turns out that most elderly people can recognize smart Robots with a positive attitude. It is very useful to use robots to improve the quality of life. It is easy to be influenced by friends and relatives in the society, therefore the word-of-mouth (WOM) which is obviously important. At the same time, seniors are very concerned about price and entertainment functions (Hedonic motivation), as well as experience and habits.

Hedonic attitudes are related to users' experiences during the interaction; emphasize the intrinsic motivations in technology acceptance; and include the factors of enjoyment, attractiveness, intimacy, social presence, sociability, and companionship. Taiwanese old people like Karaoke's self-entertainment effect, so the entertainment effect of robots is very important. These facts have a significant impact on whether or not to accept smart Robots. The three hypotheses of H10 *Ethical concerns*, H11 *legal concerns* and H4 *Facilitating conditions* are not accepted, and may be related to the perception and environment of the 69% agreed to provide services and companionship for the weak or the elderly by the robot, 62% agreed to be assisted by the robot, and up to 82.9% agree that it is necessary to use robots because they can engage in too difficult or too dangerous for people. Ethical considerations would further add on the positive impact of social

robotics in a conservative society, which would gradually earn the trust of families with mentally impaired children (Hashim &Yussof，2017).

Putting together, the EU survey is less than a quarter of respondents (22%) would be comfortable being driven in a driverless car in traffic. The elderly in Taiwan are 42.7%. Obviously, the Taiwanese are more open to Europeans with higher technology acceptance than traditional Europeans. In addition, the original research hypothesis that privacy, ethics and trust will affect the willingness of the elderly to use smart Robots. As a result, the research hypothesis is not supported. 61.7% of the Taiwanese believe that Taiwan's technology is ahead of other countries and can obtain sufficient resources and confidence. You can also trust the safe use of intelligent Robots, which is related to the common habits of Taiwanese people using Facebook and Line to share their personal opinions, without worrying about leaking privacy and ethics and trust.

Depending on the nation status, the influence, acceptance and adoption of social robotics are indeed political and the success of science for society needs has to be re-examined and perhaps redefined in order to reap the return on investment of the robot production (Hanafiah, 2017).This research is attempted to explain Taiwanese consumers behavior intention of adopting smart robots. The research model is developed based on UTAUT2. The results show that performance expectancy, social influence, effort expectancy, hedonic motivation, price value, privacy, trust and experience & habit are directly associated with, and facilitating conditions, ethics and legal concerns are indirectly associated with, consumer behavior intention of adopting smart robots. These findings have implications for the design and implementation of smart robots.

Nine robot types were identified in addressing aged care problems, including companion, manipulator service, telepresence, rehabilitation, health monitoring, reminder, entertainment, domestic, and fall detection/prevention robots. These robot types have been applied to eight key problem areas in aged care, namely social isolation, dependent living, physical or cognitive impairment, mobility problems, poor health monitoring, lack of recreation, memory problems and fall problems (Shishehgar, Kerr, & Blake, 2018)

7. Limitations and future work

This research has several limitations. Despite that the sample involves different types of participants, a bigger sample size would provide larger power. The research model was validated with smart robots in the Taiwan, the interpretation of the findings should be made with caution when generalized to other countries or cultures. Further investigations may look into the effects of individual smart robots technologies. Finally, additional

research constructs such as utilitarian、safety、convenience and moderating effects of gender, age, and culture are worthy of future exploration.

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Abstract

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Abstract

Alexa 'Turn on the Christmas Tree", Alex "Turn on living room" Alexa "what in the temperature upstairs?" Alexa "Set my stove to 450 degrees". All of these things seem useful timesaving features of home automation, but what are the risks involved with implementing home automation and not securing Internet of Things (IoT) devices. There are currently no approved security standards created for IoT devices. The API's for these the devices can be directly accessed through RESTful services and other programming languages. Most consumers purchase these smart devices for the convenience that they offer but give very little thought to the security of the devices.

Keywords: Home Automation, IoT, Security

Commonalities to all systems

Basic principles of securing traditional network devices is the first thing consumers must do. These include things such as patching and firmware upgrades, the removal of default accounts and passwords, and changing any settings from the default which could leave your IoT devices exposed to an external attack. As there are no real standards in place at this time in relation to the security of devices consumers must take measures to protect themselves from exposure to unneeded risks. Based on the small research sample conducted for this paper the basics of network security is lost on a staggering number of consumers. The simple act of securing their WiFi networks is of great concern. If the sample size were to hold true, the average number of households (Census-charts, 2018) in the city Virginia Beach which will have unsecure IoT devices (TM Forum, 2016) by 2020 is 1,396,728. Further research would need to be conducted to determine the full scale of this potential problem however, in the research

sample there were over 100 IoT devices identified on a small number of the tested unsecure networks.

Table

Table 1

Total Number of households	Number of Active Wifi SSID	Number of Unsecured WiFi	% of homes with WiFI	% of homes with unsecured WiFi
283	172	42	61%	24%
345	271	61	79%	23%
265	191	14	72%	7%
Total VA Households	Potential number of WiFi	Potential number of unsecure	Avg % of homes with WiFI	Avg % homes with Unsecured WiFi
154,455	108841.1339	27934.56278	70%	18%

Further the implementation of a firewall is crucial to securing devices on the consumer networks and most consumer WiFi routers have at least a basic firewall built into their router. As consumers are not only deploying IoT so is industry and businesses, one of the most important factors for businesses in protection is to deploy IoT devices in full and complete network segmentation (CNS). Implementing CNS and deploying IoT devices on segregated networks will help to prevent spillage of sensitive data to an untrusted source. Not securing IoT devices has the potential for them to act as launchpad for BotNet and DDoS attacks. As such consumers and businesses must take an active role in the security of the devices under their control. DARPA (Defense Advanced Research Projects Agency) has identified IoT as one project which could have a greater and wider impact than that of the internet. (Sfar, Natalizio, Challal, & Chtourou, 2018) With the rapid adoption of IoT and companies leveraging the use of cloud services it is imperative the basic security measures are taken. Knowing and understanding the network traffic which is flowing from a consumer's network from those IoT devices is imperative for consumers to monitor. On the flip side of that coin the manufacturers of the devices must ensure all of the traffic is fully encrypted and stripped of any personally identified information. Amazon is leading way on developing and enforcing standards. (Ammar, Russello, & Crispoa, 2018) They follow specific guidelines for each of the IoT devices which

they offer. They also provide an opensource hardware specification as well as enforce security on a multi-level framework which includes x.509 certificates. All of Amazon created IoT devices communicate over secure socket layer (SSL) throughout the transmission of all traffic from the IoT devices into the Amazon cloud. (Ammar, Russello, & Crispoa, 2018) The question for consumers is how do they ensure the devices which they are purchasing conform to these same standards? NEST which is now owned by Google is the leader in many home automation products. Their learning thermostat provides consumers with a digital interface to control their heating and cooling costs and enabling control from around the world through any smartphone or browser. It also could mean exposure if the management account is compromised. One of the latest features which NEST has employed to secure the management account is providing the ability to implement two factor authentication to access the account and devices. NEST however, is not perfect and in 2016 (Gizmodo, 2016) security researchers found a bug where the devices were leaking the zip codes of consumers. While this may have been a minor information point the company quickly issued a patch. Most IoT devices encrypt data traffic, but encryption simply may not be enough. All IoT devices must encrypt all traffic that they send and receive. Encryption is a good starting point, but on its own, it appears to be inadequate for full protection of user privacy. Each IoT device generate specific traffic signatures which will reveal information, such as when powered on or off. These traffic patterns such as traffic volume over time may reveal certain user activities. One of the largest indicators of their presence on a network are the DNS queries made from the devices. Further, even when the data traffic itself is encrypted, other traffic sent in clear text may reveal not only the presence of IoT on the network, but likely also information on usage patterns. Even with the encryption of the data, the other major concern is about how these companies use and share the data that they collect. How is that

information stored and who may access that data. Do companies become the data owners even when consumers don't realize what has been transmitted to the manufacturer. All of these questions need to be answered. Unfortunately, as with most technologies' security is playing catch up to innovation.

Table

Potential number of IoT VA Beach	Potential number of unsecure IoT VA Beach
1088411.339	279345.6278
2020 potential number of IoT VA Beach	2020 potential number unsecure IoT VA Beach
5442056.697	1396728.139

Table 2

Consumers' and businesses do have a level of responsibility to ensure the secure (Ammar, Russello, & Crispoa, 2018) implementation of IoT onto their networks however, manufactures must provide them with the ability to make the needed changes to secure the devices. Further, the manufactures must provide timely and consistent upgrades of these devices to allow for the closing of security gaps within their products. Everyone must be involved in security of IoT devices, this includes consumers, manufacturers, and Internet service providers and even government. In their role, government should be approving and enforcing the use of the basic framework of controls which must be met for a manufacturer to sell those goods and services. These basic controls should be the foundation of the rules of the IoT. Government should not be regulating industry to the point where the cost of producing products is outweighed by regulatory demands to be allowed to sell those goods and services. Further government should not ask nor require any sort of "backdoor" or configured for the government to have access. (Webber, 2017)This can only lead zero-day exploits later in the product life cycle. There remain many unanswered questions concerning both who is able to secure these devices and who

should. Based on the research conducted in support of this paper we should start the discussion about how to communicate the basics in consumer security for their networks where IoT devices will be located. Starting the discussion from a (Akemi Takeoka Chatfield, 2018) policy stand point to clearly define the lines of responsibility from manufacturers all the way to consumers. Further, the device designs should be as transparent as possible without giving away any intellectual property. Building a framework for standards will improve the transparency of these IoT devices, allowing the consumers and businesses to have a better understanding into what software the devices are running, and what traffic and data in being transmitted. IoT risks pose major challenges for both data security and policymaking. Nation States and Industry are challenged while attempting to address the unique security challenges to securing and maintaining that security of IoT devices. (Webber, 2017) As was seen during the National Institute of Standards and Technology (NIST) meeting there was an agreement of the need, "to set baseline requirements for ensuring the security of devices connected to the internet." However, the federal government has little power to enforce those requirements and there is also no consensus on who or how those baseline security measures should be developed and who is and how it is going to be paid for and by whom. This is a huge effort, with the enormous and diverse number of device manufacturers, the goal should be that of ensuring the underlying security of the networks and communication channels are secure. Network infrastructure should (Akemi Takeoka Chatfield, 2018) be leading the way. Installing features which would include identification of anomalous behavior could provide consumers indication of a compromise or data leak. Making these features a requirement on setup of home routers would be a gigantic step forward to ensure consumers are at least basically informed of the traffic on their networks. It would be even for IPS's to install network intrusion detection systems and firewalls and other

standard network security tools to bear on these devices. ISP's are in a better position to identify what the devices are and what their expected behavior should be. This could lead to better machine learning and stooping attacks before they happen. Capturing this data about (Akemi Takeoka Chatfield, 2018) the devices on the network, along with the implementation of smart network would help to develop better defined network security policies even at the consumer level. This would go a long way for a consumer to decide what traffic should be flowing from their individual devices such as smart camera should never be able to communicate directly to the public Internet or your smart lock being opened remotely when no one is in the home.

How we interact

Amazon has released publicly the ability to create programs or what they call "Skills", for the Alexa devices. This is an effort to drive developers to their platform and inevitably consumers to the use of their smart hubs. Even competitors understand the market share which Amazon is commanding and have enabled their devices and services to work on the Amazon ecosphere. Amazon has just launched the Alexa Skills Kit (ASK) (Amazon, 2018) to the public and have given developers of all skills the ability to create applications to interact with IoT devices. This could be a boon for Amazon, but it can also be seen as a threat vector which will truly need to be monitored. As consumers begin to explore the capabilities of developing their own applications they could potentially expose their private data unknowingly. Also, this is providing an easy way for the security research community a means to easily interact with Amazon enabled IoT devices and discover vulnerabilities. This goes for both well meaning as well as threat actors looking for ways to exploit your information and data for their own benefit. Being the bridge between the physical and virtual worlds places the security (Ammar, Russello, & Crispoa, 2018) in a position unlike any other technology. The IoT devices being developed

today control things which could in theory be used to physically harm. Using simple RESTful services it is possible to trick a gas stove to begin to release gas without hitting the igniter. As the CO2 and fire alarm sensors are also IoT devices using those simple RESTful services the alarms can be disabled or the unit shut down. (de Melo Silva, 2016) Again, as there are no defined security standards for IoT devices this scenario while theoretical could be launched on networks which are exposed due to little or no security measures. If this same attack was made against a commercial entity or a medical center the outcome could be worse. The main objective (Akemi Takeoka Chatfield, 2018) again needs to be standardizing on a security protocol on how these devices are deployed.

Where do we start and end?

The start needs to be policy and creating standards which these devices will interact with each other and the networks which they are residing on. It is imperative to develop a set of standards in programming language, ports and protocols which these devices communicate. This will make it easier for ISP's and manufacturers to identify anomalies in traffic patterns and connections to and from devices. As consumers bring these IoT devices into the home the sheer amount of data which will be generated will need to be handled correctly. Without a define policy to tell these corporations what they can do with that data could lead to mass exposures and misuse of data points. If you think the Facebook and Cambridge Analytica data use would be bad, imagine if Google or Amazon sold access to your voice recording which Alexa and Home devices have now. They could be delivered to advertisers and political campaigns to directly influence your purchase decisions and voting decisions. The use of these audio recording have deep and significant (**Pfeifle, Anne.**) ramifications. If that is buying a dollhouse you never ordered or being part of a murder investigation. These voice IoT devices will play a significant

role in the future of IoT as a whole. Consumers must understand what data they are providing to these devices and understand the consequences in the use of them. Along with policy creation there needs to be heavy efforts in consumer education in the use of current devices as well as vendors with devices deployed today deploying fixes, patches and updates to support the needed security standards for IoT devices regardless of their use. The automation and technological advances which will be brought by the onslaught of IoT will need to be done in a much more standardized fashion than it has up until this point. The sensors and data collection devices which cities and utilities are bring to market only stand to improve the efficiencies of their services but will provide a good deal of cost savings. Where we need to end up is in a place where any vendor is free to create an IoT device and where a consumer can feel secure in the deployment and use of that product.

Conclusion

API, frameworks, policies and network security. This is how the technology field must help to bring security to the IoT devices deployed to the consumer. Education of the average consumer will be difficult and costly. However, this where the ISP can take the lead enforcing basic security measures to allow connections to their networks and allowing these devices to hit the public internet. Deploying security measures at the edge will help to protect consumers IoT. How to monetize that for the ISP could mean the IoT device manufacturers have a data sharing agreement with the ISP to help offset the added security costs. Or possibly this is where there is an upcharge to the consumer and monetary fines for consumers found not in compliance with the required security measures defined by the ISP. The main takeaway is consumers are the ones who not only need to demand change but also be the force of change. They need to begin to understand the basic concepts in a connected world and work towards implementing the most

basic security measures before they begin to bring the devices in to their world where they can bridge that gap of virtual and physical.

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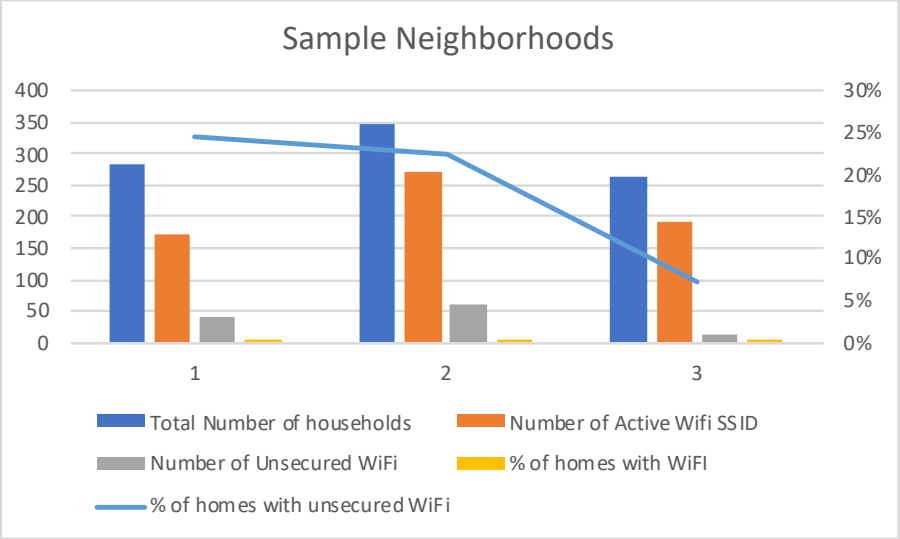
Figures


Sample Neighborhoods
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350
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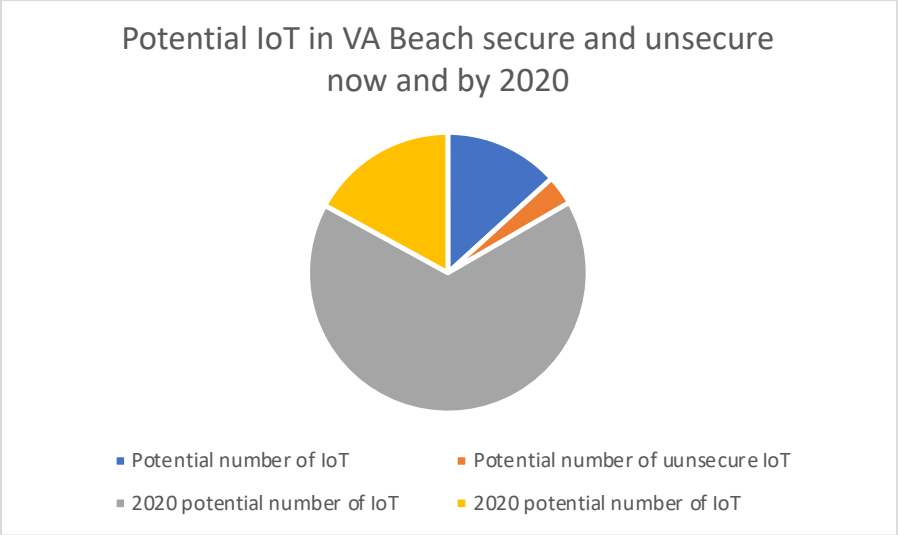
Potential IoT in VA Beach secure and unsecure now and by 2020
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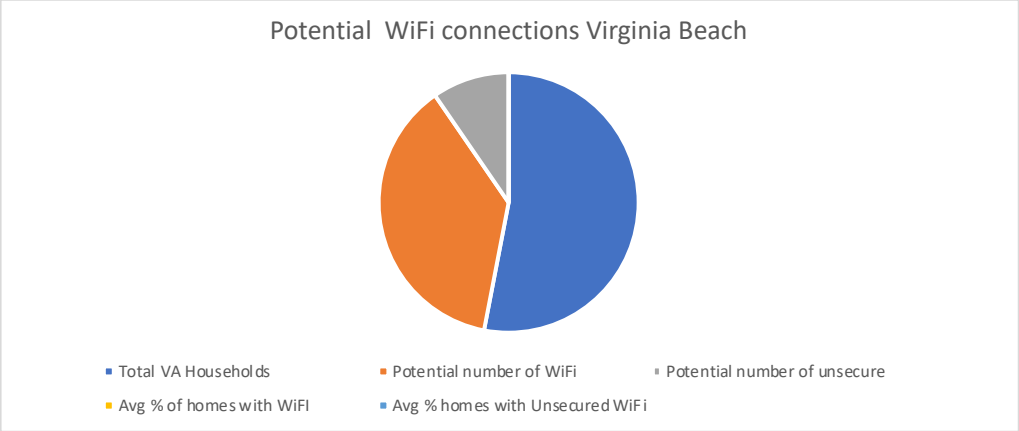
Potential WiFi connections Virginia Beach
Total VA Households
Potential number of WiFi
Potential number of unsecure
Avg % of homes with WiFI
Avg % homes with Unsecured WiFi

PALM TO PALM: SLOW PROGRESS

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PALM TO PALM: SLOW PROGRESS

Abstract

Palm to Palm, a Sierra Leone-based sustainable operations project, concluded 2018 having made slow progress towards becoming an environmentally and financially sustainable entity. Notable accomplishments include implementing an improved transaction processing and MIS system and securing a means of transporting raw materials and finished goods. Setbacks experienced during the year include three long-time project employees leaving at the start of the year, and continued struggles in the area of employee relations. The year ended on a positive note, however, with a weeklong visit by one of the two project co-directors to the project and the implementation of improvements in several key areas. Management is hopeful that solving the transportation issue and the process improvements made in December 2018 will pay significant dividends in 2019.

Keywords: Information systems maturity, Sustainable operations, Sierra Leone, Palm oil

Palm to Palm: Slow Progress

Introduction

Palm to Palm, a micro-scale sustainable operations project in Koidutown, Kono District, Sierra Leone continued to struggle in 2018. Project management continues to struggle in the area of employee relations, but did solve the transportation problem that has been plaguing the project since its inception. In addition, management implemented an improved information system. While the improved system cannot be considered "state of the art" it is definitely an improvement over the previous system. The project also began another round of farmer engagement activities in November, bringing additional farmers into the P2P project ecosystem. Unfortunately, due to employee relations, transportation, and weather issues that impacted the project for almost the entire year, operating results for the year are significantly below those of 2017, with both palm oil and soap production falling by about half from the previous year.

2018 Activities

Management's time and efforts in 2018 fall into three primary areas: Transportation, employee benefits, and information systems. Management devoted significant time to searching for a transportation solution over the first half of the year. Employee relations occupied a significant amount of time and effort over the course of the year as the compensation and benefits package negotiated in 2017 proved unworkable in 2018. The project took a significant step forward in December 2018, however, by implementing new information systems.

Transportation

The need for reliable raw material and finished goods transportation has plagued the project since its inception. In early 2018 management began an earnest effort to find a solution. Efforts in this area first focused on securing a used truck, a solution which management originally thought was workable. After investigating several options, however, the cost of a used truck exceeded the resources the project had available. So management turned to searching for a "power tilla tractor", which is a mechanical generator mounted on two wheels with a two-wheeled cart attached. Initially, the project manager traveled to Freetown and inquired about

purchasing a new power tiller tractor from a Chinese manufacturer (D. Somoyah, personal communication, March 30, 2018). However, two things caused project management not to pursue this solution:

1. Even the negotiated price was unaffordable given project finances
2. The manufacturer did not have any tractors in stock in Freetown and if an order was placed it would take four months for the machine to arrive. The project therefore wouldn't have a transportation solution available until after busy season.

The project manager therefore suggested that management should "…buy a second hand dynna truck/open van for fast transportation of raw materials."

Management then began searching for used trucks to purchase. The P2P manager found a used Dyna truck for sale for SLL 40M, but that proved too expensive, and the owner sold the truck to another entity at a higher price. The local manager then found a used Toyota truck in Freetown being sold for SLL 40M, but that option was still financially unworkable and negotiations failed to conclude successfully.

The next step for management, since busy season was underway, was to explore the possibility of signing a contract with a truck driver to utilize the driver and his truck several days per week for the duration of busy season. This option, however, was not pursued (D. Somoyah, personal communication, June 21, 2018) because heavier than usual rainfall in Kono District meant that roads were impassable.

Immediately after abandoning the effort to hire a truck and driver, however, management became aware of two used power tiller tractors on the market (D. Somoyah, personal communication, June 22, 2018). After investigating both, one (with a capacity of 180kg) was found to be both affordable for the project and in good working condition. After negotiations the purchase of this power tiller tractor closed in July 2018.

Employee relations

After a difficult year in 2017 in the area of employee relations, management felt workable compromises were made in the area of compensation and benefits. At the close of 2017 employees had a bonus system and a "healthy plan", or plan for health-related expenses. Unfortunately, the year did not start well for employee relations, as three long-time employees

left the project at the start of 2018 (D. Somoyah, personal communication, January 1, 2018), reducing the number of project employees to three, too few for the project to resume full operations. So production was spotty for the first four months of the year as management's time was consumed with other issues. In May a plan to hire new workers was put in place, but workers also insisted on further negotiations in the area of healthcare costs. The 2017 "healthy plan" called for the project to pay employee medical expenses, but in May 2018 the project's remaining employees told management that they wanted "medical agreements" prior to starting work (D. Somoyah, personal communication, May 21, 2018). A "medical agreement" is a contract between management and employees stating that management will pay medical expenses for employees. The contract negotiated agreed that management would contribute SLL 350,000 monthly to the "Medication Fund for P2P and Children" out of which healthcare expenses would be paid. The agreement was finalized and signed in early June (D. Somoyah, personal communication, June 6, 2018). The agreement called for reimbursements to be processed when receipts for healthcare expenses were submitted by employees. It soon became apparent that receipts were not being submitted, so after an initial contribution management did not fund the Medication Fund for the remainder of 2018. It remains to be seen if this contract will be a workable solution over the long term. It is management's hope that it is the case.

Information systems

As 2018 started, P2P management had for several years been relying on very rudimentary reporting of operating and financial results. Specifically, transactions were logged in a composition notebook and management reports detailing project operating and financial results were typed into MS Word documents which were then emailed to the project co-directors. As the local project manager increasingly experienced Internet connection and computer troubles, very brief management reports were even sent by WhatsApp message. A plan to develop and implement an improved transaction processing system and better management reporting was developed and implemented over the course of the current year.

Two of the most basic information systems an organization needs are a transaction processing system and a management information system. Laudon & Laudon (2019) define these two types of systems as follows:

PALM TO PALM: SLOW PROGRESS

1. Transaction Processing System: "…[S]ystems that keep track of the elementary activities and transactions of the organization, such as sales, receipts, cash deposits, payroll, credit decisions, and the flow of materials in a factory."
2. Management Information System (MIS): "…[D]esignates a specific category of information systems serving middle management. MIS provide middle managers with reports about the organization's current performance. Managers use this information to monitor and control the business and predict future performance."

An opportunity to improve upon the then-current transaction processing (TPS) and MIS systems presented itself in 2018 when one of the project co-directors planned a weeklong visit to the project. The visit occurred the first week in December. The visiting co-director developed an MS Excel-based TPS and MIS. The reason this improvement had to wait until a co-director visited the project was spreadsheets in general and MS Excel in particular were new technologies for the local project manager and the project employees, so an introduction to spreadsheet technology was needed prior to instructions for completing the MS Excel spreadsheets themselves. One factor that did make switching to the new MS Excel-based system easier was that the visiting co-director brought with him two laptops that had been donated to the project to replace the project manager's malfunctioning computer.

The new MS Excel spreadsheet system consists of three spreadsheets that are completed on a weekly basis:

1. Farmers FFB (Fresh Fruit Bunches) data: This file records all palm fruit purchases including vendor/farm, number of bunches, size/weight of bunches and purchase price.
2. Revenues P2P: This file records sales transactions. Importantly, for palm oil information is recorded for each "production" or lot of palm fruit that is processed. Information captured includes amount of oil extracted, purity of palm oil produced, production efficiency, and sale price of resulting palm oil.
3. Expenses: This file records expenses. This includes labor cost, material cost, ingredient cost for soap, fuel cost, etc.

The primary idea in developing this spreadsheet system, like in many information systems, is to reduce the number of times information has to be entered. Ideally a given piece of information is

only entered once. The system is really set up to contain aspects of both a TPS and an MIS. When information is entered for each week the spreadsheets will be saved with the date in the filename so that each week three new date-named files are created. These files will then be emailed to the project co-directors.

This new system may appear very rudimentary to many readers. But the reader should be reminded of the location and size of the project. In searching for information on spreadsheet-based information systems, the authors came across a case study detailing the MS Excel-based MIS system used by the Cocoa Marketing Company (CMC) Ghana Limited in 2010. While CMC had a computerized TPS, all management reporting was spreadsheet-based, duplicative, delayed, and prone to errors and incompleteness (Offei-Addo, I., 2011). The new P2P system is susceptible to the problems reported by Offei-Addo, namely the fact that information is contained in separate files possibly stored in separate locations and cannot be easily searched.

Organization maturity, IS (information systems) maturity, and ERP (enterprise resource planning) system maturity are concepts that have been well-developed in the literature. P2P, as a micro-scale project, is in the earliest stage of maturity in all three areas. Benbaset, Dexter, and Mantha (1980) describe a study that investigated skills required by managers and system analysts at less- and more-developed organizations, or more directly organizations that are less and more further along in terms of IS maturity. One aspect of the study is a ranking of skill categories by role (manager vs. analyst). Specifically, the study found that "…there were no differences between the ranking of the six skill categories for managers of more and less mature organizations. The same was true for analysts." In addition, the study found that both managers and systems analysts "…in both more and less mature IS organizations ranked generalist skills as being more useful than specialist skills." These two findings are interesting in light of the present stage of P2P in terms of organization and IS maturity. The three principals involved in P2P (two co-directors and one manager) are all generalists. Moving up the stages of IS maturity has proven difficult for P2P because the organization at present doesn't include anyone with the requisite specialist skills to advance the organization in these two areas. The project principals will be working to address this area in the future.

Clearly P2P is in the early stages of information system maturity. Project management does not plan for this spreadsheet-based TPS/MIS system to be a long-term

solution. In fact, P2P management has already begun thinking about and planning for the development and implementation of a web-enabled database which will serve as a true ERP system.

Holland and Light (2001) propose a stage model for ERP systems implementation. According to the authors, this model is useful "…for understanding the process and content of the development of the maturity of ERP systems in organizations." As one of their conclusions, the authors state that ERP systems "…form the core of most firms' core transactional capabilities…". For this reason, P2P management is planning to implement some form of ERP system. However, in a clear indication of how a model can differ from data, the authors clearly state that issues have been identified in how the ERP system industry has developed. In discussing how this industry has developed, the authors state:

> "It is widely recognized that organizations reengineer business processes in line with a common information blueprint inherent within any given piece of standard ERP systems. This can reduce the ability of organizations to generate distinctive capabilities and is compounded by the widespread adoption of ERP systems."

P2P management, in reviewing its options related to ERP systems, will carefully consider the implications of the above statement concerning how the development of the ERP system industry has negatively impacted organizations' abilities to become and remain competitive by developing distinctive capabilities and offerings. Any such system P2P adopts will take time to design, build and implement.

Farmer Engagement

Fall 2018 saw P2P plan and implement a new round of farmer engagement, with the project paying for "underbrushing and pruning" at additional farms and the corresponding farmers going through training sessions on proper maintenance and upkeep of oil palm farms. This new effort began in November 2018 and will conclude in January of 2019 in time for busy season. As the local project manager reported (D. Somoyah, personal communication, October 31, 2018) the oil palm farmers were very excited when told that P2P would support another round of farmer engagement. Approximately twenty farmers are included in this round of farmer engagement, bringing the total number of farms in the P2P ecosystem to about forty.

2018 Outcomes

The project's primary outputs are palm oil, soap, gari, and processed fish. Comparing the current year to 2017, there was a steep decline in both amount of palm oil processed and sold and amount of soap produced and sold. No gari or processed fish were produced during the year. Production for the first half of the year was impacted by having too few workers, the negotiations around the medication agreements, the lack of reliable raw material transportation, and the unusually heavy rains that plagued the region. In the second half of the year production was impacted by the unusually heavy rains that plagued the region. As a result, palm oil production was limited to approximately 260 battas (1,300 gallons) and only about 11,500 bars of soap were produced.

P2P's production and sales activities resulted in revenue of about SLL 50M for 2018. This represents about 60% of 2017 revenue. While 2018 has been a disappointing year for P2P in terms of operating results, management believes that solving the transportation problem and significantly enlarging the number of farms in the P2P ecosystem will allow the project to make significant strides in 2019.

Conclusion

For Palm to Palm, 2018 has been a year of progress in some areas (information systems, transportation, collaborating farmers) but a year of challenges in other areas (employee relations, transportation). It should be noted, however, that at the start of 2019 Palm to Palm is still "…alive and kicking". Management continues to believe that better days lie ahead for the project and the people of Sierra Leone. P2P management is committed to working for a better tomorrow.

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SENTIMENT AS A PREDICTOR OF THE IMPACT OF CYBER ATTACKS

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Abstract

Mitigating the effects of cyber attacks often requires major efforts. Thus, being able to prioritize incident response based on the potential impact of the attacks is important for an effective use of resources. But how can one predict the potential impact of a cyber attack at its onset? In this paper, we investigate whether online sources can provide a reliable predictive indicator of the impact of cyber attacks. Specifically, we study the feasibility of applying sentiment analysis to a sample of blog and forum posts by users affected by cyber attacks to make a long-term prediction of the impact of those cyber attacks.

KEYWORDS: sentiment analysis, cyber security, incident response.

1. Introduction

As the use of the internet increases, so does the amount of cyber attacks and their potential societal and economical impact. When an issue is discovered, it is essential to act comprehensively and quickly to contain the damage. However, mitigating the effects of a cyber attack frequently requires a major involvement of resources. As incident response teams are often spread thin, being able to prioritize the response to attacks based on potential impact and to distribute personnel accordingly has the potential for a more effective use of resources and a more streamlined incident response. But how can one predict the impact of a cyber attack at its onset? Evidence shows that public discourse in online sources, such as social media, blogs, and forums, is strongly correlated with the occurrence of real world behavior. We aim to investigate whether the same sources may provide a reliable predictive indicator of the potential long-term impact of a cyber attack.

In this paper, we propose an approach that uses sentiment polarity applied to social media posts by users affected by cyber attacks as an indicator of their potential impact. The paper is organized as follows. We begin with a short review of background and related

literature. Next, we talk about the methodology used to calculate the sentiment score of a cyber attack. In the following section, we discuss the experimental evaluation of our approach. Finally, we draw conclusions and discuss future work.

2. Related Work

A number of attempts have been made to leverage sentiment analysis in the context of cyber security. However, most have focused on predicting the occurrence of cyber attacks rather than their long-term impact. The work closest to ours is applied sentiment analysis of hacker forums to cyber security (Macdonald, Frank, Mei, & Monk, 2015). Differently from other research that has investigated the specifics of cyber attacks, the authors investigate the actual cyber actors via their communication activities. (Deb, Lerman, & Ferrara, 2018) describes an attempt to predict cyber events from the application of sentiment analysis on hacker forum posts aimed at better understanding hacker behavior. In a similar direction, (Sapienza, Bessi, Damodaran, Shakarian, Lerman, & Ferrara, 2017) presents a system for automatically generating warnings of imminent or current cyber threats. Their system leverages the communication of malicious actors on the dark web, as well as activity of cyber security experts on social media platforms like Twitter.

Apart from the context of cyber security, sentiment analysis had also been used in multiple sectors such as market research, stock market prediction and film reviews. (Yu, Duan, & Cao, 2013) used a large-scale dataset that features daily media content across various conventional media and social media outlet including blogs and forums to analyze the overall sentiments of each media resource towards a specific company on a daily basis. They suggested that the overall social media has a stronger relationship with firm stock performance than conventional media. (Tayal, 2009) also explored the potential of micro-blogging site to predict stock values. The results of sentiment analysis and previous stock price history are used to make predictions for the next day stock values. In the recent past, (Mo, Liu, & Yang, 2015) analyzed more than 12 million news article to document the presence of a significant feedback effect between news sentiment and market returns across the major indices in the US financial market. Additionally, (Tucker, Dickens, & Divinsky, 2014) mined textual data to quantify student sentiment in relation to their course performance. The data was obtained from online discussion forums generated by the students enrolled in massive open online courses.

3. Sentiment as a Predictor of Impact

In this section, we summarize our approach for using sentiment as a predictor of impact. Sentiment analysis is a type of subjectivity analysis that aims at identifying opinions, emotions and evaluations expressed in natural language. In this section, we describe our approach for using sentiment as a predictor of the impact of cyber attacks. For a given set of cyber attacks $A = \{A_1, A_2, A_3, \ldots, A_k\}$, we define a sentiment analysis algorithm $ImpactScore$ so that, for every A_i, A_j if $ImpactScore(A_i) \geq ImpactScore(A_j)$, then one can expect the impact of A_i to be greater than or equal to the impact ofA_j.

Given an attack A_i, algorithm $ImpactScore$ begins by fetching the posts related to A_i, and then obtains the sentiment score (called *term score*) of relevant individual terms[1]. The term score is then used to calculate the *phrase score* for the phrases of interest. In turn, multiple phrase scores are aggregated into a *post score* and, finally, into a cyber attack sentiment score taking into consideration the polarity and magnitude of each post.

While the calculation of term score is rather straightforward, the phrase score is more subtle. As first step in its calculation, a Part-of-Speech (POS) tagger is applied to the text in order to label each word with its POS. This allows us to weigh term score differently based on their POS when they are aggregated into the phrase score. For example, one might decide to weigh adjective more than verb. Different approaches were explored with different linguistic features and scoring schemes. It has been proposed (Singh, Piryani, Uddin, & Waila, 2013) that one should sum the scores of adjective and their adverbs. However, we argue that this is not always appropriate. For example, consider *"Installing this software has very bad consequences,"* where summing the scores of adjective and adverb will yield an incorrect outcome, because adjective and adverb have opposite polarity. Thus, in this project, we have experimented with a linguistic feature selection scheme in which we extract all adjectives and verbs, as well as any adverbs and nouns preceding them. Weights allow to decide to what proportion the sentiment score of an adverb should modify the succeeding adjectives and verbs sentiment score. Experimental evaluations led us to select a scaling factor of 4.5 for adverbs, of 2.0 for nouns, and of 0.2 for verbs.

[1] We used SentiWordNet for the calculation.

Thus, the calculation of the phrase score begins with the extraction of adjectives and verbs, as well as their sentiment scores. If the score is zero, a term is disregarded. Otherwise, we extract adjacent nouns and adverbs. The scores of adjective/verb and adverb are then multiplied with a suitable scaling factor. The resulting score is then multiplied with the noun term score, through another scaling factor, to get the final phrase score.

Next, the post score is obtained by summing all phrase scores, and the cyber attack sentiment score is calculated by summing all scores for the relevant posts. Note that the process takes into consideration both polarity and magnitude.

4. Experimental Evaluation

The goal of our experiments was to verify the viability of sentiment score as a predictor of impact of an attack. To ensure a concrete definition of the notion of impact, we focused on economic impact due to ransom payments, which is relatively easily quantifiable, e.g. (Conner Forrest, 2017), (Gibbs, 2017), (Josh Fruhlinger, 2017), (Nicole perlroth, 2017), (Paul J. Lim, 2017). Posts were obtained from various forums and micro blogging websites dedicated to cyber security[2,3,4,5,6]. We focused our collection on 6 instances of attacks: WannaCry Ransomware Cyber Attack 2017 (700 posts analyzed, $0.143M impact), CryptoLocker Ransomware Cyber Attack 2013 (710, $3M), NotPetya Malware Cyber Attack 2017 (678, $300M), Yahoo Data Breach 2013-2014 (690, $350M), Equifax Data Breach 2017 (726, $200M), and Uber Data Breach 2016 (78, $20M).

As a preliminary evaluation of the algorithm, we calculated the algorithm's accuracy in assessing a post's sentiment vs manual annotations of all posts. The algorithm performs fairly well against the human gold standard, achieving an accuracy of 77.36%.

The results of our experiments are summarized in Table 1, Table 2, and Figure 1. It should be observed that, in all cases, the sentiment scores obtained were non-positive, which confirms that the cyber attacks are generally perceived negatively by users. In

[2] "Wilders Security Forums." Accessed February 9, 2019. https://www.wilderssecurity.com/.
[3] "Whirlpool Forums." Accessed February 9, 2019. https://forums.whirlpool.net.au/.
[4] "Comodo Discussion Board and Support Forums | Comodo Community." Accessed February 9, 2019. http://forums.comodo.com/.
[5] "Reddit." Accessed February 9, 2019. https://www.reddit.com/.
[6] "Bleeping Computer." Accessed February 9, 2019. https://www.bleepingcomputer.com/.

Figure 1, the correlation between score and impact is illustrated using linear regression lines. The light blue shading indicates the width of the confidence interval.

It is clear from Table 1 that the ranking provided by the sentiment score is a close approximation of the ranking of the impact of cyber attacks. In other words, the sentiment score of the posts related to a cyber attack is indeed a good predictive indicator of the potential impact of the attack. The only outlier in our experiment is WannaCry, which has a relatively low sentiment score of -0.535 (e.g., vs. 0 for CryptoLocker), while its impact is only $0.143M (vs. $3M for CryptoLocker). Interestingly, this result reveals more about WannaCry's real impact than the figure of the economic impact conveys. No doubt, WannaCry was devastating to the NHS, affecting around 48 hospitals and trusts. However, WannaCry Ransomware mostly hit large organizations, who often could afford not to pay ransoms because they had reliable backups available. Thus, despite more than 200,000 infections worldwide, there have been fewer than 200 payments. Our findings on the correlation between sentiment score and economic impact are further confirmed by our calculation of the Spearman rank correlation, which can be found in Table 2. In particular, the coefficient of -0.828 demonstrates high linearly correlation.

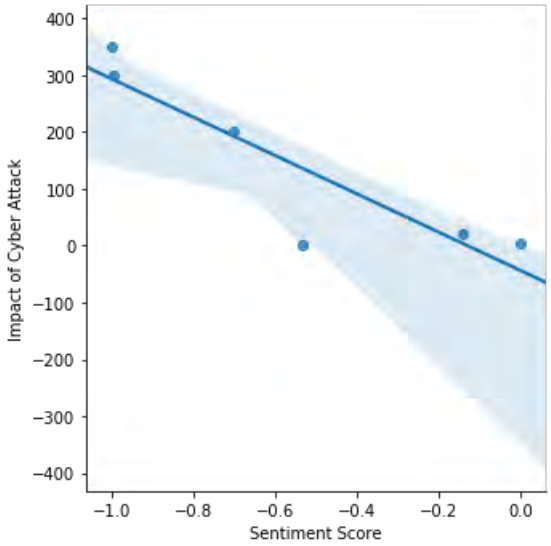

Figure 1. Correlation between sentiment score and impact

Cyber Attack	**Sentiment Score**	**Financial Impact ($M)**
CryptoLocker Ransomware Cyber Attack 2013	0.000	3
Uber Data Breach 2016	-0.142	20
WannaCry Ransomware Cyber Attack 2017	-0.535	0.143
Equifax Data Breach 2017	-0.703	200
NotPetya Malware Cyber Attack 2017	-0.998	300
Yahoo Data Breach 2013-2014	-1.000	350

Table 1. Ranking of cyber attacks according to sentiment score

Spearman Rank Correlation:	**-0.828**
p-value:	**0.00415**

Table 2. Spearman rank correlation of the above-mentioned data

5. Conclusion

In this article, we demonstrated that sentiment scores can be used as a predictor of the impact of cyber attacks. Although our study was focused on a comparatively small number of attacks, we believe that it demonstrates the viability of the approach.

This research can be expanded further in a number of interesting directions. First, a larger-scale experiment should be conducted. Additionally, one could attempt to leverage Twitter as a source of posts. Third, one could explore more sophisticated methods of aggregating the post scores rather than simply adding them. One may observe that some users have a tendency to be routinely negative in their opinions, or may be biased towards specific types of cyber attacks. To prevent these biases from skewing the results produced

by our algorithm, one could then introduce user-dependent scaling factors based on prior post history.

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THE FUTURE OF IoT SECURITY

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Abstract

The internet of things, or also known as IoT, "is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to computer interaction" (Rouse). The internet of things has been around since as early as 1999, and it is not going anywhere anytime soon except for the future. IoT security is a big issue in today's world. According to Kaspersky's lab's researches the total number of malware samples targeting smart devices has reached more than 7,000, with over half of them emerging in 2017 (Kaspersky). The internet of things is transforming our world and will create a huge amount of value, but as new devices connect to the internet and integrated, the more we open up ways for hackers to cause harm. In this paper I will attempt to discuss IoT security, the challenges of securing the internet of things, how to better secure IoT, and where IoT is heading along with the importance of why IoT needs to be more secure today and moving into the future.

Keywords: IoT, Security, IoT Security

The Future of IoT Security

The internet of things according to the Merriam Webster dictionary is "the networking capability that allows information to be sent and received from objects and devices". The internet of things matters because when a device is connected to the internet, it means that it can send and receive information which has a lot of benefits such as being able to change the temperature in your house while away or being able to unlock your doors before you get home. When you think about a smart phone, it's not smart because it has everything you want to hear, see, or learn stored on it, but because your smart phone can send information requesting something and receive that information easily in the palm of your hands, and it's because of the internet of things, but is the internet of things safe? How secure is it? According to an article released on February 2018, there are roughly 8 billion IoT devices connected, and by 2020 there will be 25 to 30 billion devices worldwide and 25 % of cyber-attacks will be targeted toward IoT devices. (Tommey). A major issue with IoT security is that manufactures are so concerned with getting a product out on the market that the developers are rushing through and not paying attention to the security aspect of these devices. For that very reason the internet of things needs to be more secure and so far, we have not done a great job of it.

Why the Need for IoT Security?

There is a huge need for IoT security, but first when did the internet of things come about? Internet of things was first mentioned in 1999 by Kevin Ashton who is the co-founder of the Auto-ID Center at MIT in a presentation he made. Although Ashton mentioned it in 1999, the idea of connecting devices has been around since the 70's. Ashton's idea according to an article states that "focused on using radio frequency identification technology to connect to connect devices together" (Pierre). Radio frequency devices are wireless devices that work on radio

frequencies such as mobile phones, routers, Bluetooth devices, radars, etc. It wasn't until recent years that IoT became a hot topic. There are several things according to Pierre changed to make the internet of things possible such as the "expansion of networking capabilities, the introduction of large-scale data analytics tools, and the creation of new standards which make it easier for IoT hardware and software from different vendors to interact" (Pierre). While IoT will and does add tremendous value, they are very much at risk for being hacked and bring harm to people. For instance, one of the dangers is the breeches in individual privacy. In 2013, there was an attack on Target in which hackers "stole the personal information of 70 million individuals" (McClelland). It has also been shown how certain baby monitors are capable of being hacked which allows a third party the capability to watch live video on the other side. This is a huge security risk because not only can that person watch who is on the other side, but it allows them to also know if the occupants are home, making it an easier target for a burglary. By not having proper security in place for IoT, two security researchers according to McClellan have "demonstrated the ability to hack into a Jeep Cherokee in motion, even shutting off the brakes and accelerator" (McClelland). This is a huge security risk and could cost lives if not fixed. If that's not bad enough the two researchers could also lower the speed of the vehicle, abruptly engage the brakes, and even cut the brakes off all together. Not only is our personal information at risk with the lack of IoT security, but there is also a danger to our systems, business, and our government. In just 2009, US and Israeli designed a computer worm called Stuxnet which would infect an Iranian nuclear facility. The worm infected the systems which caused centrifuges to malfunction and be destroyed. Ben Dickson is quoted for saying "IoT botnets are one of the biggest threats to internet stability, and there seems to be no stopping their growth because neither manufactures nor consumers are concerned with IoT security" (McClelland). This lack of

concern is dangerous because that means that vulnerable devices are being connected everyday opening the door for botlords and their zombie armies. Botnets are very dangerous and back in 2016, the largest DDoS attack ever was launched using an IoT botnet. The result of this attack was very catastrophic resulting in huge portions of the internet going down. This shut down included Twitter, Netflix, and CNN. What made this botnet so effective was that it was infected using a malware called Mirai, and this made the computers continually search the IoT for devices that were vulnerable would then use a default username and login to gain access and infect them with malware. This attack although more inconvenient than anything goes to show just how easy it is to infect devices on the IoT to cause harm to people and organizations.

Challenges with Securing IoT

We are at a great risk for being invaded and having our personal identities stolen by someone with malicious intent. Many people think that they are secure or that their devices are un-hackable, but that couldn't be further away from the truth. In a study conducted by HP's security unit, they found that "70 percent of popular consumer IoT devices are easily hackable" (NSS Lanbs). That is a very scary number. As I mentioned previously there is a big problem with today's IoT security due to rushing to get these insure products out in order to meet the needs of the businesses. Because of the rush to get these products out so fast means that there is lack of power and storage to be able to host some kinds of endpoint security software. It's shocking that with all of the IoT security issues is it just now becoming a concern, and the bad thing is that it is not just about a few devices, but out IoT security issue is with all devices ranging from TV's to cars or even by just connecting to the internet. According to an online article there are still many challenges to securing the internet of things, one of them being the lack of bandwidth and

networking infrastructure (Pierre). As more and more devices enter into the world, the challenge of securing those devices becomes harder and harder. An online article on IBM Developer gives a list of the top ten security challenges. Some of those challenges include secure constrained devices, secure communication, detect vulnerabilities and incidents, insufficient testing and updating, brute-forcing and the issue of default passwords, IoT malware and ransomware, data security and privacy concerns, small IoT attacks that evade detection, and being able predict and preempt security issues. When it comes to secure constrained secure devices, many of the devices that are on the market today have limited amount of storage, memory, and processing capability and those devices need to be able to operate on low levels power. The issue with devise like that rely on encryption and that is not good for constrained devices, and that is because these devices are not capable of performing functions such as complex encryption and decryption fast enough to transmit data securely. It's not just enough though to have a secure device. According to IBM Developer IoT needs to ensure that communication across the network between devices and cloud services or apps is secure (Gerber). A lot of IoT devices will not encrypt a message before sending it which is extremely risky if on a public network. A good remedy for such an issue is using transport encryption and using Transport layer security (TLS) which provides security for transferring data over the network. With detecting vulnerabilities and incidents, it's hard to prevent because at some point there will be incidents. When we look at the large scale of IoT devices, it becomes complex when trying to detect vulnerabilities and incidents due to the number of devices connected along with the many different types of devise, apps, and other services involved. However, with proper monitoring and keeping logs to track anomalies can help prevent the number of incidents that occur within a network. Another challenge with IoT security is being able to predict and preempt security issues. This is more of a

long-term security challenge. As mentioned earlier, there are over 20 billion IoT connect devices and the number is rising dramatically. An article on peerbits says that one of the main problems with tech companies building all of the devices is that they are too careless when it comes to handling of device related security (Harper). There is apparently a big issue with device updates and some devices not even being updated at all and manufactures only offer firmware updates for short periods of time. The co-founder and CEO of ZingBox, Xu Zou says "Just as the underlying operating systems and firmware of these devices are difficult to update" (Xu Zou). Another concern with regards to IoT is that many devices that we purchase come to us with default passwords but never told to change them. The Mirai botnet is used in some of the largest and most disruptive DDoS attacks according to Harper is one example of issues that come with shipping devices that have default passwords that should be changed once the device is received by the consumer. Mirai was such a success because it was able to identify vulnerable devices and use a default username/password to gain access and infect them. While it is not legal for manufactures to continue this practice, there are some reports that advise manufactures against selling devices with default credentials such as the username "admin". Not having a strong password and username leave devices weak and vulnerable to the bad guys. As the number of IoT devices increase so do the chances of becoming a victim of malware or ransomware. There is a hybrid version of malware and ransomware in which the attack could disable a devises function while stealing user data at the same time. Peerbits gives the example of an IP camera which is ideal for dealing with sensitive information can be "locked and that information can then be funneled to an infected web address which could extract sensitive data using malware access point and demand ransom to unlock the device and return the data" (Harper). Perhaps the largest IoT concern to date is data security and privacy. This makes sense because everyday data

is being harnessed, transmitted, processed, and stored by large companies. IoT devises such as smart TVs, speakers and lighting systems, and smart thermostats all contain user-data which is shared or sold to various companies, and this clearly violates our rights for privacy and data security. Clearly there is a big issue with this and why it is so important to secure IoT devices. Lastly, we should be concerned with the smaller IoT attacks that are harder to detect. As previously mentioned, I discussed the Mirai botnet which was the largest threat to IoT devises, but in 2017 the Reaper emerged. This botnet mimicked the Mirai and was a much more dangerous botnet. While the large-scale attacks are important to catch, it may be even more important to catch the smaller IoT attacks that can go undetected. These micro breeches are believed to occur more as move into the future because of their undetectability.

How to Better Secure IoT

A big issue within the IoT development is that manufactures aren't sure as to what exactly to secure. There is a lack of awarenss on what should be secure and the types of vulnerabilities that exist which is one of the biggest reasons why devices are so vulnerable. According to an online article, experts are saying that "attacks have jumped 280 percent" (Dinha). The problem has gotten so bad that now the U.S. Department is taking notice and beginning to set standards for organizations and their security standards. Although we have experienced such a difficult past with IoT security doesn't mean that our future has to be. There are some basic rules as to how we can be better secure when it come to the internet of things. One precaution to take is not to connect a device to the internet without some sort of firewall. By not using a firewall we are at risk because as mentioned earlier, most devices from the manufacture are not protected. Also, by changing the default passwords on our device to

something that we can only remember. The good news is that if we forget we can most likely retrieve it through reset password link. Another great way to secure your IoT device is by checking the default settings. Many time devices come with default setting already on, and we forget to change them but there are settings that we don't necessarily use or need. By not changing the default settings can leave a person and its device vulnerable to an attack. If you're not sure how secure a firewall is, there are programs online that are able to give a relatively good idea as to how strong a firewall is. Although there is not direct correlation between cost and security, it is usually a good rule of thumb to consider the cost. It has been shown that devices toward the lower end of pricing are the ones that are more vulnerable and attacked. When it comes to our device, you're more likely to get what you paid for.

The Future of IoT

"In just one year alone, we went from 5 million IoT devices connected to the internet to billions" (Schuetz). It's believed that the future is now, and rightfully so with all of the IoT devices that are planned to be connected to the cloud. It's clear that we have some way to go to secure the IoT looking at our past and present state. The good news is that legislators are taking the issue of IoT security more seriously now. In fact, according to Toomey Senator Mark Warner introduced the Internet of Things IoT Cybersecurity Improvement Act of 2017 (Toomey). This is a good thing because this bill would establish standards for IoT devices purchased by the U.S. government. Along with that, the devices bought must be free from any known vulnerabilities and have proper data encryption. Not only that, but IoT vendors would be required to have patches available once a device is able to be updated and that said devices do not use unchangeable passwords. There are some issues with this bill in that it has yet to be passed and it only covers devices sold to the government, but it's a step in the right direction. However, some

states are already passing bills. For instance, California passed its first bill that will take effect in the year 2020 according to an online article. The law will set minimum standards for IoT devices including mandating that preset passwords be made unique to each device (Matthews). I believe the future of our IoT is in the hands of our manufactures. They need to be building with a security mindset, which means selecting better operating systems that are both secure and ready for the future market. Malicious attackers are constantly evolving in the way they attack people and business, and therefore companies must be more proactive when it comes to security. Jonathan Penn, the director of strategy for Avast says this "IoT security will see many interesting developments arise from the connectedness and automation of devices and systems. These developments include new forms of authentication, more dynamic authorization, and improvements in behavior analysis at the machine and system level to detect indicators of threats" (future of everything). IoT is not the only transformative tech out there. The future of IoT is the convergence of IoT and AI along with blockchain and fog computing according to an online blog (Zafarino). To add on to that, Zafarino goes on to add that "AI and machine learning integration provide IoT business devices with the intelligence they need to act on the data they are producing, rather than operating as simply data producers" (Zafarino). Today IoT is associated with things such as our smart fridge, HVAC system or virtual assistants such as Alexa, but the future of IoT is believed to take shape in other ways such as intelligent sensors. Lastly, there are people out there trying to fix these issues and a study which was led by Daniel Miessler, practice principle for Fortify on Demand at HP Fortify said "that a sizable percentage of the vulnerabilities that came to light after testing were not reoccurring" (Razemba). Miessler along with other researchers in process of working on the OWASP Internet of Things Top Ten Project, which has a means of focusing on some of the top security problems and how best to deal with them. In the meantime, business can take certain

steps to ensure that they are taking proper security measures. Some of those steps include having backups in order to restore information in case systems need to be rebooted. Organizations can also plan and protect for a security breech. While a company would love to have no incidents at all, that is highly unlikely, so organizations should have backups, or installing endpoint protection software. There are other procedures that can be followed such as having a two-step verification process, using encryption, and by adding a firewall and real-time backups.

As you have read IoT Security is very much a relevant topic today as it should be too from looking at the past. The IoT is the future and we as consumers should be ready for it as we bring more and more IoT devices into our homes and business. Despite all of the insecurities in IoT and malicious attacks against IoT devices, there is hope for the future. Those involved in IoT are aware of the issues that have been presented and are working to combat them and make things better. It is inevitable that more and more IoT devices will be connected in the future, but the risk of being attacked by someone with malicious intent is inevitable if manufactures start now by looking into their own security and building devices with security at the fore front. While we cannot completely secure the Internet of things, there is definitely room for improvement and steps to take to secure our devices at the office and at home.

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Submission To:

NORTHEAST DECISION SCIENCES INSTITUTE

TRUSTED MACHINE LEARNING MODEL FOR CLINICAL DECISION MAKING – AN EMPIRICAL STUDY

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Abstract

Despite machine learning models increasing being used in medical decision making and increasingly meeting numeric performance objectives, they remain untrusted black boxes due to decision makers inability to understanding their inner logic. Therefore, it is necessary to develop models that will engender trust in the knowledge they generate and contribute to individual clinical decision maker's intention to adopt them in the field.

The purpose of this proposed study is to develop and evaluate a machine Learning model that can be trusted clinical decision makers. The study will formalize an integrated machine learning interpretability score that could be used by practitioners and researchers to evaluate the viability of utilizing machine learning models in clinical decision making.

The interpretable machine learning model will be demonstrated by solving a binary classification problem of predicting the risk of heart failure patients requiring emergency readmissions within 30 days of being discharged. The machine learning model will use ensemble techniques to produce high accuracy predictions. The resulting predictions will be presented to clinical decision makers using model agnostic techniques (LIME and Anchor) to generate human interpretable explanations. Human subjects will evaluate the quality of the explanations and validate the ability to gain insight from the machine learning model predictions. Finally, human subjects will evaluate the trustworthiness of the machine learning model and its generated predictions.

Keywords: Classification, Hospital Readmissions Reduction Program (HRRP), Clinical Decision Making, Machine Learning, Trust

Introduction

Clinical decision making is evidence-based, probabilistic, fraught with uncertainty and needs to balance conflicting decision criteria (Broekhuizen, Groothuis-Oudshoorn, van Til, Hummel, & IJzerman, 2015). Decisions to trust a system are made despite uncertainty based on the belief of an expected positive outcome (Luhmann, 1979). Trust is a necessary element of a relationship in the presence of uncertainty (Mayer, Davis, & Schoorman, 1995). Machine Learning (ML) algorithms have the potential to improve decision making and provide added insight. However, their use introduces an added element of uncertainty that a decision-maker needs to account for. Managing the added uncertainty introduced by ML models requires assuring healthcare practitioners that their adoption will yield better decisions.

ML techniques are increasingly being applied to support a broad range of health care decisions (Dey & Rautaray, 2014; Kaur & Singh, 2014). Examples include rationalizing the allocation of limited healthcare resources (Bayati et al., 2014), predicting patient risk (Caruana et al., 2015), diagnosing medical conditions (Foster, Koprowski, & Skufca, 2014) and image analysis in digital pathology (Madabhushi & Lee, 2016). The two primary characteristics of successful ML predictions are prediction accuracy and interpretability with the more accurate complex models being less interpretable and the interpretable models being less accurate (Choi et al., 2016).

ML classification models use training data to build algorithms that map input parameters into a finite number of categorical output categories (Abu-Mostafa, Magdon-Ismail, & Lin, 2012). The output categories can be used as the basis for assigning risk or supporting decisions. ML methods improve at a given task through experience gained by learning from data. The learning is manifested in the form of tuning input parameters to generate the desired output. The parameter tuning is used to derive generalized ML models to produce outputs on new unseen data. ML models are designed to optimize quantitative performance metrics such as maximizing predictive accuracy and minimizing categories of error (Jordan & Mitchell, 2015; Mitchell, 1997). The characteristics of ML models required for their mathematical optimization can result in algorithms that are too complex for human-scale reasoning and styles of interpretation (Burrell, 2016). The complexity of ML algorithms can make them incomprehensible to

human decision makers resulting in perceiving them as untrusted black boxes not suitable for adoption (Lipton, 2016).

A glaring example of the risks posed by using black box ML models is noted by (Caruana, 2017). In this example, the ML algorithm was tasked with identifying high-risk pneumonia patients by predicting the probability of death. The black box ML model predicted that pneumonia patients with a history of asthma had a lower probability of death than pneumonia patients with no history of asthma. Medical experts attributed the lower probability of death for the asthmatic patient group to a higher level of medical intervention. Absent of the explanation provided by domain experts identifying the presence of a moderating variable (increased medical intervention), the simple prediction of the ML model could have led to an incorrect decision path of minimal medical intervention.

The assumed risks involved from using ML black box models were responded to legislatively by the European Parliament's General Data Protection Regulation (GDPR). The legislation included the "right to an explanation" mandating human interpretation of ML decisions (Goodman & Flaxman, 2016). The legislation mandated opening up ML black box models for inspection, highlighting the importance of human interpretation as a condition of adoption and granting subjects the right to opt out of automated decision making. It is evident that the drive for regulatory safeguards requiring human control over automated systems is a manifestation of distrust in ML algorithmic decisions.

Considering the increased penetration of ML models in medical decision making, it is necessary to develop models that will engender trust in the knowledge they generate and contribute to individual clinical decision maker's intention to adopt them in the field. Existing literature includes work providing an overview of the problem, identifying unanswered questions, explaining how black box models work and attempts at explaining them (Guidotti, Monreale, Ruggieri, & Turini, 2018). Nevertheless, there is a need for application-grounded evaluations conducted on human subjects performing real tasks (Doshi-Velez & Kim, 2017).

The goal of this study will be to construct a trusted ML model that clinical decision makers can successfully interact with to support their decision making. The ML model will be used to predict the risk of heart failure patients requiring emergency readmissions within 30 days of being discharged. The ML model will be developed

using ensemble techniques to produce high accuracy predictions. The resulting predictions will be presented to clinical decision makers using model agnostics techniques that can generate human interpretable explanations. Human subjects will then evaluate the quality of the explanations and validate the ability to gain interpretable insight from the ML model. Finally, human subjects will evaluate the trustworthiness of the ML model and its generated predictions. This outline of the proposed study is depicted in Figure 1.

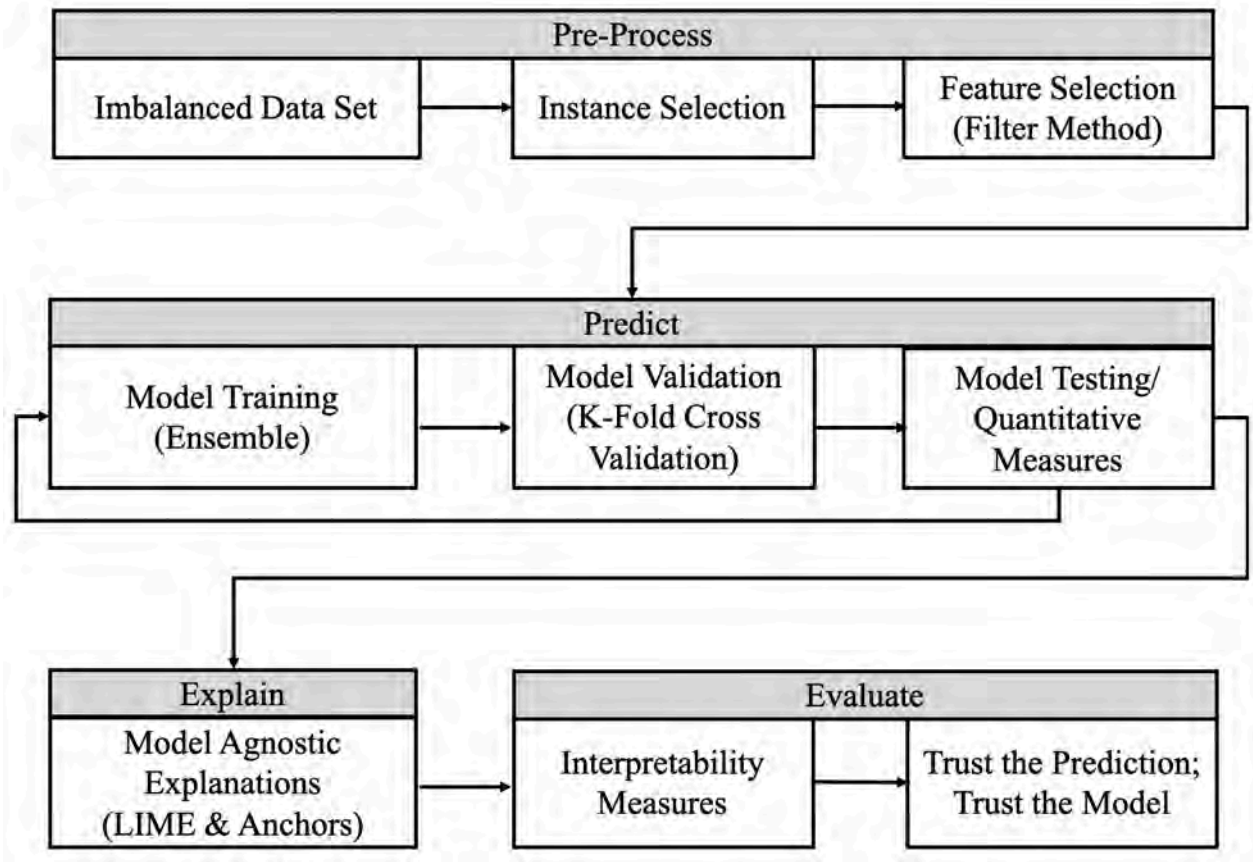

Figure 1- Study Outline

The rest of this paper is organized as follows. An overview of the prediction problem and its clinical significance; a formulation of the prediction task that the ML model will perform; a reference to the dataset that will be used and reason for choosing it; the characteristics of the clinical decision maker expected to use the ML model; the individual ML steps used to pre-process, predict and explain the clinical risk assessment. Finally, the conclusion section will summarize the objectives of the study and the planned approach to achieve it.

Research Design

The Prediction Problem

Hospital readmissions refer to unplanned hospitalizations that occur within 30 days of discharge. Jencks, Williams, & Coleman (2009) estimated an annual cost of avoidable Medicare readmissions of $17.4 billion and 20 percent of Medicare fee-for-service patients had readmissions within 30 days of discharge. These findings established managing preventable readmissions as a key goal for policymakers to save cost and improve healthcare quality (Betancourt, Tan-McGrory, & Kenst, 2015).

The Patient Protection and Affordable Care Act of 2010 established the Hospital Readmissions Reduction Program (HRRP) requiring the Centers for Medicare & Medicaid Services (CMS) to reduce payments to hospitals with excess readmissions starting the fiscal year 2013 for select clinical conditions. A 2016 report to the U.S Congress noted that HRRP imposed $420 million in penalties against 78 percent of hospitals (Medicare Payment Advisory Commission, 2016).

Heart failure is among the conditions targeted in the HRRP and is the leading cause of death in the United States. Cardiovascular disease accounted for over 17.3 million deaths in 2013 and is expected to account for over 23.6 million deaths by 2030 (Mozaffarian et al., 2016). Additionally, heart failure is the leading cause for hospital admissions and readmissions in the United States among patients over the age of 65 (Arundel et al., 2016; Joynt & Jha, 2011).

The increasing availability of electronic patient data presents opportunities to leverage ML methods to predict patients at high risk of readmission and consequently aid in clinical decision-making (Bayati et al., 2014). While not all readmissions are preventable, a high rate of readmissions has been established as an indicator of poor quality of care (Goldfield et al., 2008). Additionally, several studies have reported successful outcomes in readmission reduction through the allocation of limited post discharge resources such as scheduled outpatient visits and the application of telehealth and patient education (Bayati et al., 2014; Messina, 2016; Ross et al., 2009). Therefore, accurately and reliably predicting patients at high risk of readmissions is useful to healthcare practitioners to assist in the identification of patients who should be targeted for post-discharge intervention.

The Binary Classification Problem Formulation

At the time of patient discharge, the patient instance $\boldsymbol{I}$ is mapped into one and only one of two class labels: $\boldsymbol{y} \in \{\boldsymbol{p}, \boldsymbol{n}\}$. The positive class label ($\boldsymbol{p}$) is a prediction of readmission within 30 days. The negative class label ($\boldsymbol{n}$) is a prediction of no readmission within 30 days.

Data

The data for this study will be sourced from National Readmissions Database (NRD) made available by the Healthcare Cost and Utilization Project (HCUP) dataset. The use of a publicly available dataset lends itself to reproducing the research results and benchmarking them against alternative methods.

Human Subjects

The clinical research subjects will be healthcare practitioners that would assess the risk of readmission for heart failure patients at the time of discharge. The clinical decision-makers are expected to have significant domain expertise and prior knowledge about the discharge decision but minimal expertise in ML. The clinical decision-makers will need to explain the risk assessment to patients that are expected to have no ML or domain expertise. The ML model is expected to be used for added insight and perspective to support a human decision.

The research subjects will be drawn from multiple hospitals to ensure external validity (generalizability) of the findings. Readmission risk assessments will be fixed to heart failure patients to control for the possible medical condition effect. All participants will be required to sign an informed consent form, and the study will be subject to Institutional Review Board (IRB) approval.

Data Pre-Processing

ML algorithm data are organized as instances (examples) and features (attributes describing the examples) (Kotsiantis, 2007). For supervised ML classifiers to produce accurate and efficient results, they require the execution of data pre-processing techniques such as imbalanced data pre-processing, instance selection and feature selection (Garcia, Luengo, & Herrera, 2016).

Imbalanced Dataset

Imbalanced data refer to datasets with unequal distribution between classes where one class is outnumbered and underrepresented. Learning algorithms induced from imbalanced class distribution have low error rates for the majority class and high error rates for the majority class. Hence, resulting in models with low predictive accuracy for the minority class (Galar, Fernández, Barrenechea, Bustince, & Herrera, 2012; Lipitakis & Kotsiantis, 2014). Managing data imbalance is particularly important for predicting health risk for patients where the minority class usually represents the class of interest (López, Fernández, García, Palade, & Herrera, 2013).

The extent of data imbalance is measured by the ratio of the number of majority class instances to the number of instances in the minority class. Imbalanced learning requires assessment criteria beyond overall accuracy to include operating characteristic curves, precision-recall curves and cost curves (He & Garcia, 2009).

An illustrative example demonstrating the need to manage data imbalance for a health risk prediction classification process was reported by (Khalilia, Chakraborty, & Popescu, 2011). The paper highlighted the use of a highly imbalanced dataset from the Healthcare Utilization Project (HCUP) with only 3.59% of the patients having heart disease. As this study will be based HCUP dataset, managing the imbalanced data distribution will be required.

Data mining literature outlined three groups of techniques address class imbalance: algorithm-based methods to account for the class imbalance, data-based techniques to rebalance the data before to processing and cost-based methods combining data and algorithm approaches (Galar et al., 2012). The ensemble techniques of Bagging and Boosting have also been reported as methods to address the class imbalance problem (Galar el al., 2012).

Instance Selection

The instance selection data pre-processing methods identify a subset of records from the dataset to be used by the learning algorithm. The goal is to eliminate records that contain noisy or redundant data. In doing so, instance selection can reduce required computation resources and improve the accuracy of the classifier (Carbonera & Abel, 2015; Liu & Motoda, 2002). The instance selection for this study will be performed as a data cleaning step.

Feature Selection

Feature selection is the process of examining the pool of available features, systematically identifying and selecting a subset of features that are most relevant to the learning algorithm while ignoring the remaining features that are irrelevant or redundant (Dash & Liu, 1997; Kohavi & John, 1997).

The goal of feature selection is to find the smallest possible feature subset that will minimize the generalization error (Vergara & Estévez, 2014). The benefits of feature selection include reducing sensitivity to noise, lowering the risk of overfitting, reducing computation time and complexity. As a result, feature selection improves the prediction accuracy and the ability to generalize learning algorithms to new datasets. Since feature selection maintains the selected features in their original form, the contribution of input parameters to the predicated label remain transparent, hence contributing to model intelligibility (Chandrashekar & Sahin, 2014; Saeys, Inza, & Larranaga, 2007).

An exhaustive feature selection process is computationally prohibitive for large datasets, requiring targeted methods based on heuristics or random search to reduce computational complexity. The steps to identify a feature subset are subset generation, subset evaluation, stopping criterion, and result validation. Subset generation employs a search strategy to produce candidate features; candidate features are then iteratively evaluated based on pre-established evaluation criterion. The iterative evaluation of subsets continues until a stopping criterion is satisfied and submitted for validation (Dash & Liu, 1997; Liu & Yu, 2005). Feature selection algorithms fall into three categories based on how the feature selection process is combined with the classification model: filter, wrapper and embedded methods (Saeys, Inza, & Larranaga, 2007). Filter methods rank individual features based on relevance and eliminate features below a threshold. The wrapper methods evaluate a subset of features based on maximizing an objective function of classification performance. Embedded methods include feature selection as part of training the model (Chandrashekar & Sahin, 2014).

Filter methods evaluate the feature based on the characteristics of the data as a pre-processing step independent of the induction algorithm. Feature relevance is established based on features being independent of each other and being correlated with the class label (John, Kohavi, & Pfeger, 1994; Vergara & Estévez, 2014). Filter methods

minimize algorithms overfitting error and improve their ability to generalize (Saeys, Inza, & Larranaga, 2007). Since filter methods are model agnostic and ignore the impact on classifier performance, they may yield lower prediction accuracy than the wrapper and embedded methods (Kohavi & John, 1997; Saeys, Inza, & Larranaga, 2007). As the aim of this study is to balance prediction accuracy with intelligibility, filter methods could provide the advantage of solving independent optimization problems that can be better explained and visualized. The literature includes several filter method algorithms such as FOCUS, RELIEF (Blum & Langley, 1997). The choice of filter method algorithm remains an open question for this study.

Ensemble Methods

For classification problems, rule ensembles combine the prediction of multiple base learners to generate new classifiers (Bauer & Kohavi, 1999). Empirical studies have demonstrated that ensemble methods often produce more accurate predictions than base learners (Bauer & Kohavi, 1999; Freund & Schapire, 1996). The ensemble techniques of Bagging, Boosting and Random Forests will be used in this study and outlined below.

Bagging is an acronym for bootstrap aggregation. Bagging is a sampling method that trains multiple base learners, each using different parts of the dataset drawn at random with replacement. The sample size used by each learner is equal to the size of the original training set. The learners are combined through a majority vote to predict a class (Breiman, 1996). Bagging does not change the distribution of the training set based on the performance of previous classifiers (Bauer & Kohavi, 1999), each learning instances is chosen with equal probability. (Rokach, 2010). The independence of individual classifiers in Bagging characterize it as parallel ensemble method that exploits the independence of base learners to reduce the generalization error (Zhou, 2012). Bagging has been demonstrated to be well suited for handling noisy and imbalanced data (Khoshgoftaar, Van Hulse, & Napolitano, 2011) and for use tree-based methods that are characterized as high-variance, low-bias (Friedman, Hastie, & Tibshiran, 2001; Friedman J. H., 2008)

Boosting is a sequential learning algorithm that identifies errors in the early predictions as hard examples to focus on in subsequent iterations. The emphasis on hard examples is implemented through assigning higher weights to the incorrectly classified examples and lower weights to the correctly classified examples. The iterative process

combines many individual weak learners into a complex predictor (Schapire & Freund, 2012). The committee of weak learners are individually tasked with developing rough rules of thumb that perform slightly better than random. (Schapire R. E., 2003). AdaBoost is an algorithm implementation of Boosting (Freund & Schapire, 1995) and will be used in this study.

Random Forest (RF) is an ensemble algorithm that extends boosting of decision trees. RF makes the final prediction through a majority vote (Breiman, Random forests, 2001; James, Witten, Hastie, & Tibshirani, 2013). For many problems, RF achieves the same performance as boosting but is simpler to train and tune (Friedman, Hastie, & Tibshiran, 2001).

Model Validation

K-fold cross-validation will be employed to estimate the accuracy of the model. The data will be randomly partitioned into equal size disjoint k subsets. The model will then be trained on (k-1) subsets and validated on the held-out set. The process will be repeated k times using a different validation subset for each iteration and the remaining subsets as the training set. The average error of all the validation sets will be used to evaluate the quantitative performance of the model. The use of cross-validation will minimize the risk of resulting model overfitting to the training data and will increase the likelihood of the model generalizing to unseen data (Arlot, 2010; Wong, 2015).

Quantitative Measures

The predicted label of a binary classifier falls into one of four categories: true positive (TP), false positive (FP), false negative (FN) or true negative (TN) (Metz, 1978), (Fawcett, 2006; Linden, 2006) as represented in the Figure 2 adapted from (Metz, 1978). The frequencies of the classification label across the four key measures are represented by a confusion matrix with key empirical metrics derived from these measures include: accuracy, sensitivity (recall), specificity, precision, error rate F-Score and Area Under the Curve (AUC) (Fawcett, 2006; Linden, 2006; Metz, 1978).

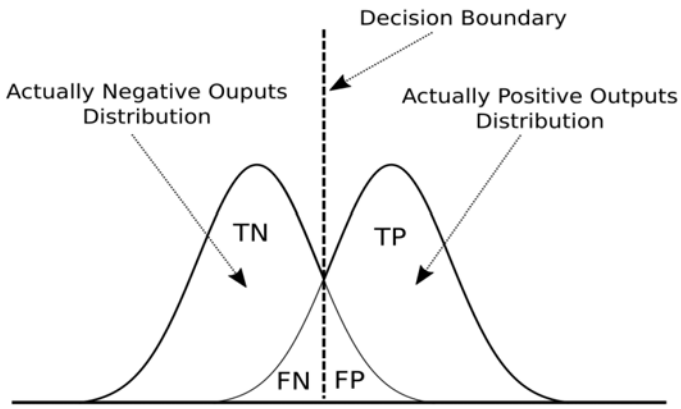

Figure 2 - Binary Classifier Predicted Label

Accuracy, the percentage of classification labels decided correctly, has key limitations as a measure of classifier prediction performance. First, an unbalanced data set in which the minority class is completely misclassified can be reported as a highly accurate prediction, hence providing a misleading characterization of good performance. Second, the accuracy measure does not identify if the misclassified labels were in the false positive or false negative side of the decision boundary. Additionally, the types of misclassification errors are dependent on the decision boundary (Fawcett, 2006; Metz, 1978). Therefore, the distinction between the types of misclassifications can be an important consideration in decision making and will be used to measure the performance of the ML model.

Model Explanations

There are multiple approaches to explaining black box models. First, model explanation describing the inner workings of the model of the classifier. Second, model inspection explaining the internal workings of the model in response to input changes. Finally, outcome explanation which supports the reason for a decision (Guidotti et al., 2018). The focus of this study will be on outcome explanations. The model agnostic explanation in this study will be done through LIME (Local Interpretable Model Agnostics Explanations) (Ribeiro, Singh, & Guestrin, 2016b) and its recent successor "Anchors" method (Ribeiro, Singh, & Guestrin, 2018).

LIME explanations main attributes are being model agnostic and local. Model agnostic explanatory methods approximate the behavior of underlying ML models to generate end user explanations that are independent of the internal logic used to generate

predictions (Ribeiro, Singh, & Guestrin, 2016a). Model agnostic explanations enable the use of black box models for tasks requiring explanations as we can take advantage of the accuracy offered by black box model without sacrificing the need for interpretability (Ribeiro et al., 2016a).

The LIME localized explanations zoom in to the part of the model relevant to the individual prediction and identify an interpretable model that is locally faithful to the classifier without attempting to generalize or establish global rules for other instances in the input space (Ribeiro et al., 2016b). While the global decision boundary might be complex and squiggly, the localized explanation can be achieved through a linear approximation close the decision point as illustrated in Figure 3.

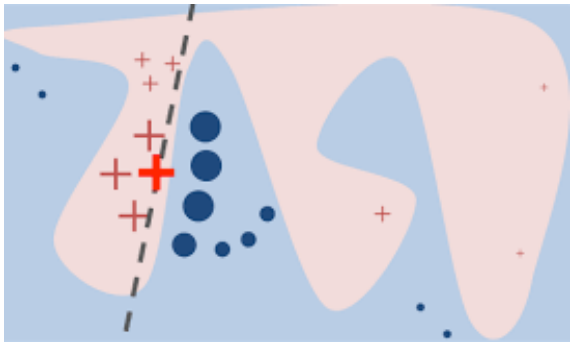

Figure 3. LIME Example Decision Boundary. From "Why Should I Trust You?" Explaining the Predictions of Any Classifier", by M. T. Ribeiro, S. Singh and C. Guestrin, 2016, ACM SIGKDD international conference on knowledge discovery and data mining *(pp. 1135-1144).*

In this figure, the bold red cross represents the decision being explained, the blue and pink regions represent the global decision boundary and the localized LIME explanation is represented by the dashed line. The localized explanation identifies parts of the input that are necessary for the prediction, contributing to an intuitive and easy to understand explanation (Ribeiro, Singh, & Guestrin, 2016b). In the context of medical decision-making, localized explanations can identify the specific attributes of the patient condition that drive a decision. While the global decision model needs to account for complex edge cases such as rare medical conditions, a localized simple explanation would suffice for most patients. Additionally, highlighting the key input parameters that drove the decision such as the presence of a medical condition or the number of recent emergency admissions allows the decision maker to recognize potential flaws in the logic of the model.

Anchors is another model agnostic local explanation method designed to explain the predictions of any classifier. Anchors highlight parts of the input space that are sufficient to generate a local prediction region within a complex model. The anchors generate explanations are represented through if-then rules describing the boundaries of the input region (Ribeiro et al., 2018). Figure 4 illustrates two anchor regions and how they compare to LIME decision lines.

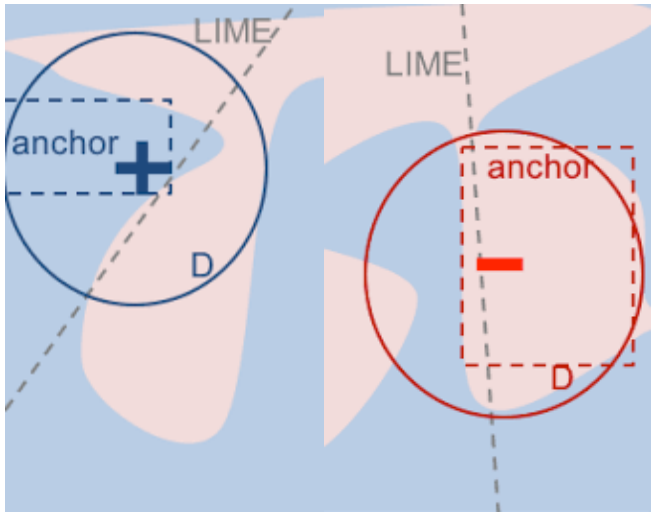

Figure 4 – Anchors. From "Anchors: High-Precision Model-Agnostic Explanations," by M. T. Ribeiro, S. Singh and C. Guestrin, 2018**,** AAAI Conference on Artificial Intelligence

An example anchor explanation could be presented to the decision maker as

IF Gender = Male **AND** Age > 65 **AND**
Number of Emergency Admissions in last 6 months > 4
THEN PREDICT High Risk of Readmission within 30 Days = **YES**

Interpretability Measures

Interpretability is of paramount importance in clinical decision making to ensure patient safety and maintain human oversight. Although ML interpretability can be intentionally obstructed to protect corporate trade secrets and maintain a competitive advantage (Burrell, 2016), this study aims to address opacity arising from the distinct difficulty of interpreting classification results leveraging large datasets and ML models that achieve accuracy through model complexity. Unlike quantitative characteristics of ML algorithm performance such as accuracy, there is no universally accepted definition of ML interpretability. Rather, interpretability is context specific and varies depending on

the problem domain using the ML model to support a decision (Guidotti et al., 2018). Absent of such definition, a multi-dimensional construct based on the literature will be used for the prediction problem proposed in this study as outlined below:

#	Dimension	Definition
1.	Time Sensitive	The explanation is available based on timing that is aligned with the task. Urgent decisions require simple, easy to understand explanations. While non-urgent decisions might warrant a more exhaustive and complex explanation (Guidotti et al. 2018).
2.	Explainable to Humans	The ability to represent information in the way humans think and understand at their experience level (Doshi-Velez et al.; Kim, 2015). Example intuitive representations include natural text and images (Guidotti et al. 2018).
3.	Aligns with User Expertise	The detail and level of explanation is aligned with the expertise of the user performing the task (Guidotti et al. 2018).
4.	Mimics Human-based Reasoning	The level of agreement with independent expert judgment and intuition (Doshi-Velez et al., 2017; Kim, 2015).
5.	Support Case-based Reasoning	The ability to explain the decision based on similarities to previous cases. This dimension incorporates domain knowledge back into the system (Kim, 2015).
6.	Sparsity	The ability to select a subset of features that are important in the decision and present them as key drivers behind the decision (Kim, 2015).
7.	Localized Explanation	The ability to focus on a local area and provide localized insight (Ribeiro et al., 2016b).
8.	Inspecting Individual Predictions	The ability to inspect through textual or visual artifacts that provide a qualitative explanation between the model inputs and resulting prediction for a single case (Ribeiro et al., 2016b).

#	Dimension	Definition
9.	Inspecting Multiple Predictions	The ability to guide the user in selecting multiple predictions and their corresponding explanations to illustrate the efficacy of the model and to provide a global understanding of the entire problem space (Ribeiro et al., 2016b).
10.	Comprised of Cognitive Chunks	The ability to form basic units of explanation and define the interaction between them (Doshi-Velez et al., 2017).
11.	Expose Internal Logic	Combine the presentation of the classification with a user-facing explanation of the internal ML algorithm logic (Burrell, 2016).
12.	Model Fidelity	The level of alignment between the interpretable model and black-box model (Guidotti et al. 2018).
13.	Can be Edited by Experts	Domain experts have the option to identify an anomaly in the data and manually intervene to prevent incorrect or biased predictions (Caruana et al., 2015).
14.	Understand Feature Contribution	The contribution of a single feature to the final prediction is clearly understood (Caruana et al., 2015; Lou, Caruana, & Gehrke, 2012; Lou, Caruana, & Gehrke, 2013).
15.	Identify Causal Associations	The ability to distinguish between causal associations and non-causal associations (Lipton, 2016).
16.	Human Precision	The percentage of predictions made by humans that correctly identify model output on unseen instances (Ribeiro et al., 2018).
17.	Human Coverage	The percentage of instances predicted by the user after seeing the explanation (Ribeiro et al., 2018).

Trust

Trust in automated systems plays a leading role in the willingness of humans to use them in a mission-critical domain such as healthcare where the environment is characterized by uncertainty (Hoff & Bashir, 2015). Empirical evidence demonstrated that trust is established gradually based on ongoing two-way interactions (Siau & Wang,

2018). Although trust and adoption decisions of ML include organizational factors such as environmental complexity (Hengstler, Enkel, & Duelli, 2016), this study will be limited in scope to individual decision makers. Ribeiro et al. (2016b) provided two categories of ML trust that will inform this study. First, trusting the individual prediction sufficiently to take some action based on it. Second, trusting the model to function correctly if deployed. The study will measure the level of trust for users receiving the ML explanation and compare it with the level of trust for users not receiving the explanation.

Conclusion

Machine Learning (ML) models supporting medical decisions continue to grow in availability. Despite ML models increasingly meeting empirical performance metrics, they remain black boxes that are too complex for human-style reasoning and interpretation. The proposed empirical study aims to construct an ML model that achieves high accuracy by using ensemble methods and high interpretability by using local interpretable model agnostics methods (LIME and Anchors). The ML model will be used to solve a binary classification problem of predicting the risk of emergency readmissions for heart failure patients at the time of discharge. The model interpretability and trust will be evaluated empirically by conducting experiments on human subjects.

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INNOVATION AND CREATIVITY - ABSTRACTS

DRIVING INTELLIGENT DECISION MAKING THROUGH THE INNOVATIVE APPLICATION OF BLOCKCHAIN TECHNOLOGY

ABSTRACT

Blockchain is peer-to-peer, secure technology that may be implemented to facilitate data sharing scenarios. This paradigm shift in technology shows promise for improving supply chain management decision-making scenarios. Business models typically develop with multiple trading partners in collaborative agreements as organizations focus on their core competencies. Traditionally, data sharing among partners is accomplished through the electronic transfer of transaction blocks from separate databases. With this schema, an organization electronically transmits transaction data only to direct trading partners and not to the multiple organizations who are participating in the collaborative agreement. A blockchain shared ledge process innovatively supports a method of sharing data with all partners not just with the partner immediately prior or immediately after an organization in the supply chain. This innovation addresses multiple operational issues including delay and lack of information, mistrust between parties, and lack of management controls. Implemented appropriately, blockchain can provide high quality, secure transactions that may be shared among supply chain partners. With blockchain technology, the scope of data sharing is increased. The transaction content can be designed to drive intelligent decision-making. The purpose of this research is develop a framework based on blockchain technology, for sharing transactions and transaction content that supports decision-making. The report describes blockchain technology and electronic data sharing techniques. A framework, based on blockchain, is presented that addresses data sharing and decision-making issues and opportunities.

KEYWORDS: Innovation, Information Technology, Supply Chain Management, Decision Making, Blockchain

FOSTERING A CREATIVE MINDSET AND COLLABORATIVE PERSPECTIVE IN HIGHER EDUCATION THROUGH 3D PRINTER SYSTEM

Abstract

Higher education institutions are challenged with not only developing knowledge in a particular discipline but also developing a wide variety of skills that indicate a career-ready graduate. Research reports that hands-on teaching methods lead to successful learning that targets multiple skills. Studies consistently report that incorporating hands-on teaching activities in education leads to improvement in student retention, engagement, risk mitigation, and problem-solving skills. One of the biggest benefits gleaned from hands-on learning training experiences is the opportunity for instant feedback, instruction, and critique. This benefit makes it easier for learners to garner real learning from an exercise. Often 3D printing design and fabrication laboratories are found in engineering-related higher education curriculum. The 3D printing lab integrates experiential learning activities with the application of engineering principles and development of innovative product ideas. Less common is the implementation of a 3D printer design and fabrication laboratory in a college of business curriculum. With appropriate planning, implementation, and focus, a 3D printer lab can develop creativity, innovation, social responsibility, project management, teamwork, and interdisciplinary business acumen. This case study research describes the implementation of a 3D printer system laboratory in a college of business. The case study outlines technological issues to consider in the selection and implementation of hardware and software. The administrative framework for establishing laboratory management is described. Finally, projects and curriculum are presented that promote student engagement and development.

KEYWORDS: Innovation, Creativity, 3D Printer, Curriculum, Case Study

How Well Do Executives Trust Their Intuition?

In this age of Big Data and analytics, knowledge gained through experiential learning and intuition may be taking a back seat to analytics. However, the use of intuition should not be underestimated and should play an important role in the decision process.

How Well Do Executives Trust Their Intuition covers the Fulbright research study conducted by this international team of editors. The main question of their investigation is: How well do executives trust their intuition? In other words, do they typically prefer intuition over analysis and analytics. And equally importantly, what types of intuition may be most favorable looking at different variables? The research utilizes survey and biometrics approaches with C-level executives from Canada, U.S., Poland, and Italy.

In addition, the book contains chapters from leading executives in industry, academia, and government. Their insights provide examples of how their intuition enabled key decisions that they made.

This book covers such topics as:

- Using intuition
- How gender, experience, role, industry, and country affect intuition
- Trust and intuition in management
- It's a matter of heart
- Trusting intuition
- Leadership intuition and the future of work
- Creating an intuitive awareness for executives
- Improvisation and instinct.

The book explores how executives can use intuition to guide decision making. It also explains how to trust intuition-based decisions. **How Well Do Executives Trust Their Intuition** is a timely and prescient reminder in this age of data-driven analytics that human insight, instinct, and intuition should also play key roles.

CRC Press
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DATA ANALYTICS

ISBN: 978-1-138-49262-2
90000
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How Well Do Executives Trust Their Intuition?

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MANAGEMENT AND HUMAN RESOURCE DEVELOPMENT OF NANOTECHNOLOGY WORKFORCE: DIALOGUE AT THE INTERFACE

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School of Business Quinnipiac University

Northeast Decision Sciences Institute (NEDSI)
48th Annual Conference
Philadelphia, Pa, USA

April 4 - 6, 2019

Extended Abstract

Nanotechnology presents an unprecedented potential for the wellbeing of society through technological advances and innovation. This is a fact acknowledged by almost every major governmental and intergovernmental organization. This potential is creating an unprecedented opportunity for scientific, ethical, legal, economic, political, public, and social dialogues in one bundle that better represent the pace and complexity of the modern human enterprise (Yawson, 2011). This "dialogue at the interface" as I prefer to call it, is not an easy path, but a challenge that needs to be overcome as a test of the innate part of our humanity - our enduring will not just to survive, but to thrive. While the initial claims of the promise and perils have lost some level of steam, the unprecedented, disruptive nature of nanotechnology is real.

Emerging technologies by their nature demand a set of fundamental skills that can either be specific or general at different levels of occupations, with the ability to promote innovation and enhance research and development (Yawson, 2017). Therefore, failure to identify specific skill gaps and skill shortages to enhance management and human resource development of nanotechnology workforce may significantly limit the growth and application potential of this emerging new field. Skill needs identification, workforce management, and human resource development present unique challenges due to the multi-, inter-, and transdisciplinary nature of the evolving field of nanotechnology.

Effective management will drive advances and innovations in nanotechnology. The first step is to create the platform for effective technology management of the advantages and challenges of nanotechnology and its convergence with other technologies so that they may evolve safely and reasonably. One of the missing voices at the interface is that of education policy professionals and experts. Issues of nanotechnology workforce management and development have currently seen little input from education and human resource development professionals and academics (Yawson, 2011). As a result, what has been most striking is the extent to which so much of the dialogue ignores history and oversimplifies the realities of the need for the workforce, skill, and human resource development as part of the overall management of these leading emerging technologies (Yawson, 2012). However, considering multi-, inter-, and transdisciplinary nature of Nanotechnology and its convergence with other existing and emerging technologies, the dialogue at the interface is critical, and there should not be any missing links.

This study describes a proposed ‘architectural framework’ involving different methods and tools to develop an ‘ecological system of innovation’ for dialogue at the interface for nanotechnology which involves all the ‘voices’ to enhance efficient technology management, skill needs identification, and workforce and human resource development. These methods and tools include *inter alia*: Expert Elicitation (Van der Fels-Klerx, Goossens, Saatkamp, & Horst, 2002), Quadruple Helix (Yawson, 2009), Stakeholder Analysis (Parmar et al., 2010), Complex Adaptive Systems Modelling(Allen, 2014), Sociotechnical Systems Analysis (Wiek, Lang, & Siegrist, 2008), and Strategic Flexibility Analysis (Raynor, 2007).

An ecosystem is not linear; it is a web of interrelationships, different systems, niches and pathways coming together to sustain life. An innovation ecosystem framework should not be linear but rather a web, interlocking systems and pathways helping to sustain and formulate a functional evidence-based decision making (Yawson, 2009).

Keywords: Nanotechnology, Convergence, Ecological System of Innovation, Human Resource Development, Technology Management

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INNOVATION AND CREATIVITY - PAPERS

DECISION SCIENCES INSTITUTE

SUSTAINABLE INVESTMENT PLANNING FOR DECISION MAKERS IN PRIVATE EQUITY LEVERAGED BUYOUTS FIRMS: A DATA DRIVEN MODEL

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ABSTRACT

DECISION SCIENCES INSTITUTE

ABSTRACT

Leadership, corporate culture, long-term vs. short-term strategies, and innovation are familiar concepts in a business environment and their impact on the success of organizations is firmly established. Significant research was conducted on Private Equity (PE) and their influence on corporate innovation at Leveraged Buyouts (LBO) firms with inconclusive research results. This research investigates the influence of leadership on sustainable corporate innovation in PE LBOs and focuses on the reasons for lack of sustainable innovation in these companies. The research objective is to increase the success rate of the PE LBO investments through the modification of the PE firms' execution strategies. This objective is significant since each success creates value for investors, employees, suppliers, sales channels, customers, and the local economy. The hypothesis of this research is that PEs are more focused on short-term objectives that discourage entrepreneurship and long-term innovation due to their conventionally short-term investment horizon. In this regard, public data and questionnaires will be utilized to investigate the effect of the short-term nature of the ownership on failures of PE LBOs. The research also proposes a systematic approach to preserve the innovative nature of PE LBOs.

KEYWORDS: Private Equity, Leveraged Buyouts, Short-term Investments, Long-Term Investments, Corporate Innovation,

INTRODUCTION

PE firms acquire publicly traded firms and highly leverage them for an investment period of 4 to 7 years (Hersh, 2018). They align the management team with their objectives through a well-crafted compensation package that is designed to incentivize short-term performance as well as well as long-term growth (Masulis & Thomas, 2009). The conflict between the short-term and the long-term objectives of the PE firms and how these impact innovation is still debated in the literature (Link, Ruhm, & Siegel, 2012). This research will show that short-term strategies that are mandated by the PE firms to reduce the significant debt of the acquired companies, hinder the innovation and hence the sustainability of these organizations. It also shows a direct relationship between executive compensation, long-term, and short-term investments (Hersh, 2018) as illustrated in Figure 1. This research objective is significant since each success creates shareholder value, improves future company performance and enables future employment and career growth opportunities for many employees.

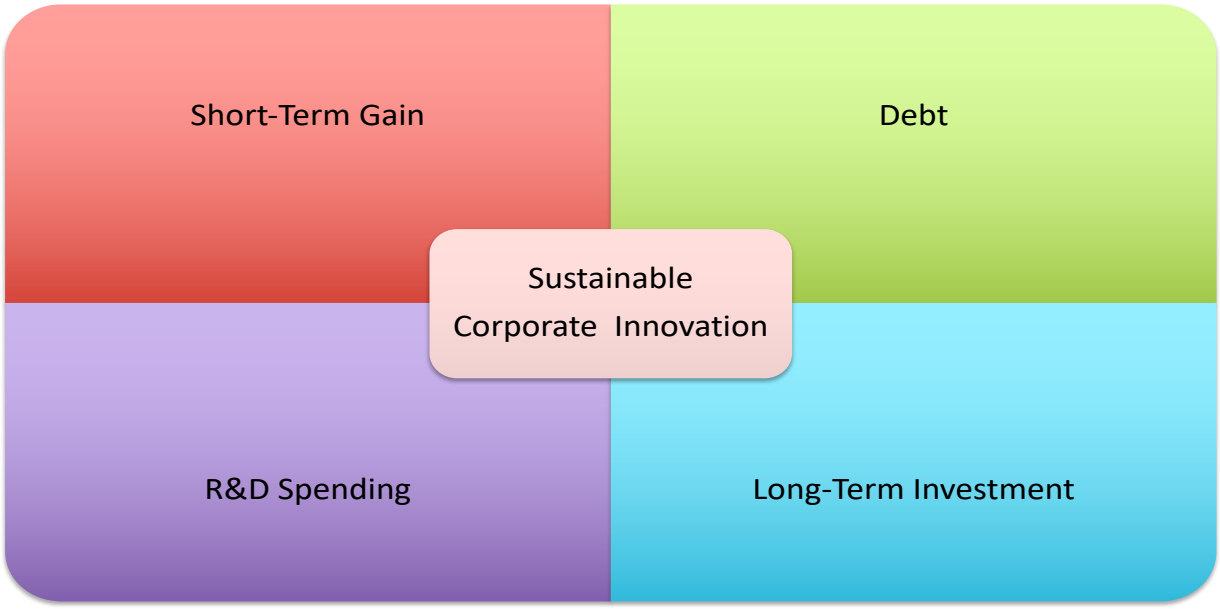

Figure 1. Factors that influence sustainable corporate innovation (Hersh, 2018)

LITERATURE REVIEW

Firms that pursue cost leadership strategy increase emphasis on sales and cost control. These firms utilize transactional leaders that emphasize short-term goals and self-interest which prevails over group's objectives. They enforce strong processes and controls that foster an environment where employees hesitate taking risk, are constantly watched and are pushed hard to perform. On the other hand, companies that implement a differentiation strategy, put strong emphasis on innovation and marketing. These firms utilize transformational leaders that align the company's culture with their vision, that lead by example, and create a sense of purpose. Leaders and followers share goals and commitments that are long term in nature (Balsam, Fernando, & Tripathy, 2011; Bass & Avolio, 1993). Managers naturally tend to create long-term growth opportunities for their organization. Unfortunately, the market and investors force them to manage for short-term gains. As a result, managers are resorting to accounting tricks, obsession with earnings or other short-term investment opportunities (Alexander, 2017). Short-term strategies can negatively impact future business growth since R&D investments and short-term profits don't go together. Such conflicts may result in decisions that reduce investments in R&D (Terry, 2017). Research that studied the relationship between leadership's behaviors and employees' innovation identified a dozen of behaviors that positively influence innovation. According to this research, one behavior that motivates employees is the communication of corporate vision and mission, which provided a sense of long-term direction to employees in the creative process. Additional leadership behaviors that emerged from the study and are important to mention are: (1) financial rewarding for innovation; and (2) providing resources that support innovation, such as allowing employees to spend 10-20 percent of their workweek on innovation (Jeroen PJ, 2007). Relatively new research by Michael and Julian (2014) argues that the presence of external influencers was associated with improvements in the innovation and performance of an organization. The authors used on-the-job training by external experts as an example to enhance decision making skills (Michael & Julian, 2014).

Similarly, PE firms are the external influencers of their acquired companies. They acquire public companies for investment purpose with the objective of improving their performance and valuation during the investment period. The acquisition transaction removes the acquired company from the public markets and is consummated through a leveraged buyout at a 15-25%

down payment in cash and a 60-80% loan from creditors. In order to improve the performance of their acquired firms, the PE firms recruit more competent managers to create a high quality decision making management team (Bacon, Wright, Meuleman, & Scholes, 2012). PE firms improve their portfolio firms' performance through the enhancement of management control systems. These systems facilitate better decision making and align the management team with the investors objectives (Humphrey, Matthias, & Christoph, 2014). The PE firms also act as a refocusing instrument and there is sufficient evidence that they are able to influence more effective decision making management practices (Bruining, Verwaal, & Wright, 2013). They are essentially active investors who carefully monitor the performance of the management team in their acquired companies. A strong board representation in their buyout firms enables the PE firms to be aware of all the strategic decisions that are made by the management team and react accordingly (Amess, Stiebale, & Wright, 2016). Factors that influence short-term gain strategy and behavior are depicted in Figure 2 below.

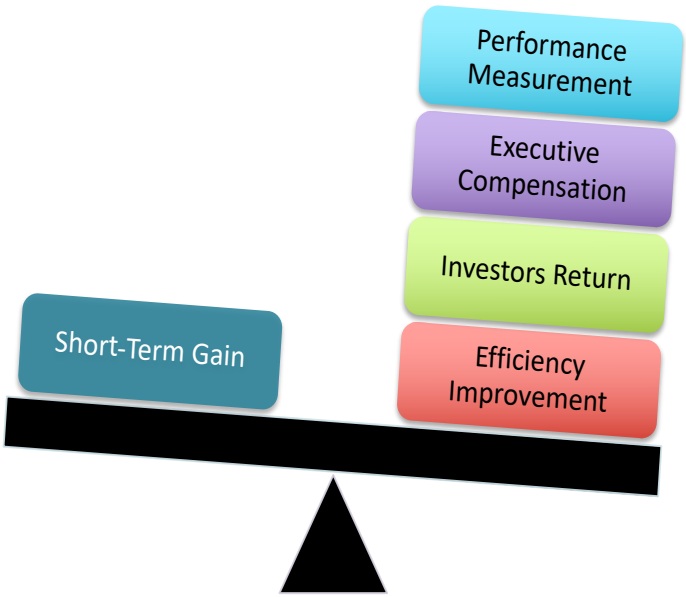

Figure 2. Factors that influence short-term gain strategy and behavior (Hersh, 2018)

Research into why some LBOs are associated with entrepreneurship and innovation suggests a strong link to the entrepreneurial mindset of one or some of the senior managers (Wright, Hoskisson, & Busenitz, 2001). Studies show that large grants of stock options influence CEO behavior. The correct compensation design of current vs. prospective options can create the desired behavior that correctly balances the CEO's support for short-term or for long-term project investments (Martin, Wiseman, & Gomez-Mejia, 2016). Incentive plans can be designed to promote the desired executive behavior. There are short-term incentives that are designed to pay for performance such as annual bonus or financial rewards for delivering desired results. The optimal incentive plan that motivates innovation tolerates early failure and rewards long-term success. This is accomplished through a mix of stock options, options repricing, and powerful severance plans (Manso, 2011). Companies align executive incentive plans with their business strategy. A study conducted by Benson and Davidson (2010) proposes that firms incentivize their management to pursue stakeholder value. Their study examines the relationships between firm value, executive management, and compensation. It concludes that managers' compensation is designed to influence them to maximize the firm's value and that they are more successful in achieving it when they optimize their relationships with the stakeholders (Benson & Davidson, 2010). Another study shows that a company's financial performance and R&D innovation are orthogonal in nature. It indicates that CEOs' long-term behavior negatively changes after they exercise their stock options. It also shows that a carefully crafted compensation plan that maximizes the management team's wealth at designated milestones, can positively influence the performance of the firm and its innovative activities (Tien & Chen, 2012). A different study that is based on 1406 Belgian firms shows that managers that don't hold stock options, underinvest in innovation while those that do are taking the risk and are investing in R&D (Beyer, Czarnitzki, & Kraft, 2012). Lastly, research data demonstrates that short-term and long-term investments can successfully co-exist and provide a better financial outcome to the investors and the company (Barzuza & Talley, 2016). A depiction of how a balanced compensation package influences desired outcome is depicted in Figure 3 below.

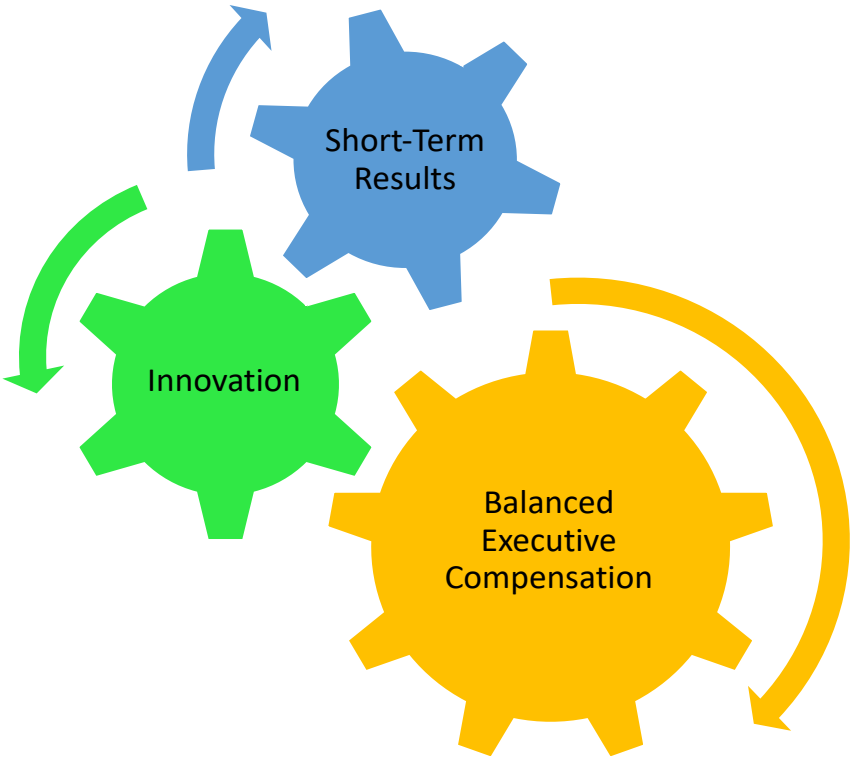

Figure 3. Relationship between compensation and desired outcome

Research Methodology

This study aims at utilizing public data and questionnaires to investigate the following questions: (1) Are failures of PE LBOs influenced by the short-term nature of the ownership? (2) Is it possible for PE LBOs to be innovative despite the short-term horizon of their business strategy? In this regard, the study will utilize survey research and interview data to evaluate two test groups. First group (control group) will include successful PE LBOs whereas the second group (test group) will consist of a number of failed PE LBOs. The study population will include partners from the associated PE firms and executives and employees of the LBOs. Data will be obtained through in person or phone interviews. To facilitate consistent data collection, a questionnaire will be designed to specifically focus on topics related to leadership and compensation package, the impact on employee's performance, investment in R&D and the

duration of these projects, brain drain as a result of employees leaving the company, innovation, energy and motivation, percentage of management that participates in the financial success of the PE and more. Data from public filings, websites, social media, product announcements, trade show keynote speeches, and recruiting sites will be used to correlate with the collected data from the interviews. A schematic representation of data collection strategy is provided in Figure 4.

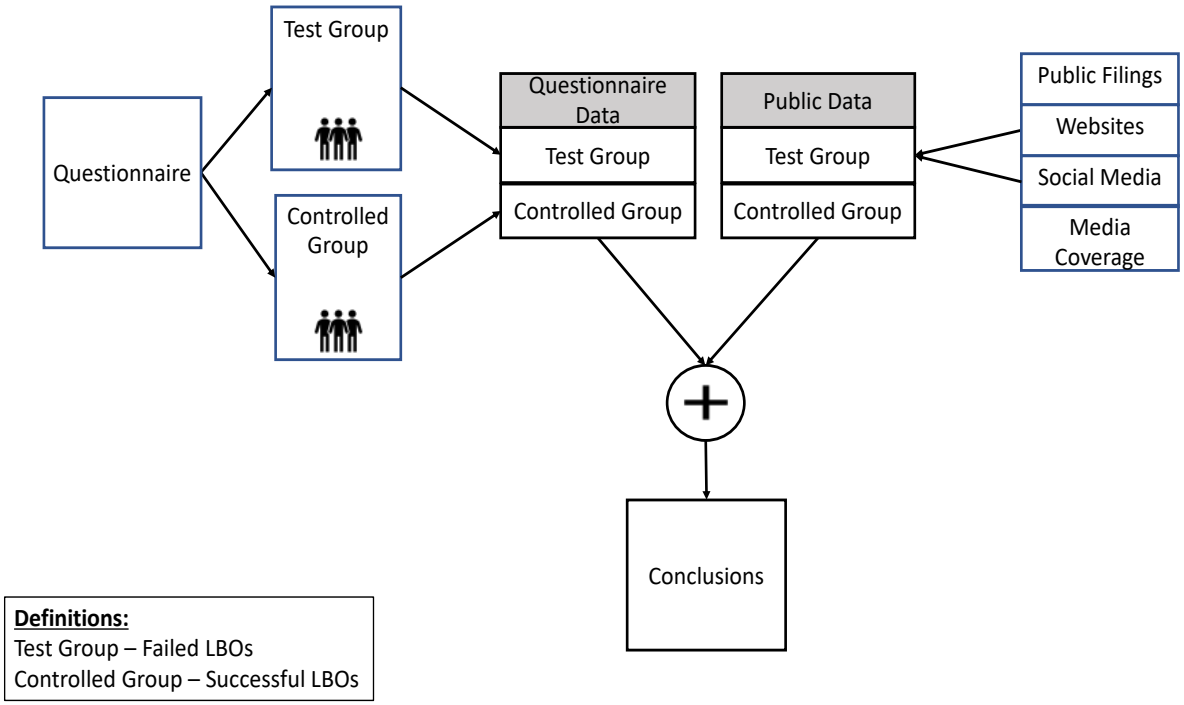

Figure 4. Research method data collection strategy

CONCLUSIONS

Increasing the success rate of the PE LBOs investments can create tremendous value for investors, employees, suppliers, sales channels, customer and local economy. A success of one company positively impacts the local economy including office suppliers, food vendors, real estate market, restaurants and entertainment. This research intends to contribute to such outcome through the modification of the PE firms' execution strategies.

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INTERNATIONAL BUSINESS AND LAW - ABSTRACTS

INTERNATIONAL BUSINESS AND LAW - PAPERS

LEGAL, ETHICAL, AND SOCIAL ISSUES - ABSTRACTS

THE INFLUENCE OF INTERGROUP CONTACT THEORY IN THE 1996 GANGES TREATY: LEGAL, ETHICAL, AND SOCIAL ISSUES

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Abstract:

The initial objective of developing and operationalizing the Farakka barrage is to clear out the stored sediments in Kolkata harbor. The problems arise when the flow of the diverted water could not able to solve the sediment problem in Kolkata. On the other hand, the communities in Bangladesh who were directly dependent on the flow of the Ganges water did not get enough water. This results in negative impacts on the overall socio-economic condition in Bangladesh. The reduced flow of the water causes increased salinity in water, challenging environmental condition, and economic loss for the country. This paper analyzes the events that lead to the Ganges treaty between Bangladesh and India in 1996 and how the interactions between these two groups followed the structural framework of the intergroup contact theory and ultimately resulted in improved intergroup relations. The next section offers in-depth insight into the theoretical framework of the intergroup theory and why The Ganges Treaty is considered as the outcome of the intergroup contact between two groups. This paper also explores the main four stages of

intergroup contact and how that was beneficial in intervening the ongoing water conflict between Bangladesh and India since the operationalization of the Farakka Barrage in 1975. Finally, this paper describes the intervention process of the Farakka Barrage Dispute and how both parties mutually come to an understanding in terms of sharing the Ganges water to improve the ongoing problematic situations.

Keywords:

The intergroup Contact Theory, Conflict Resolution Management, Decision Making Process, Integrative Negotiation, Reducing Group Biases

LEGAL, ETHICAL, AND SOCIAL ISSUES - PAPERS

DISRUPTING HUMAN TRAFFICKING: A SUPPLY CHAIN APPROACH

The United Nations defines human trafficking as the recruitment, transportation, transfer, harboring, or receipt of persons by improper means (such as force, abduction, fraud, or coercion) for an improper purpose including forced labor or sexual exploitation. Human smuggling, a related but different crime, generally involves the consent of the person(s) being smuggled. (Human Trafficking: National Institute of Justice, 2017).

Global human trafficking is a multi-billion-dollar industry that generally exploits those from conflict nations, developing nations and those trying to take refuge. The victims are from all across the lands. Human trafficking requires a supply chain of business units moving humans from different ages, genders, and ethnicities. In this way, it resembles a regular legitimate business model. Indeed, a supply chain is a pipeline or a network type organizational structure starting from raw material suppliers all the way to the end customer (Lee et al., 1997; Fisher, 1997). Human trafficking requires the involvement of multiple criminal groups and transnational organized groups in various stages of the human supply chain.

This study explores new options to disrupt the supply chain of human trafficking by proposing a supply chain disruption model. Our model is grounded on prevention, response, protection and recovery model of Hopp et al. (2012) proposed for legitimate business supply chains to survive and overcome with minimal loss against unexpected disruptions. Our approach for human trafficking supply chains is based on the "reverse" of the ideas in this model, which is based on Mean Time To Failure (MTTF) and Mean Time To Repair (MTTR) concepts drawn from reliability theory (Barlow & Proschan, 1996).

We apply the reverse of these ideas on human trafficking supply chains in such as fashion that MTTF should be shorter (i.e. frequent disruptions), and MTTR should be longer (i.e. longer time to recover). Ideally MTTR is infinite - no recovery from the disruption. In Hopp et al (2012)'s model, a longer MTTF is achieved by (1) prevention, and (2) protection activities. On the other hand, a shorter MTTR is achieved by (3) fast response, and (4) fast recovery activities. We take the reverse of these ideas and present a list of general strategies to disrupt Human Trafficking Supply Chains (HTSC).

Keywords: Supply chain disruptions; human trafficking; law enforcement

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Smart Homes: IoT Security and Ethical Concerns

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Abstract

Smart Homes are homes with integrated technology included in the design. This technology comes in the form of Internet of Things (IoT) devices, which are simply standard appliances with added internet-connectivity. These devices tend to be very insecure by default and create lots of security risks on networks. In some cases, IoT devices don't even have security settings that can be changed by the user. Thankfully there are ways to help mitigate the risks presented by IoT devices. One way involves placing the device in a DMZ on your network, while another involves purchasing a security appliance to provide IoT security. The easiest way would be researching devices and ensuring that they have adequate security, then setting those security settings on the device when it arrives. Security isn't the only issue plaguing IoT devices, as smart devices have brought about many ethical issues as well. Data privacy has been a big issue where IoT is concerned, as IoT devices collect lots of data while in your home. Some devices collect voice data continuously and send that data back to the manufacturer. Overall, the security issues can be mostly mitigated or avoided, but on the ethical side of things, there needs to be a response from manufacturers, as well as some regulations put in place to hold them accountable for their data collection and retention.

Keywords: smart home, IoT, security, ethics

Smart Homes: IoT Security and Ethical Concerns

Smart Homes are a new and exciting innovation emerging and impacting the market. "Smart" devices are devices that have Internet connectivity and therefore have advanced connectivity and functions. Smart Homes are just normal homes with smart devices incorporated throughout. All smart devices collectively make up what is known as the "Internet of Things" (IoT), which is simply the world-wide network of internet-connected devices (West, Dean, & Andrews, 2016). IoT and smart home security are hot topics, as most of these devices are more vulnerable than a typical computing system. Throughout this paper those security concerns will be outlined and addressed; in addition to security, the issue of ethics related to smart devices will also be covered. One of the biggest questions asked by mainstream users and professionals alike is are these devices worth the risks and controversy that they bring up, or would we be better off without all of this "smart" technology?

Smart Home Devices

There are quite a few types of smart devices, and they aren't simply limited to home use. Today's culture is intimately familiar with one specific type of smart device: the smartphone. Beyond the smartphone, you can find smart watches, smart key fobs, and almost anything else you can imagine. Smart home devices are quickly becoming a large part of the smart device market.

History

What makes a home "smart" are the interactive and internet-connected technologies within that home (Harper, 2003); incredible innovations in the types of devices possible have been made over the years. One specific innovation that has taken off is the ability to use your voice to activate certain functions within your devices. This capability allows users whose hands may be "tied up" to still operate devices and bring about different actions as necessary (Harper,

2003). When voice-activated devices are brought up, one incredibly popular solution probably comes to mind: The Amazon Echo. The Echo first debuted in 2014, and since then Amazon has released an array of voice-activated devices sporting different features and functionalities, but the core design is still the same: a device that can be used with your voice to complete different actions (Crist & Carnoy, 2017).

Types of Devices

The Amazon Echo can actually be used as a special type of smart device, known as a hub. A smart device hub can be used to control other smart devices connected to it. For example, a user can connect a smart device, such as a light switch, to their Amazon Echo. If the user for some reason is unable (or unwilling) to manually operate the light switch, all they need to do is use the "wake word" of the device and issue a command to turn on or off the light. All voice-activated smart devices have some form of wake word in order for user to issue commands; once the wake word is used the device listens for commands for a specific amount of time. For example, the Echo responds to 'Alexa,' which is the name given to the AI that controls the Echo. For example, in the previous example of a user wanting to turn off a light, the user may say something along the lines of: "Alexa, turn off the living room light." The Echo/Alexa will respond by complying with the command. It should be noted that the Echo can only follow the user's commands if the device has been configured correctly to link to the smart device being referenced.

Another popular application for smart technology is in home security systems. These device suites usually feature several internet-connected cameras (IP cameras) and some form of central hub. One example is the Ring Doorbell. The Ring Doorbell is exactly what the name implies: a doorbell, but with a "smart" twist. The Ring incorporates the internet-connectivity implied of smart devices, but also features a camera built in. When someone rings your Ring

Doorbell or the device detects nearby motion, users are notified via the Ring mobile application. Users can then see and speak directly with whoever is at their door. Part of the beauty of the Ring Doorbell is that since it is managed through a mobile device, a user can be halfway around the world and whoever is at the door won't know the difference (Ring, n.d.). Not only can the Ring be managed from a mobile phone, it can also be managed by Amazon's Alexa. If you're seeing a pattern, you aren't mistaken. Amazon has a massive stake in the smart device market; even devices that aren't theirs boast about the ability to natively work with Alexa, resulting in even more sales of smart devices for Amazon.

Smart devices don't just toggle lights or monitor your front porch, however; as mentioned, there are vast numbers of devices on the market for just about any task. Devices range from useful, "normal," everyday devices like a thermostat, to a more exotic smart device like a water filter (PYMNTS, 2017). While the idea of an internet-connected water filter that monitors its use and determines when it needs to be replaced is interesting, not everyone has need for that. Yet, there is still a market for exotic and unique devices because people do use smart devices for menial tasks, whether it be out of convenience or laziness.

Security

If a device is connected to the Internet, it now is at risk to some extent. Once a device is no longer segmented off from the web, it begins communicating with other devices, inherently placing itself at risk. For smart devices that require internet connectivity, it is no different. These devices require advanced communication platforms allowing for the integration of these devices across many platforms, thus placing them at risk (Trend Micro, n.d.).

Risks

Devices that are internet connected can be hacked, but what does this really mean? "Hacked," is a term thrown around quite a bit, but it can mean many different things. To hack, as

defined by Google, is to "use a computer to gain unauthorized access to data in a system." So, for a device to be hacked, that hacker essentially has access to all the data on that device in most situations. This is very bad in an enterprise environment because of the presence of proprietary or classified information that could be present on that device, but it can be just as bad for a personal device to be hacked. Considering the level to which smart home devices can be integrated into a home, someone having unauthorized access to all of those devices and their data can lead to some pretty dire consequences. One alarming example is when a couple from Cincinnati discovered that their baby monitor had been hacked. This device allowed them to remotely view the monitor's feed from their smartphones, and even talk to their child right from their phone. This works both ways, however, as the couple discovered in the middle of the night that someone was screaming at their child from the baby monitor (Barak, n.d.). The hacker had managed to access the baby monitor, including the remote camera feed and the capability to talk through it. This is just one horrifying example of what someone can do if they can access your smart home devices. While not every situation is as harrowing at this one, there are still quite a few risks associated when someone gains illegitimate access to one of your devices.

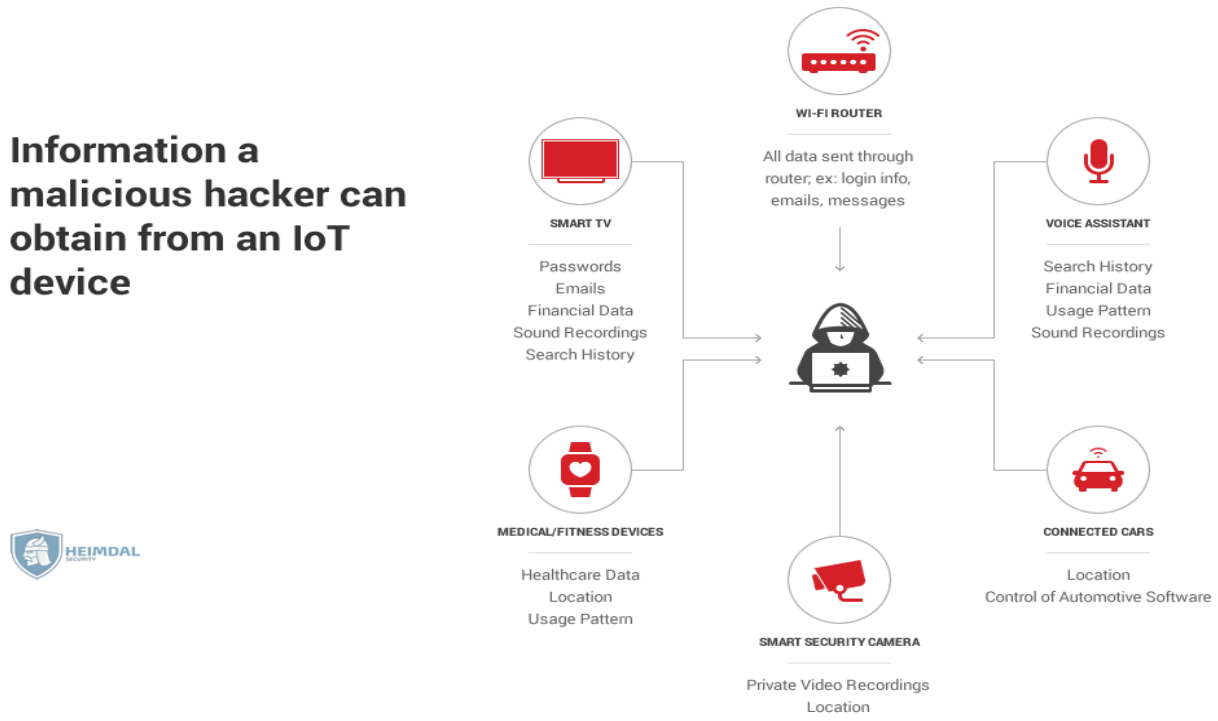

Figure 1: Information a Malicious Hacker Can Obtain from an IoT Device (Heimdal Security)

Lack of Security Features

While all devices have risks associated with their use, many of these risks can be at least partially mitigated by using proper security configurations alongside other best practices (like strong password and et cetera). Unfortunately, security capability is one category in which IoT devices fall short. These devices are designed for connectivity and integration, not for security, and in a lot of situations companies neglect even the most basic of security options. This makes them an easy target for malware and botnets, which will be mentioned more later. In fact, some IoT devices have been known to actually ship with malware already on them (Fortinet, n.d.).

While malware existing natively on smart devices is bad, it isn't a frequent occurrence. Unfortunately, what is a frequent occurrence is the incredible lack of security options on these devices, as well as the very poor default authentication settings. Many devices require no username or password by default to access critical system settings (Metz, 2013).

User Negligence

While many of the security issues related to smart devices are the fault of the manufacturer, some of the responsibility falls on the user. Users have the responsibility to change default security settings in order to ensure their devices are adequately protected. One study conducted shows that less than half of users were concerned about the lack of security with smart devices (Zeng, Mare, & Roesner, 2017). This fact could be part of the cause behind the negligence to properly secure their devices.

Security Benefits

So far quite a few risks have been outlined, but if an IoT device was all risk and no reward, no one would use it. Many of these devices provide significant benefits, whether it be convenience or, ironically enough, security. Home security devices provide physical security for your home, even if some of them create security risks in your network. Ring, for example, not only allows you to see if someone stole a package from your front porch, they also have a neighborhood watch option that comes with their products allowing communities to share data with each other and with law enforcement (Ring, 2018).

Solutions

There are ways to integrate smart devices in your home safely; there have already been quite a few studies conducted on IoT/smart device security, which has been a very hot topic in the world of IT and security (Farooq, Waseem, Khairi, & Mazhar, 2015).

The easiest way to secure your device is to configure security settings appropriately and setting strong passwords. Beyond simple configurations, there are still other things users can do to ensure smart device security. The first is to research devices before purchasing; some devices have more security capability than others, so users should aim to purchase those over the more insecure devices.

Another method, which is more on the technical side, is to place all of your IoT devices in a DMZ (demilitarized zone) on your network. A DMZ functions as a middle-ground between the Internet and your primary network. Devices such as web servers, FTP servers, and IoT devices should be placed in the DMZ. This allows the device to still function as intended by connecting to the internet, but should the device be hacked, the hacker cannot reach your primary network and the other devices on it (Rouse, DMZ, 2018). This doesn't prevent your IoT device from being hacked, but it does prevent an attacker from compromising something like a smart light switch, then pivoting to a laptop on your main network where they could access the webcam, microphone, or sensitive data.

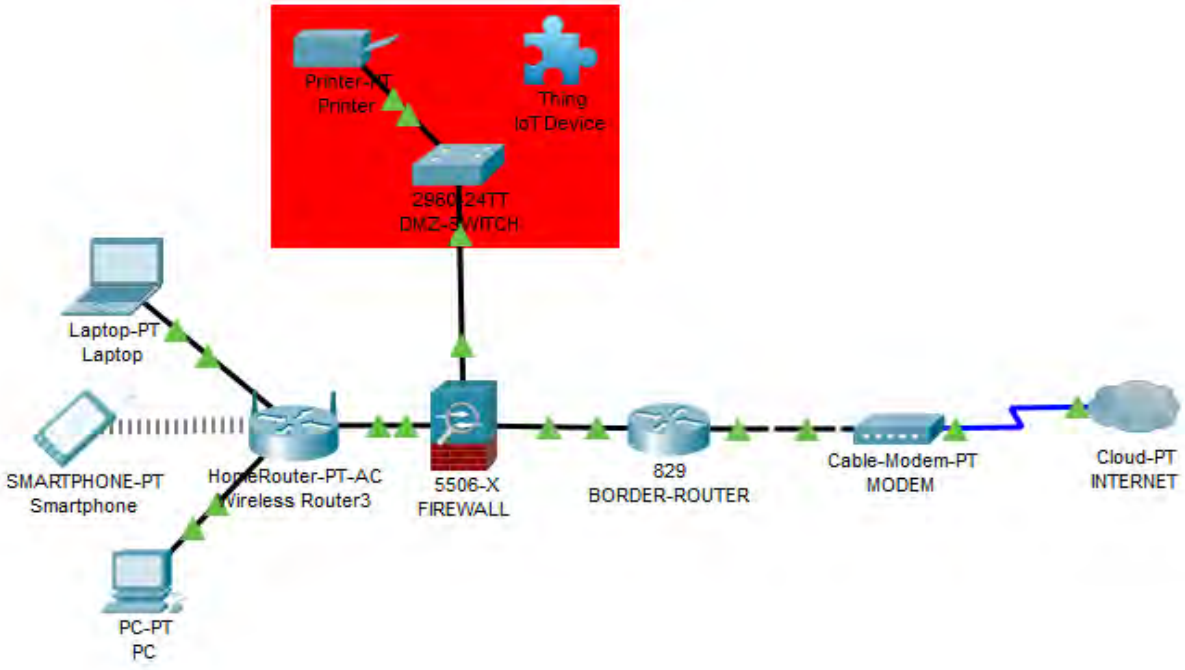

Figure 2: DMZ Architecture Example

For the less technologically proficient, there is hardware you can purchase to help secure your IoT devices. The Bitdefender BOX is an example of this. The BOX functions as a centralized hub for network security in the home, sporting powerful parental controls, tight

security options, and finally, IoT security options (Bitdefender, 2018). Devices like this allow users that aren't as knowledgeable to purchase a solution that works out-of-the-box and helps increase their network security. Ideally users should aim to purchase devices that can be configured to be secure and then lock these devices down, but for those unwilling to do these things, a solution like the BOX helps offset that.

Figure 3: Bitdefender BOX (Bitdefender, 2018)

Ethics

The world of smart devices is a new and emerging market with lots of pros and cons. Devices help with daily life and are very convenient, but they present various security concerns as well if not properly secured. In addition to all this, IoT devices have also brought about some ethical controversy.

Multimedia Privacy

There is quite a bit of controversy surrounding IoT devices, and one of the primary reasons why has to do with privacy. Devices that are inherently connected to the Internet don't just put that data at risk, in most cases they send that data back to the manufacturer. The Amazon

Echo sends commands and audio received back to Amazon for processing and improvement of the Echo (Laux, 2017). The goal of many IoT companies, especially those like Amazon in regard to the Echo, is to be able to better predict what it is that a person needs or wants (McCallum & McOwan, 2014). This allows their personal assistant AI to be more helpful, therefore making them more appealing for integration into smart homes and devices. The primary way to do this is by collecting as much data as possible on users, like what they're saying to the device, and if the device appeared to respond correctly to the user's commands. Naturally, some people are concerned about these devices sending their commands back to the manufacturer, and rightly so.

One thing that many don't realize about devices like the Echo is that they are always on and listening. In order to respond to the wake word, a device like the Echo must always be listening for it. Amazon claims that the Echo does not record anything until the device has been activated, but there have been several reports that seem to contradict this claim. One such report actually claims that a private conversation was recorded and sent to someone that the conversing party knew (Carey, 2018). Reports like this are alarming because if these devices are actually recording at all times, owners essentially have a listening device in their home connected directly to not only retailers, but also to anyone who is on their network. This means that if Amazon were to suffer a data breach that involved recorded Alexa conversations, hackers may have access to some very personal information.

GPS Privacy

Another prominent concern is that of GPS privacy. Many smart devices can track geographical locations, using this data for processing but also sending it back to the manufacturer. While for your typical smart devices (like the Echo), the only location the manufacturer will be getting is your home. This may concern some people, but it is far worse

with smart wearables. These IoT devices are worn on your person, usually as often as possible, with some models continuously collecting your GPS location (Clubb, Kirch, & Patwa, 2015).

Again, this does sound concerning, but average users tend not to worry about their GPS location being tracked since a good portion of the users purchased the IoT device for its advanced capabilities, of which GPS is one. On the other hand, this can still present many security and ethical issues. In one particular circumstance, an IoT device by Strava revealed not only the locations of classified military bases, but also patterns of personnel around the facility. This came about because the IoT device in question was used to track runners or cyclists and produced GPS heatmaps and other sensitive geolocational information that Strava released as part of their "global heatmap." Strava's response to this beach of sensitive information was that the responsibility falls on the user to mark their information as private or sensitive (Allison, 2018).

The problem with responses like Strava's is that in a lot of situations users are unaware of the type or volume of information being collected. While it seems like a valid argument that users should be responsible for their data, organizations should be held responsible for how they handle a user's data. In many situations user data is sold or distributed without any more express permission than agreeing to a 'terms of service,' which the service or device can't be used properly without accepting (Forbes Technology Council, 2018).

Botnets

Another ethical concern that has been brought up recently in relation to IoT devices is the creation of botnets. A botnet is a "collection of internet-connected devices … that are infected and controlled by a common type of malware" (Rouse, Botnet, 2017). Botnets can be used to disrupt internet connections and actually damage devices by sending massive amounts of traffic to their targets in a distributed-denial-of-service (DDoS) attack. A botnet that began causing

chaos in late 2016 and it still prevalent today is known as the Mirai botnet, named after the malware behind it. Botnets like Mirai are able to be so destructive thanks to the poor security on many IoT devices (Waddell, 2017). It was estimated by McAfee that at its peak, the Mirai botnet had under its control more than 2.5 million devices with about five new devices being infected every minute. These devices in one circumstance were observed flooding one unfortunate company with a peak of 1.2Tbps of traffic (Beek, 2017).

Botnets are a big issue and can cause lots of damage and some would argue that manufacturers should be held at least partially responsible since it is their poorly designed devices that are being utilized to cause the damage (Waddell, 2017). Regulation is needed for manufacturers of these devices, as many of them don't even have security settings included in the system settings, making them easy targets for botnets like Mirai.

Conclusion

The Internet of Things has brought about incredible innovations, creating devices that simplify the lives of their users, even to the point where they are being incorporated in every aspect of their homes. These devices do have their drawbacks, however, when it comes to security and ethics. IoT devices are notorious for having poor security configuration options, making them an easy target for botnets, malware, and hackers. Thankfully some of these issues can be mitigated with specialized security hardware or by segmenting IoT devices into network DMZs. Regardless, there needs to be a response from the manufacturers of IoT devices in the form of additional security options.

On the side of ethics, there is a serious lack of privacy where most IoT devices are concerned, in some situations even resulting in breaches of sensitive information. Organizations try to push the responsibility of poorly managed data off on customers, but there needs to be some reform in order to hold them more accountable. In addition, companies need to be more

transparent with what data and how much of it they are collecting. This is being brought about in Europe thanks to GDPR, but there has yet to be a relative response in the United States.

Over all, IoT devices have many risks associated with them, both ethically and in a security-sense. On the security side, at least some user actions can help reduce the risk. Unfortunately, on the ethical side of things, the response needs to come primarily from the manufacturers in the form of taking responsibility for device pitfalls.

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TEACHING ETHICS IN E-LEARNING

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Abstract

Fake news and postings, are becoming a norm creating ethical nightmares. This is creating confusion among millenniums what is ethical and what is not. Many organizations and societies have their codes of conduct (American Medical Association of code of ethics for doctors, American Accounting Association for accountants and so on) medical Association, etc.), that members must follow. Unfortunately, such is not the case with the Internet, perhaps because the Internet is not controlled by a single entity. Many academic institutions provide their own code of ethics for students. Implementation of code of ethics can be challenging. Instructors are facing challenges of teaching ethics. More and more students are taking on line classes. This is making teaching ethics even more challenging since, many times, instructors do not know who is on the other side. This paper will discusses strategies that may be useful in this new environment.

Key words: Ethics; e-learning; Ethic-legal framework

Introduction

Ethical issues are challenging in current environment. Fake news, fake postings, demeaning of other people is becoming a norm. Twitter is becoming major source of information creating twitter "war' between personalities. This is creating confusion among students what is ethical and what is not. Are old definition of ethics disappearing? This puts tremendous pressure on professors on how to teach ethics to millenniums who are struggling with ethical issues. Many organizations and societies have their codes of conduct (American Medical Association of code of ethics for doctors, American Accounting Association for accountants and so on) medical Association, etc.) that members must follow. Unfortunately, such is not the case with the Internet, perhaps because the Internet is not controlled by a single entity. Academic institutions provide their own code of ethics for students. Implementation of code of ethics can be challenging. Instructors must face these challenges by incorporating ethics as part of their courses. More and more students are taking on line classes. This makes ethics even more challenging since, many times, instructors do not know who is on the other side. This paper will discusses strategies that may be useful in this new environment.

The Course

The course is currently delivered at an urban public university in the Mid-Atlantic area. The university has diverse student population. Two undergraduate on line introductory courses were selected for this study. The introductory course is required of all students, Both courses have

diverse student populations in terms of gender, race and nationality. Several discussion cases were posted in the forum and were asked to study both ACM and university code of conduct. After reading code of conducts students will be asked to discuss them in terms of legal and ethical 4x4 framework. Small case studies will be used for this purpose.

Since ethics is every day topic, we will not be surprised if students do not read the codes and discuss cases based on their pre-conceived notions of ethical behavior. This will create more challenging since pre conceived notions are hard to change. Course is still evolving and we will report the results of our strategy.

Conclusions:

As e-learning diffuses, more and more monitoring is needed to keep everybody ethical. Ethics sometimes is derived from "current" behaviors which make it difficult to implement if the current ethical standards are different than existing standards. While it is hard to monitor and enforce ethical standards on the twitter/social media, professors can provide guidelines for students groups in academic environment. This paper attempts to teach ethics to a specific group (e-Learning) of students which could create a groundwork for further studies

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THE LEGAL LIMITATIONS ON COLLEGE ADMISSION STANDARDS WHEN DOES THE PURSUIT OF DIVERSITY BECOME ILLEGAL DISCRIMINATION?

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ABSTRACT

The value of diversity in the workplace, classroom, and c-suite is universally proclaimed as a given by scholars, experts and even the courts. In the abstract this presumption may be true, but in application the concept of inclusively having a diverse workplace or a diverse elite college student body is problematic. Fraught with incongruent denotations and insurmountable applications, achieving a critical mass of historically underrepresented employees or students resulting in a diverse workplace or student body is elusive if not unattainable.

In Students for Fair Admissions, Inc. (SFFA) v President and Fellows of Harvard College (Harvard University), the United States District Court, and eventually the United States Supreme Court will weigh in on the value, definition, and legally permissible process to achieve diversity in creating a college class. The holistic admissions process employed by Harvard has been cited by previous courts as an example of the appropriate balance of being race conscious and color blind to achieve the optimal learning environment for colleges to prepare students to productively excel in a diverse society.

This paper will summarize the history of the federal court system's attempt to reconcile society's simultaneous desire to create diversity and avoid discrimination based on those same classifications necessary to consider in order to achieve said goal. From the Bakke v University of California at Davis decision to prohibit quotas, but allowed race to be considered as one of many factors to achieve diversity to the Gratz and Grutter cases against the University of Michigan and University of Michigan Law School which were decided based on the weight race was awarded as a deciding factor in admission. Fisher v University of Texas(I and II) affirmed the Equal Protection Clause standard to be applied to test the state's use of race conscious albeit holistic standards in their admission's selection process.

The current lawsuit against Harvard alleging discrimination based on race in their holistic admissions process will be examined from the viewpoint of how to define and achieve the appropriate level of diversity within the environment of a changing United States Supreme Court. If the Harvard case, as many believe, makes its way to the high court, what will be the consequences of eliminating race as a permissible variable in college admissions processes?

KEY WORDS

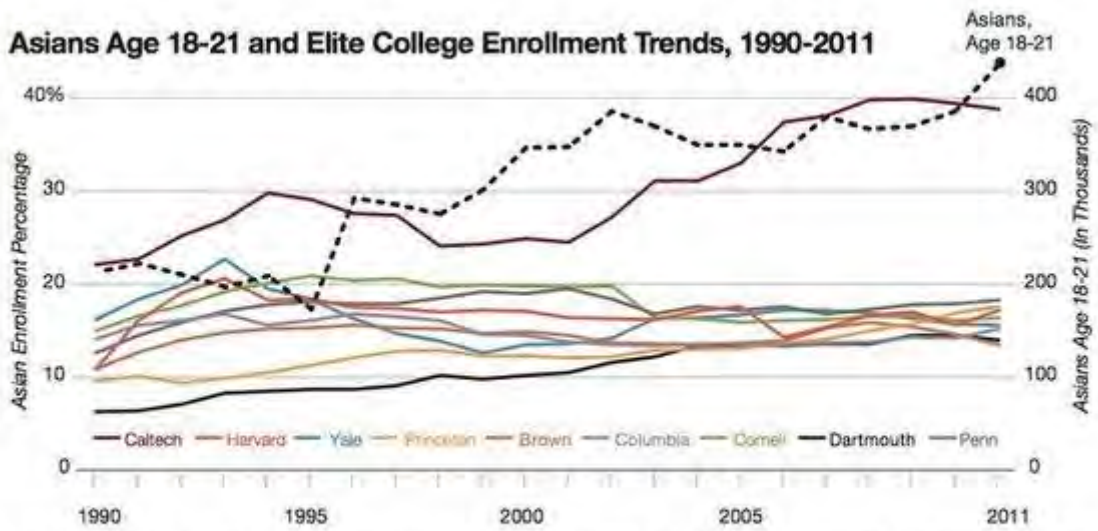
Affirmative Action, Strict Scrutiny, Racial Discrimination

DISCRIMINATION OR AFFIRMATIVE ACTION

The plaintiffs in Students For Fair Admissions, Inc. v President and Fellows of Harvard College (Harvard Corporation), hereafter SFFA v Harvard, allege the Harvard admissions process intentionally discriminates against Asian-American applicants. Harvard acknowledges their

holistic admissions process considers race as one of many factors. Harvard denies using any factor within the process to discriminate against Asian-Americans. They further contend, in compliance with applicable law, race is a considered, but not a dispositive factor in their admissions process.

Edward Blum, President of the Students for Fair Admissions, (Halper, 2018) alleges Harvard intentionally discriminates against Asian-American applicants. He argues Harvard maintains a quota for Asian-American applicants' admission to Harvard. After the Justice Department closed an investigation in the early 1990s into charges that Harvard University discriminated against Asian-American applicants, Harvard's reported enrollment of Asian-Americans began gradually declining, falling from 20.6 percent in 1993 to about 16.5 percent over most of the last decade.

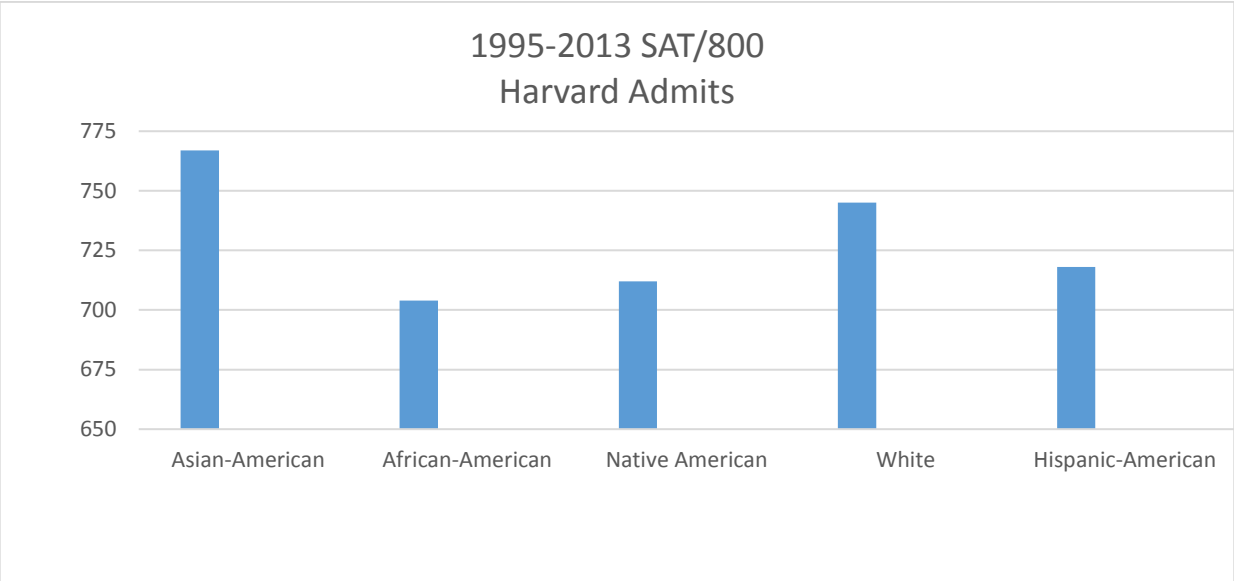


Trends of Asian enrollment at Caltech and the Ivy League universities, compared with growth of Asian college-age population; Asian age cohort population figures are based on Census CPS, and given the small sample size, are subject to considerable yearly statistical fluctuations. Source: Appendices B and C.

The Asian student population at Harvard can be viewed from multiple perspectives. Compare Asian Americans at Harvard as a percentage of the college age Asian American applicant pool. This pool having increased by almost 100%, while the Asian population as a percentage of Harvard's student body has actually declined slightly from 20.6 in 1993 to 18.6 in 2015. As the chart above illustrates, the Asian population at other Ivy League institutions has also not increased in proportion to the increase in the Asian college age applicant pool. Coincidentally, the percentage of Asian students at these elite institutions has converged, settling at approximately the same percentage.

In contrast, Asian Americans at California Institute of Technology have increased as a percentage of the student body to 43%. Approximately the same increase in percentage as the Asian American college age applicant pool. The same percentage as Model 1, indicating what percentage of Harvard's class would be Asian if only academics, not athletics, legacy, personal and extracurricular activities were factored in.

According to data released at trial, over an 18 year period from 1995-2013, Asian-American applicants admitted to Harvard earned an average SAT score of 767/800 across all sections. During the same period Hispanic American admits scored 718/800, African-American admits 704/800 and White admits 745/800.



Harvard's holistic admissions process considers race as one of approximately 200 factors. Models presented at trial, demonstrated the weight given some of the variables considered and their impact on the class profile based on race.

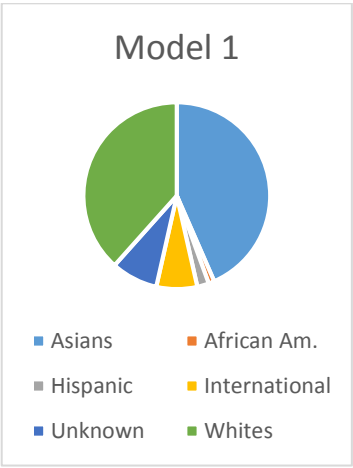
Model 1 illustrates what the Harvard class would look like if only academics were considered. Asian-Americans under this construct would constitute approximately 43% of the Harvard class. Highly selective private university California Institute of Technology states academics is the most important admissions criterion. Under the Prop 209 amendment to the California State Constitution race may not be used as an admissions consideration. (Cal. Const. art.1 sec. 31(a)) In 2016, 43% of the undergraduate population at Cal. Tech. was Asian-American. (Jaschik, 2017)

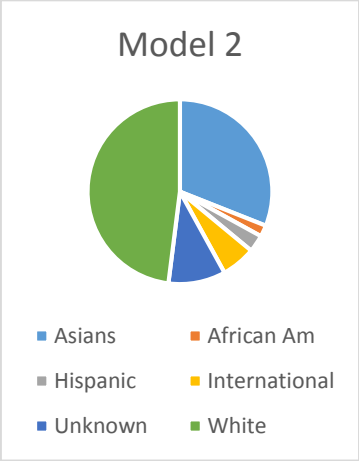
Plaintiffs claim that despite receiving the highest average ratings in academic ratings, Asian-Americans received the lowest scores in "Personal" ratings. (Korn, 2018) It is the admissions notes on student files referring to Asian-American applicants in stereotypical terms such as "quiet, shy, science/math oriented and hard worker" that came from a previous Department of Education investigation and plaintiffs' contend remains Harvard's discriminatory behavior today. (Hartocollis, 2018) It is this behavior, the suit argues, Harvard uses to maintain an illegal quota on Asian-American students admitted.

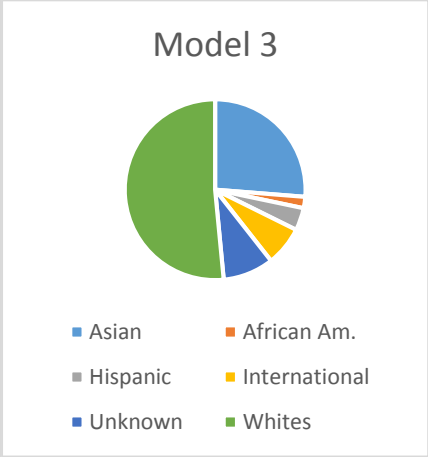
Model 2 illustrates what the Harvard class would look like if only legacies were admitted. Model 3 illustrates the student body diversity if only recruited student athletes were admitted. Model 4 shows the resulting diversity if extracurricular activities and "personal scores" were considered for admission. The final Model "Actual" is Harvard's student body currently, factoring in all variables in their holistic admissions process.

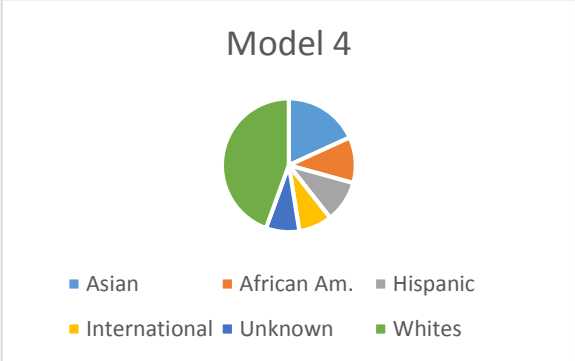
According to an analysis by one plaintiff's economist, 86% of recruited athletes were admitted. Almost 50% of applicants with a parent employed by Harvard was admitted. 33.6% of applicants who had at least one parent attend Harvard received admittance to Harvard. (Korn, 2018) This at an institution with an overall acceptance rate of below 5% (DeCosta-Klipa, 2018)

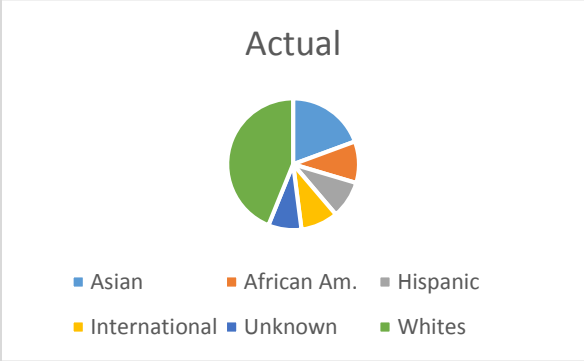
Harvard acknowledges a statistical disparity, but contends such does not prove intentional discrimination.











Unlike Bakke (Regents of the University of California v Bakke, 1978), Grutter (Grutter v Bollinger, 2003), Gratz (Gratz v Bollinger, 2003) and Fisher (Fisher v University of Texas at Austin, 2016), the United States Supreme Court cases establishing how much race may be considered in the college admissions process, Harvard is a private institution. As Judge Burroughs correctly pointed out in her pretrial motion ruling, this is not an Equal Protection Clause case. She does go on to inform the parties that as a federally funded private university the same test applied to public universities would be appropriate.

Race conscious admissions decisions, which includes Harvard's holistic process utilizing race as one of many variables, are permissible if the process is narrowly tailored to further a compelling

interest. The educational benefits of a diverse student body have been recognized by the court as a compelling interest. (Grutter v Bollinger, 2003) What admissions process is "narrowly tailored," and what constitutes this valuable and compelling interest of a "diverse student body" remains unclear.

What is established law is that the Strict Scrutiny test of the Equal Protection Clause will apply to this Title VI claim. Furthermore, race may be a factor in a holistic admissions policy but it may not be a dispositive factor. (Regents of the University of California v Bakke, 1978) Receiving a specific number of additional points to enhance the possibility of admission is specifically a violation based on current applicable analysis. (Gratz v Bollinger, 2003)

The Harvard case went to trial after Judge Burroughs cleared up during motions that strict scrutiny standard would apply and the plaintiff's four claims of intentional discrimination, racial balancing, race as a plus factor, and race-neutral alternatives were not moot and best decided at trial. (Huffman, 2019)

Many legal observers have opined that no matter what the outcome of this trial, the appeal is likely headed to the United States Supreme Court. Fisher and Grutter agree that the standard for review is strict scrutiny. However, Bakke and its progeny further have held that race may be considered as a factor in admissions policy if nondispositive, to achieve the compelling interest that is a diverse admissions class. This Court and this Justice Department have indicated a desire to prohibit any race based considerations in admissions.

Justice Thomas's dissent in Fisher II may be the majority decision if and more likely when the U.S. Supreme Court grants cert for Harvard. "… use of race in higher education admissions decisions is categorically prohibited by the Equal Protection Clause. The Constitution abhors classifications based on race because every time the government places citizens on racial registers and makes race relevant to the provision of burdens or benefits, it demeans us all. That constitutional imperative does not change in the face of a "faddish theor[y]" that racial discrimination may produce "educational benefits." (Fisher v University of Texas at Austin, 2016)

The Justice Department filed a Statement of Interest in Opposition with the U.S. District Court supporting the plaintiff's lawsuit, arguing against granting defendant's motion for summary judgment. In it the DOJ argues "Harvard has failed to demonstrate that its use of race is narrowly tailored to serve a compelling interest, that Harvard has failed to engage in good-faith consideration of race neutral alternatives,… (and) Harvard has not defined its diversity-related goals but nonetheless rejects race-neutral alternatives as inadequate to achieve them." (Gore, 2018)

CONCLUSION

Harvard uses race as a factor in their admissions process. Harvard denies the use of race is a dispositive or plus factor. Harvard further denies any quota to admit students based on race is in effect. If true, Harvard's holistic policy is legal under current law. The admissions data seems to indicate these statements are statistically unlikely and probably untrue.

It is also very unlikely the statistical evidence, admissions data, and testimony as to the use of race in Harvard's admissions process is legally sufficient to establish intentional discrimination against Asian applicants to Harvard.

Whether Harvard is in compliance with the parameters of using race as a factor in admissions in a narrowly tailored manner to achieve a compelling interest is unlikely, but very probably moot. The use of race based admissions policies in both public and private universities, whether inclusive affirmative action or illegal and inadvisable discrimination is also likely not what this case will ultimately be a vehicle for determining.

Open questions such as how to define "Asian-Americans," "what is a critical mass," and "how nondispositive must race be as a factor" will no longer need to be addressed.

SFFA v Harvard will be the United States Supreme Court case that creates the constitutional standard for any use of race in college admissions. Public or private, holistic or dispositive, with inclusive or discriminatory intentions, the U.S. Supreme Court will reconstruct the permissible process for college admissions of the next generation.

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MARKETING - ABSTRACTS

BRAND PERSONALITY AND INNOVATIVE PRODUCT DESIGN ADVOCATING FOR A DESERVING POPULATION

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There are many individuals with developmental disabilities who have the capability to make every day purchases and who frequent particular brands. Scholarly research that focuses on how this deserving population associates with particular brands in relation to innovative product design could yield beneficial results.

This paper will investigate how individuals with developmental disabilities associate with particular brands utilizing the Brand Personality scale (Aaker 1997) and its influence on innovative product design in the following three forms: aesthetics, features, and ergonomics (Moon, Park, & Kim, 2015).

It is also posited that many purchase situations among individuals with developmental disabilities can be moderated by government funding and professional staff, while mediated by caregiver coping abilities. These factors will also be investigated regarding their impact on the brand personality and innovative product design relationship.

Keywords: brand personality, innovative product design, persons with special needs.

As markets continue to evolve with reduced barriers of entry, it is imperative that marketing practitioners be able to address the changing demands of their consumers.

Considering today's 21st Century technological advances, it is important to examine consumer interaction that could lead to success or failure of new product innovations (Gruner & Homburg, 2000). New product innovation can be rooted in product qualities, such as aesthetics, unique product features, or carefully thought through ergonomic factors in a product. Having potential consumers as a part of the product development process in examining product qualities, taking notes on the characteristics of

consumers who are participating in this process, and empirically reporting their influence during various stages of the process can yield valuable results.

Arising from the interactive between product qualities and customer perception of their qualities could generate brand personality. Brand personality is a multidimensional construct, one that includes: sincerity, excitement, competence, sophistication, and ruggedness where some dimensions may be more relevant and expressive of particular brands than others (Aaker, 1997). Humanizing a brand can serve as a self-expressive meaning beyond the practical function of product-related attributes.

Business owners and/or top management should take into account a number of considerations when marketing to those with developmental disabilities. Prior literature has focused on individuals living in the U.S. who have a disability 'of some sort' and speaks to the constraints of this consumer population and how it applies to this area of study (Baker, 2009). Research that focuses on ways to effectively and sustainably implement viable marketing strategies toward those with developmental disabilities can present diverse complications. Some purchase situations may be subjective to government funding whereas certain product purchases may be limited to the level of governmental aid. Other product purchases can be predisposed by professional staff that work on a daily basis with persons with special needs who may be partial to superior brands.

Consideration should also be given to families of those who have a family member(s) with a disability living within the same household. Sometimes this population's coping abilities are overlooked and can impact consumer behavior among those with developmental disabilities (Mason & Pavia, 2006).

For these reasons, it would be beneficial to explore these factors and how they contribute to the brand personality and innovative product design relationship.

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IMPACT OF PRODUCT-LEVEL SUSTAINABILITY/CSR DISCLOSURES ON CONSUMERS' WILLINGNESS TO PAY.

ABSTRACT

We explore the impact of product-level sustainability and corporate social responsibility cost disclosures on customers' willingness to purchase. We analyze survey data collected by recruiting Amazon M-Turk workers. We observe that different types of product-specific cost disclosures have different effects on consumer attitudes about the product.

KEYWORDS: Pricing, Cost Disclosures, Sustainability, Corporate Social Responsibility, Survey research

INCOME ELASTICITY OF DEMAND FOR COMMUNICATION AND IT PRODUCTS: MEASUREMENTS AND IMPLICATIONS

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ABSTRACT

In this paper we explain the income elasticity of household's demand and measure the such elasticity for communication and IT (CIT) products in 23 countries from OECD (The Organization for Economic Co-operation and Development) during 2008 from 2015. We use both panel data analysis and regression analysis. By using fixed and random panel data analysis, we find that CIT products are necessary to the households in the OECD countries as a whole. By using linear regression for individuals, we compare the change of each country's income elasticity over two time sections (during 1989 to 2001, and during 2008 to 2015). We find that communication and IT products are considered as luxury goods by the households in these countries from 1989 to 2001. However, from 2008 to 2015 such products are considered as necessary, luxury, or inferior goods separately in various countries. Over the period from 1989 to 2015, the trend is that the income elasticity is decreasing, and households in some countries start to take such products as necessary goods. Both panel analysis and linear regression results suggest that most of households take CIT products as necessary. We also discuss managerial implications for marketing strategy associated with our findings.

Keywords: Income elasticity; Luxury goods; Necessary goods; Marketing strategy

SOCIAL SPATIAL IMAGERY AND XENOCENTRISM: THE ROLE OF CULTURE IN ONLINE SOCIAL NETWORKS

Anshu Arora, University of the District of Columbia

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Amit Arora, University of the District of Columbia

Vas Taras, University of North Carolina at Greensboro

ABSTRACT

The current research demonstrates how high social spatial imagery (SSI) enhances xenocentrism amongst users in global virtual teams (GVTs), and this further increases negative electronic word-of-mouth (eWOM) shared in social media networked environments. The authors provide evidence suggesting that group culture moderates the relationship between SSI and WOM, which further impacts project outcomes. The authors discuss theoretical and managerial implications for social media based projects with group culture and xenocentrism influencing these relationships in strongly- versus weakly-tied online social networks.

Keywords: social spatial imagery, xenocentrism, word-of-mouth, group culture, social media

Tittle: WHAT MAKES GRANDMA FEEL LIKE HOME IN A NURSING HOME? A QUALITATIVE STUDY ON ONE NURSING HOME IN TEXAS

Abstract

This study explores how servicescape elements impact on the service development in the context of old aged citizens in the nursing home. Conducting interviews and observation method, researchers find out that servicescape elements rely not only on physical dimension but also on social, socially symbolic and natural environment dimensions. The findings support Rosenbaum and Massiah's (2011)'s multi-dimensional model and suggest many improvements in the nursing home servicescapes for the old people. Researchers find that factors such as ambience, signage, layout and socially symbolic structure at the old age nursing home are highly appreciated by study participants; whereas other factors such as privacy, quiet environment and social interactions among patients via group activities need to be improved and require more attention.

Keywords: servicescape, nursing home

Why Should You Take It 'Personally'? The Influence of 'Interpersonal Closeness' on Consumer Messaging Efficacy in Social Media

Gabriel Gabriella and Rosa Labra, Graduate Students, University of the District of Columbia, Washington, D. C.

Abstract

The research focuses on the role of interpersonal closeness (IC) in differing types of psychological motives triggered in consumers. The research investigates the idea that communicating with "close" versus "distant" others can activate specific psychological responses that drive consumers' behavior in both their social interactions and the kinds of information they share. High levels of IC increase the negativity of information shared, whereas low IC increases the positivity of information shared. These findings suggest that sharing positive information is typically instrumental to consumers' motives to self-enhance, whereas sharing negative information is typically instrumental to consumers' motives to protect others. In our research, we conceptualize and present 'Social media supported IC-Information framework' and investigate the role of consumers' motives to self-enhance and/or protect others through the use of case studies. The research addresses the following questions:

1. What is IC, and how does it influence social behavior in online networks?

2. What effect does the level of IC have on the positivity or negativity of information shared?

3. What are the implications of this research for marketers in charge of designing word-of-mouth campaigns?

Finally, we discuss the managerial applications of our findings along with limitations and opportunity areas for further research.

Keywords: *social media-supported IC-Information framework, interpersonal closeness, word-of-mouth, social media, psychological motives, messaging strategy*

MARKETING - PAPERS

THE INFLUENCES OF CONSUMPTION VALUES ON ELDERLY IN-HOME CARE NEEDS OF HOUSE INTERIOR ATTRIBUTES AND SERVICE INNOVATIONS

ABSTRACT

This purpose of this study is to examine whether the consumer‟s consumption values will influence elderly in-home care needs of house interior attributes and service innovations. One-hundred and eighty-three valid sample wereas collected from households that have at least one elderly living in the family. The analysis results of structural equation model show that the consumption values indeed positively affect elderly in-home care needs of house interior attributes and further lead to the demand for in-home care service innovations.

Keywords: Value, Elderly, In-home care, Housing attributes, Service innovation

INTRODUCTION

According to WHO's(Word Health Organization)statistics, age above 65 years old happens “Falling accident ”events annually around 28～35% .And the falling accident events happen every year. more over, age above 70 years old happening rate increasing to 32～42%.Besides , 20%～30% of elderly residents happen falling accidents afterward's .Their activity and independence are appearing “retarding” situati.It even increases the risk of early death(World Health Organization 2008). Thus, Orienting to different properties creation service and system facility in house-living environment .For upgrading the idealization and safety as the elderly residents constant living mode.

On the other hand, Some foreigw studies have different explanation and definition toward the high-age elderly: Association of American Retirement Personnel (AARP，1986)expresses: Age 55 above is called“elderly”group And explains that in economical ability health, social relations,family relationship, leisure and daily life…etc levels concern and needs so that the article is through the elderly group's Physical and psychological needs levels presenting relating to the high-age consumers value point and house-living creation service the influence in relations .

Xceptionally,Wang-C-Zem(2015) pointed out, basis on Consumer‘s behavior view point research, the contents of elderly group toward house care service in consumer's viewpoint. Emphasizing the high-age consumer's value of viewpoint influence factor. And building up the consumer's value mode .In order for catering to value- ism to and service value-ism. Thereafter constructing “high-age” level consumer group's needs in house-living level service contents. Via the Consumption Value mode finding the motivation of promoting elderly group's house-living needs consumption.it is the most input in house-living service creation. All in all, in this study, reckoning that the problem of house-living care-taking needs attributes . It shall

impose or orientation to the elderly group's viewpoint in value and the house-living property level.Suggesting to process further studies basis on interfering mode.

LITERATURE REVIEW

Consumer Value Motivation and Home Care Attributes Needs

The motivation of consumption value and home-living care-taking attributes needs Pointing out from Holbrook(1990),Starting from the relative theories of consumption value.“Initiative Value" is the Consumption experience from Customers toward product and service which plays the initiative controlling role. then the passive value is to say the consumption experience of customers toward product and service. Which plays the passive reaction role Besides it, researching for the motivation factor of consumption value Among them, Customers are the main who an purchasing. Due to the Purchasing Consumption experience, the value is gained .The important experience is the main factor that Customers Can be able to Consume Continuously.

Sheth-Newman Gross (1991) expressed, To customer‟s different consumption sinarios opions,.which produes 5 styles of cosumption value.(Function Value, Emotion Value, Social Value, Novelty Value and Scenario Value) This article is basis on Consmption value with 5 levels of Concern, Imposing the diverse groups toward house-living environment and Service creation needs .Basis on as said theory and inferring the high-age elders to home-living care-taking viewpoint of Value. therefore creating the home-living service According to Sheth-Newman Gross (1991) expressed, the 5 modes of influencing on Consumer's value options.

function value explaining the Consumers choices of products and of their functions and efficacy. Via the external property in order to gain the perception value.

At the same time , also explaining the main function efficiency of products. Social value explaining the products selected by consumers are connected with multiple social groups, and thus they have mutual perceived utility. And gain social value through consumer connections to the social economy and the community. Emotional value: The emotional or emotional state and service experience triggered by the consumer's choice of product, and then the utility of perception,and the emotional value is the factor that can change the value of the consumer to the product. Novelty value: Explaining the curiosity and freshness that consumers trigger when they choose products, and the satisfaction they bring to the purchase of products; and then the novel value of consumer perception. Scenario value: Explaining the consumers in different environments, in the special situation when choosing products, the cognitive value of products will increase, and at the same time create context value.

According to the demand for home care attributes, Khwla A.M.H.Alarji and Mahmud Bin Mohd Jusan(2015)，pointed out that the flexibility of housing attributes can be used as a context indicator of self-impression and expression, giving older occupants the opportunity to enhance .their attachment to the house through responses. And further adapt to the housing attributes and personalization of its life cycle by adapting to the flexibility.

In the service innovation of home care, how to choose the service model suitable for introduction based on the consumer perception of the elderly. According to Barlow et al. (2003), the trade-off between the standardization and the level of customization of home care attributes also implies the use of different service supply models.

According to Dodds, Monroe, and Grewal (1991), consumer perceptions of perceived value come from subjective and objective perceptions of the price of a product or service; while product prices,brands, And sales information affect

consumers' perceptions of products and services value. Therefore, in the face of the main view of the consumption behavior of the senior age layer, the objective value theory is used to derive the demand for the home care attribute of the innovative service, which will be the value of the elderly consumer motivation that this study needs to explore. Therefore, this study proposes hypothesis 1:

H1: The motivation of consumer value has a positive relationship with the demand for the attributes care of the elderly In-home care . When the motivation of the consumer value is higher, the demand for the attributes of the elderly In-home care to care for the home is higher.

Home care attribute needs and service innovation needs

Betz (1993)，stated that the concept and method of creating a home-based property product is only seen as an invention; innovation is the introduction of home-based attributes products and services into the consumer market, and the resulting interest. Therefore, the integration of the elderly consumer values and market demand, and jointly develop innovative home attributes in the field of houseing technology services. In order to meet the needs of the growing elderly home environment care.

For the relationship impact of service innovation introduction in the environment, Johne and Storey (1998)， stated that service innovation is defined as: new developments in service products, or new concepts, new jobs, and new goals for organizations and their related environments. According to Luecke (2003), services are solutions to solve customer-level problems, and innovation is the integration of knowledge to create valuable new products, processes or services.

In addition,According to Den Herttog and Bliderbeek (1999), the service innovation model consists of four facets that include new service concepts, new customer

interfaces, new service delivery systems, and technical options. The concept of service innovation is as intended in this paper to propose the concept of innovation in home service to meet the consumption needs of the elderly. Therefore, this study proposes hypothesis 2:

H2: There is a positive relationship between the demand care of the elderly In-home care and the demand for service innovation. The higher the demand for the care of the elderly In-home care, the higher demand for service innovation.

Consumer value motivation and service innovation needs

McCall (2000) suggests that long-term care is a systemic home care system for people with long-term health problems who do not have to take care of their daily lives, including medical services, social services, and residential services Wait. Therefore, if we can integrate the application of consumer value perspective and related residential attribute requirements, and continue to provide the security facilities for the elderly In-home, it will be the goal for this study.

Tidd, J. & Hull, F. (2003) stated that service innovation delivers added value to customers in a novel and different past service concept, in a service delivery process through novel approaches, or in a way that proposes improved problem solving. Therefore, based on the transmission of the perspective of consumer value, through the service innovation process required by the elderly In-home for the attributes of the home environment, this study proposes the hypothesis 3:

H3: The positive consumption value opportunity affects the demand for service innovation through the intermediary effect of the demand for attributes care of the elderly In-home.

METHODS

This study is to explore the relationship between the demand for positive home care attributes, the view of consumer value and the demand for service innovation. In order to meet the research problems of this study, quantitative research methods were used to collect research data. The selection of this research sample is based on the students of Yuanzhi University EMBA-102 alumni and EMBA-105, EMBA-106, and the learning members of Yuanzhi Lian University Learning Center. According to McClusky (1971); education intervention can provide a perspective on the quality of life of the elderly, and the learning needs of the elderly are divided into five categories of needs (such as the demand, the performance, the contribution, the impact and Beyond the needs, etc.): Thus, the functional value in the perspective of consumer value corresponds to the need to provide a positive view of the quality of life of the elderly people. Therefore, the sample selected in this study should be appropriate.is study is shown in Figure 1.

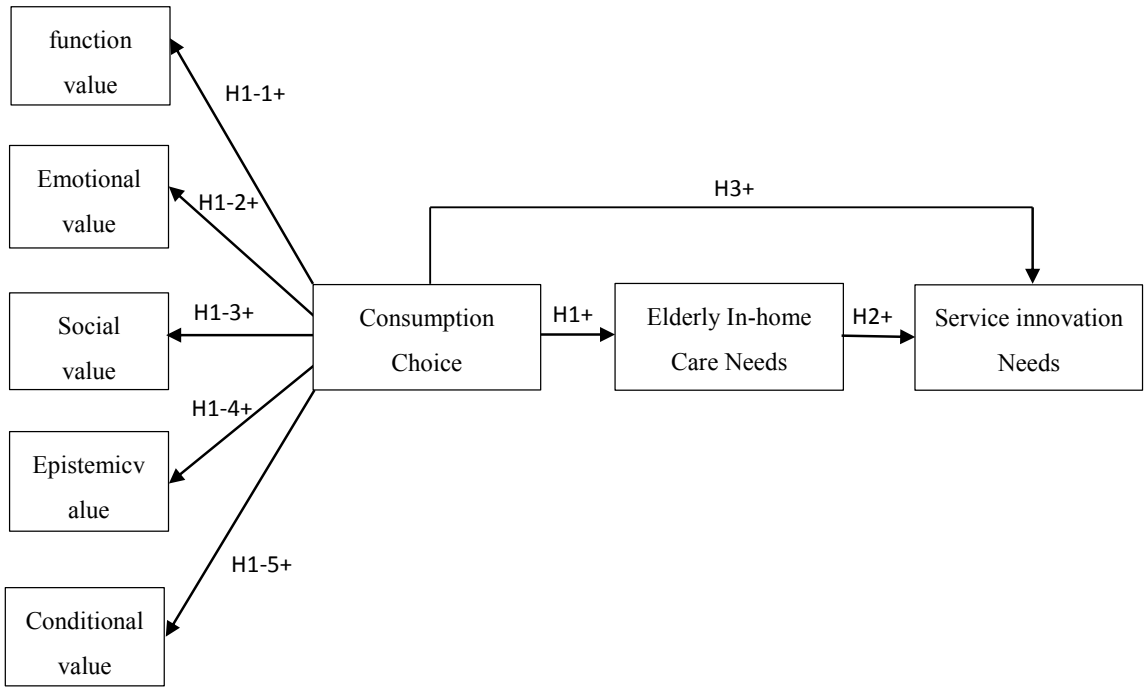


Figure 1 research structure

Research variables and measurement methods

（1) Consumer value perspective

The measurement questionnaire of the consumer value perspective are based on Sheth Newman Gross's (1991) consumer value theory and Chen Yueying, Lin Rongtai, and Chen Ruyi (2010). The research on the design of the consumption value survey scale has been jointly compiled; there are 20 measurement topics. This study used the Liker seven-point scale to conduct a questionnaire survey, and the application included: narrative statistics, Cronbach"s α coefficient, and confirmatory factor analysis (CFA) as analysis data.

(2) Elderly In-home care attribute needs

The measurement questionnaire for the demand for the care of the home of the elderly In-home care jointly compiled by Veitch & Gifford (1996) and Beisi (1995, 2004) according to their home attribute content; there are eight measurement topics, and the EMBA alumni are invited by the Liker seven-point scale. With the students in the school, as well as the learning members of the Senior Citizen University Center, the questionnaires were conducted according to the needs of each kind of positive home care attributes.

(3) Service innovation needs

The measurement questionnaire for service innovation acceptance are based on the service innovation model proposed by den Hertog and Bliderbeek (1999) and the service innovation acceptance study proposed by Wu Mingxiao (2016). There are twelve measurement topics, using Liker. The seven-point scale, based on self-viewing of each of the needs of positive service innovation, conducted a questionnaire survey.

DISCUSSION AND RESULTS

Homogeneous test

Since the source of this research design questionnaire has two parts, one is the school paper questionnaire and the other is the online group questionnaire. Therefore, before the data is combined, it is necessary to understand whether the two groups are homogeneous (whether the variance is the same, category Whether the variable is the same as the number of times). And the general inspection is based on demographic variables, because it is a category variable, so the chi-square test is used. In this study, the Pearson chi-square value of the chi-square test is 3.187 less than X2(1df)=3.8415, p=0.074 > 0.05, so the null hypothesis is not rejected, and the chi-square test description (see Table 1).

Table 1 Chi-square verification

	Numerical value	Degree of freedom	Asymptotic significance (both ends)	Precise significance (2 ends)	Precise significance (1 end)
Pearson card.	3.187	1	.074		
Continuity correction.	2.665	1	.103		
Approximate ratio.	3.181	1	.075		
Fisher's Accurate Verification.				.093	.051
Linearity versus linearity.	3.169	1	.075		
The number of valid Observations.	183				

CORRELATION ANALYSIS

The correlation coefficient between the number of average, the standard deviation and the variable of each variable in this study (refer to Table 2). It can be

seen from Table 2 that there is a positive correlation between the view of consumer value and the demand for attribute care of the elderly In-home (r=.202, p<.01), which emphasizes that the higher the motivation of consumption value, the more positive the elderly In-home will be expressed. There is no significant correlation between the demand for attribute care and the demand for service innovation (r = .524, p >.05); in addition, the relationship between consumer value and service innovation needs Positive correlation (r = .253, p < .01) shows that the consumer value of the opportunity through the intermediary effect of the elderly In-home care attribute needs, will express the more positive impact on service innovation needs.

Table 2: Flat number, standard deviation and correlation coefficient of each variable

Variables	Mean	SD	1	2	3	4	5	6	7	8
1.Consumer value	3.05	.04	.12							
2.Care needs	1.66	.32	.20**	.43**						
3.Emotional value	2.28	.42	.28**	.46**	1.14					
4.Scenario value	2.01	.42	.25**	.24**	.56	.70				
5.function value	-	-	.12	.20**	.28**	.25**	.36**			
6.Novelty value	2.34	.49	.28**	.47**	.65	.57	.28**	.17		
7.Social value	1.48	.31	.18	.30**	.41**	.36**	.18	.42**	.55	
8.innovation needs	1.07	.40	.25**	.52	.58	.51	.25**	.59	.37**	1.46

Note: 1: The diagonal coefficient is Cronbach's α value.

2:*p<.05 **p<.01

MEASUREMENT MODE ANALYSIS

This study refers to the analysis of Anderson and Gerbing (1988), and conducts confirmatory factor analysis (CFA) before structural analysis to test the fit degree of the model. The results of confirmatory factor analysis are shown in Table 3. The fit of the two-factor model (consumption value perspective, demand for elderly based home care attributes) proposed in this study is still acceptable.

Table 3 Confirmatory factor analysis results (consumption value perspective, needs for elderly In-home care attributes)

model	X^2	df	X^2/df	RFI	CFI	IFI	RMSEA
One factor model	429.989	165	2.606	.725	.851	.855	.093
Two-factor model	891.354	344	2.591	.657	.794	.799	.092

STUCTURAL MODEL ANALYSIS:THEORETICAL MODEL

This study uses Amos to verify the proposed theoretical model (see Table 3). The results show that the X2/df of this model is 2.867, the RFI is .603, the CF1 is .731, the IFI is .736, and the RMSEA is .100. The fit of the model is still ideal.

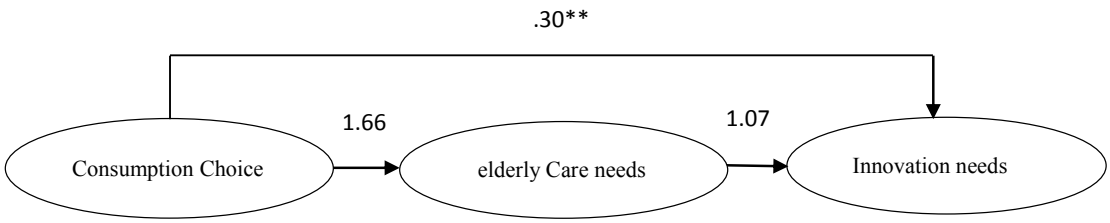
Table 4 theoretical model

model	X^2	df	X^2/df	RFI	CFI	IFI	RMSEA
theoretical model	2101.76	733	2.867	.603	.731	.736	.100

HYPOTHESIS VERIFICATION

This study is the hypothesis outcome (see Figure 2) In hypothesis 1 ,finding the positive viewpoint of consumption value and positive elderly group's house-living care-taking ,,and it's path faction is 1 .66 (p<.01). when the consumption value motivation is higher ,it creates the needs of positive elderly group's house-living care-taking attribute. But not reaching the standard yet,thus the hypothesis is not supported. In hypothesis 2 ,the analysis demonstrates,the needs of elderly group's house-living care taking attribute and positive service creation needs ,the path factor is 1.07(p<.01) .it shows,When the elderly group's house-living care taking needs is

higher .It will show more positive service creation needs But not reaching the standard either,So hypothesis 2 is not supported either. In hypothesis 3, the analysis consumption value motivation and positive service creation needs path factor is 3.0 (p<.01) shows the consumption value motivation will go through the elderly group's home-living care-taking it's interfering effect, It appears the more positive influence on service creation needs .Therefore the hypothesis is supported.



Note: 1: *p<.05 **p<.01

Figure 2 Structural equation analysis results

CONCLUSION

In this study,discovering the mutual relations between the consumption value of viewpoint and service creation .Gaining the further explanation at the same time, saying basing on elderly home-living needs attributes for interfering variation,it's practical meaning . Current,to elderly group's individual and family,will be able to better up home-living mode via service creation practical contents. more efficient management and improving it's organization to elderly group's home-living service creation. For example: Providing elderly groups individual and family home-living medical service, the convenience of planning schedules for the elderly.As well as combing with offering “Cloud Top” intelligent medical service Convenient for the

elderly's home-living medical creation service.

LIMITATIONS AND FUTURE RESEARCH SUGGESTIONS

This study is verified by designing and data collecting with best. Still some Points of study Constraint Remarks:

(1) Paper questionnaire during distributing on campus Course processing, is unable to predict the numbers of attendees. So that increasing the difficulty of effective sample recycling backed.

(2) The service innovation of the elderly In-home hold attributes discussed in this study is only for the questionnaire survey of the individual and family members of the elderly In-home. For the technical and system equipment-side organization service industry and managers, it needs more Empirical research is explored.

(3) Future Studies Direction Besides the relative studies, continuous studying can help find out the interfering variation of elderly group's home-living Care taking care-taking attribute. Further on different kinds of environment modes Basis on home-living Studying environment. transferring into Community Day- care center and nursing-living place. Tidd, J.&Hull,F.(2003)Said: service Creation is based con new mode of service very different from the old service Can contracting on service transferring process via a new method.Or issuing the problem solving plan transferring , attaching the value to Customers. Thus, the future studies can focus on as said topic doing further researches.

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WHAT FACTORS INFLUENCE PEOPLE TO ABANDON THEIR ONLINE SHOPPING CARTS?

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Abstract

The main objective of this study is to understand better what influences consumers to leave an online shopping cart before making a purchase so that organizations with e-commerce websites can take preventative steps to help their sales from being impacted. The survey was distributed to students taking undergraduate level business courses in a public university in the Northeast region. The variables in this study included perceived waiting time, perceived risk/privacy and security concerns, transaction inconvenience, entertainment value, research tool, intention to wait for a lower price, and lack of physical examination. We ran a full regression model on the data as well as several reduced models. The results showed that specific factors led to abandonment more than others. Entertainment value and perceived risk were statistically significant in relation to shopping cart abandonment. Using the shopping cart as a research tool was found to be moderately significant in regard to the dependent variable.

Keywords: E-Commerce, Online Shopping Cart Abandonment, Entertainment Value, Perceived Risk, Research Tool

Introduction

Having an understanding of which factors play a role in consumers' decision making is extremely important to businesses. It can be challenging for companies to predict and forecast sales accurately, but understanding which driving factors influence buyers to make purchases and which factors influence them to walk away from purchases is important and valuable. Many

businesses invest resources to understand their target demographics' buying traits better. Having an understanding of factors such as who their demographic is, where they tend to shop, and what drivers influence their spending decisions assists a company in marketing to its audience better. When it comes to online shopping behaviors, unless companies are collecting data on website visitors before they make a purchase, it can be difficult to know who is coming to the website, who is putting items into the shopping cart, and why some consumers decide not to make a purchase. "While marketing literature is replete with investigations focusing on virtually every aspect of consumer and shopping behavior, little academic research focus has been directed toward understanding why consumers abandon a shopping cart towards the end, after they have selected the product" (Rajamma, Paswan & Hossain, 2009). The importance of our research lies in analyzing the human behavior and the perceived hesitations that lead to shopping cart abandonment.

Past studies introduced us to variables such as perceived waiting time, perceived risk/privacy security concerns, perceived transaction inconvenience, using the cart as a research tool, intention to wait for a lower price, entertainment value, and lack of physical examination. Except for perceived waiting time, these all have positive relationships in relation to shopping cart abandonment. We adopted research questions from the relevant literature in order to gain further information and insight into what leads to the abandonment of an online shopping cart (Rajamma et al., 2009; Kukar-Kinney & Close, 2010; Cho, 2003; Kummar, Thakur & Gour, 2016; Egeln & Joseph, 2012; Moore & Mathews, 2006; Huang, Korfiatis & Chang, 2016). Some studies do not specifically relate to shopping cart abandonment but either to e-commerce or to shopping in a physical location (Lian & Yen, 2014; Liang, 2016; Changchit, Cutshall, & Lee, 2014; Sreya & Raveendran, 2016). They relate to our study as they tested same independent variables we use to determine if any of them is statistically significant regarding shopping cart abandonment. They focus on the variables of perceived waiting time, perceived risk/privacy security concerns, using the cart as a research tool, intention to wait for a lower price, and lack of physical examination. However, no prior studies analyze shopping cart abandonment directly concerning entertainment value, perceived waiting time, or perceived security risks. Therefore, our research paper will attempt to fill in the gaps from the literature.

We aim to discover which attributes are important when drawing customers to your website and which factors could influence consumers to abandon their online shopping carts. Studies estimate that approximately 60-75 percent of shopping carts are abandoned before purchase is made (Goldwyn, 2002; Eisenberg, 2003; Oliver and Shor, 2003; Gold, 2007). Our research will contribute insight into what influences people not to make an online purchase after they have added item(s) to their shopping carts. This will help to provide businesses with insight on which factors negatively contribute to consumers' purchases so that they can make efforts to prevent those factors affecting customers in the future.

The sample data is collected from a population of 2000 undergraduate students in the School of Business at a public university in the northeast of the United States. An in-class survey is distributed to business major students.

We summarize previous studies and develop research hypotheses in the next section titled Literature Review. The methodology section describes the variables and analytical model. The results section reports the statistical results for shopping cart abandonment. Managerial implications are presented in the discussion section. The last section will conclude and summarize our study.

Literature Review

Shopping Cart Abandonment Studies

Rajamma et al. (2009) explained the three drivers in shopping cart abandonment: perceived waiting time, perceived risk, and perceived transaction inconvenience. Transaction inconvenience had the most statistical significance in regard to online shopping cart abandonment. Kukar-Kinney & Close (2010) examined the following variables: entertainment value, research tool, intention to wait for a lower price, and privacy/security concerns. The research showed that using the cart as a research tool, waiting for a sale, concern over total cost, and concern over online security, all showed signs of leading towards shopping cart abandonment. Cho (2003) found constructs that lead to a likelihood of shopping cart

abandonment such as: lack of physical examination, concerns over delivery and return, the frequency of purchasing from catalogs, and past purchasing experiences online. These risk perceptions were confirmed to have a directly negative effect on abandonment. Results of the Kumar, Thakur & Gour (2016) showed that information search and convenience were significantly correlated with online shopping. Egeln & Joseph (2012) revealed that there is a positive significant correlation between the strength of perceived ownership in intended behavior and perceived ownership in actual behavior. Moore & Mathews (2006) explained that the greatest risk associated with shopping online was performance and the financial risks associated with the purchase itself. Huang, Korfiatis & Chang (2016) showed that convenience, timeliness, speed, entertainment, interest and fashionableness were the top positive attributes for abandoning an online shopping cart. The negative attributes included lack of safety, too small screen size, unstable connection, complex operation, slow speed and privacy concerns.

Relevant Variable Studies

Lian & Yen (2014) explained that just like younger consumers, older consumers are driven to shop online by performance expectation and social influence. The major barriers for older generations are value, risk and tradition. The Liang (2016) study concluded that 87.2% of the respondents would wait 30 minutes when making an important purchase. It is concluded that if a company improves their waiting setting, that customers are more likely to wait longer times in order to make the purchase. Changchit, Cutshall, & Lee (2014) found there was no significant differences between Taiwanese and Americans when it came to online shopping. Both cultures showed that the perceived benefits of online shopping included better prices, more selection, and less time consuming than doing the same in a brick and mortar store. Sreya & Raveendran (2016) determined that online shoppers are still hesitant about financial transaction over the internet. They noted that secure payment gateways could be established to help obtain consumer confidence. The research identified five perceived risks: payment/transaction risk, hidden charges risk, product risk, privacy, and time risk.

Theoretical Background

Rajamma et al. (2009) and Kukar-Kinney & Close (2010) serve as a framework for our research. Rajamma et al. (2009) showed much insight into the resources an organization used to understand why consumers abandoned their online shopping carts. The three drivers in shopping cart abandonment in this study were: perceived waiting time, perceived risk, and perceived transaction inconvenience. However, more independent variables could have been tested the reason behind why a consumer might abandon a website in the final stage of completion. Another caveat of Rajamma et al. (2009) was that it was so focused on the final stage of the shopping process, that it did not help consumer attitudes at the beginning and middle stages of the process as well. Not paying attention to the consumer attitudes at these stages might have led to a decrease in satisfaction in the final checkout phase.

Kukar-Kinney & Close (2010) analyzed what factors could drive shopping cart abandonment. However, they identified some limitations in their study. First, their sample only included shoppers residing in the United States. Expanding the sample to include international shoppers could lead to other results. Second, their findings were based on self-reported surveys. Using more precise methods, like clickstream models or in-depth experiments could provide a complimentary piece to their existing data collection. Finally, one could go even further and look into shopping cart abandonment for certain types of products. To see if there is any correlation there.

Hypothesis Development

Perceived waiting time can hinder a customer's outlook on the consumer process as a whole. This is the amount of time that an individual has to wait for a good or service. Waiting time becomes more of a factor for online shopping as opposed to in-store shopping because online shoppers are known as individuals who are time conscious. When a website has lengthy forms to complete and timely downloads or uploads, a customer is more likely to abandon their shopping cart. Rajamma et al. (2009) showed that perceived waiting time was significant in the influence of shopping cart abandonment ($p=0.044$). However, the results did not support the hypothesis that perceived waiting time to complete a transaction is positively associated with the propensity to abandon the shopping cart. The study showed that when perceived waiting time increased,

shopping cart abandonment reduced. Rajamma et al. (2009) believed that the negative relationship could have occurred due to the time and effort that the customer has already put into the shopping process. Liang (2016) proved a hypothesis in which improvements of the waiting environment that create or increase enjoyable waiting time experiences are likely to reduce customers' perceived waiting time ($p<0.001$). 87.2% of the respondents would wait thirty minutes when they were making an important purchase. The extant literature are not clear about the direction of impacts of perceived waiting time on the shopping cart abandonment. In this study, we hypothesize that perceived waiting time may influence shoppers to abandon online shopping carts.

H1: Perceived waiting time has impacts on shopping cart abandonment.

As with all online activity, people may have concerns over privacy and security. Potential consumers may not be willing to give out their financial information if they do not feel comfortable with the website. Also, websites may ask a customer for more information than they are willing to provide (i.e. credit card information, birthdate, last four digits of their social security number, etc). If they are concerned over security, then they could not complete the order and abandon their shopping cart. Rajamma et al. (2009) identified perceived risk as a significant factor to shopping cart abandonment. Consumers have fears that websites are not secure and do not have privacy settings that will keep their data secure. Lian et al. (2014) found that in older consumers, a barrier for shopping online is the perceived risk of security. There is a greater concern among older consumers for making financial transactions online and with the amount of security that is available with e-commerce sites. This leads to greater shopping cart abandonment. Egeln et al. (2012) found that out of the six dimensions of risk, the most common perceived risk for abandoning a shopping cart was financial risk. Moore et al. (2006), explained that the greatest risk associated with shopping online was the financial risks associated with the purchase itself. Changchit et al. (2014) found that compared to American shoppers, Taiwanese shoppers were more likely to have security concerns with providing personal information while shopping online. All of these studies show that concerns with perceived security risks would have a positive relationship with shopping cart abandonment. Unlike the studies above, Kukar-Kinney & Close (2010) found that privacy and security concerns had a negative impact on a

shopper's intention to abandon a shopping cart. In particular, they predicted that the degree to which online shoppers are concerned about their online privacy and security should directly impact if they abandon their online shopping carts. Most literature shows perceived risk/ privacy security concerns were found to have positive relationships to shopping cart abandonment. Therefore, we hypothesize that individuals are more likely to abandon a shopping cart when perceived security risk increases.

H2: Perceived security risk is positively related to shopping cart abandonment.

Transaction inconvenience occurs when customers of e-commerce websites do not receive the fast and efficient service that they expect when using an online shopping source. A specific example of perceived transaction inconvenience is when a customer goes through the entire checkout process and is then revealed that they have to pay a high shipping and handling fee that was not announced at the beginning of the process. Rajamma et al. (2009) concluded that transaction inconvenience had the most statistical significance in regard to online shopping cart abandonment. Consumer's perceived transaction inconvenience is mainly derived from complicated order forms, website glitches, and lack of flexibility on the website itself. Transaction inconvenience was found to significantly influence shopping cart abandonment ($p=0.01$). Kumar (2016) found that convenience was a significant determinant for making online purchases. Therefore, if there were transaction inconveniences, it would result in a positive relationship of cart abandonment. Therefore, we hypothesize that individuals are more likely to abandon a shopping cart when transaction inconvenience increases.

H3: Transaction inconvenience is positively related to shopping cart abandonment.

Online shopping as a form of entertainment value can lead to shopping cart abandonment. Studies have shown that some individuals shop online for fun or to dissipate boredom. It is similar to window shopping in brick-and-mortar stores. In situations like these, the shoppers have no intention of purchasing a product. Therefore, they leave their shopping cart unattended when done. Changchit et al. (2014) provided insight into why consumers would use their online shopping carts for entertainment purposes. It was shown that the entertainment aspects of online

browsing and purchasing activities have increased the rate at which customers will abandon their online shopping carts. Kukar-Kinney & Close (2010) found that the more consumers seek entertainment from online cart use, the more likely they are to use their shopping cart for research and as an organizational tool. The study showed that the more consumers use a cart for research and as an organizational tool, the more likely they are to abandon their purchases in it. The results showed the greater use of a shopping cart for entertainment purposes, the more likely the respondents would abandon their online shopping cart ($p<0.01$). Therefore, we hypothesize that individuals are more likely to abandon a shopping cart when entertainment value increases.

H4: Entertainment value is positively related to shopping cart abandonment.

Another way individuals use online shopping is as a research tool. In these scenarios, they gather information about the various products they are interested in. Their shopping cart compiles a list of the products in question, allowing them to identify the key information about them quickly. The more research a consumer does, the likelier chance of them finding a better place to buy the product. Therefore, the more a customer uses their cart to perform research, the more likely they are to abandon it. Changchit et al. (2014) provided insight into how the Internet is used as a research tool by online shoppers and not necessarily for customers to purchase items. Kukar-Kinney & Close (2010) showed that using the cart as a research tool showed signs of leading towards shopping cart abandonment ($p<0.01$). Therefore, we hypothesize that individuals are more likely to abandon a shopping cart when use of shopping cart as a research tool use increases.

H5: Research tool use is positively related to shopping cart abandonment.

Along the same lines as using the cart as a research tool, consumers also hold items in their cart as they wait for a lower price. When they have all of the items in the cart, the total price of all the items may discourage them from continuing. If they are concerned with the overall price, they are more likely to wait for sales or a discount. This indirectly can lead to a shopping cart being abandoned. Kukar-Kinney & Close (2010) found a positive relationship between waiting for a lower price and abandoning a shopping cart. When shopping online, consumers are found to be

more likely to abandon their carts if the items in the carts are not on sale, the price of those items or shipping costs and/ or handling costs are too high, or taxes are too high. Being able to put items in a cart and wait before purchasing them allows customers to research pricing and either to make a purchase when they are comfortable with costs or to abandon the items in the cart. Sreya & Raveendran (2016) determined that payment-related risk during online shopping occurs when consumers perceive that online payments are not safe or that they may lose money if the same product is available at lower prices in physical stores. This leads to a positive relationship of increasing the likelihood of consumers abandoning their shopping carts. Therefore, we hypothesize that individuals are more likely to abandon a shopping cart when the intention to wait for a lower price increases.

H6: Intention to wait for a lower price is positively related to shopping cart abandonment.

When a consumer does not have the ability to physically examine a product before purchasing it, this can increase the chance that the consumer will abandon the items in a shopping cart before completing the transaction. The majority of e-commerce sites provide descriptive information about the product, as well as photos and customer reviews. Even though there is information available about most products for consumers to review before making a purchase, some consumers feel that the lack of in-person examination is a reason not to move forward with an online transaction. Cho (2003) ran tests to determine what constructs would make an impact on whether consumers would abort an online transaction or not. The lack of physical examination had a significant positive influence on aborting a transaction. Sreya & Raveendran (2016) determined that some consumers are wary about making financial transactions online for a number of different reasons. They identified the inability to touch and feel products that they are purchasing would negatively influence a consumer's intention to complete a transaction. Consumers are unable to touch or try on products such as clothes and shoes when purchasing online. Because of this, there is an increased risk of those consumers abandoning their purchases. Therefore, we hypothesize that individuals are more likely to abandon a shopping cart when there is an inability to examine a product physically before purchasing it online.

H7: The lack of physical examination of a product is positively related to shopping cart abandonment.

Methodology

Perceived Waiting Time

Perceived waiting time is the amount of time that a consumer has to wait for a good or service. When a website has lengthy forms to complete and timely downloads or uploads, a customer is more likely to abandon a shopping cart. Rajama et al. (2009) discussed perceived waiting time. Different items that contributed to an increased waiting time or transaction inconvenience were complicated order forms, website glitches, and lack of flexibility on the website itself. To measure the perceived waiting time construct, we modified three items from Rajama et al. (2009) as follows:

- I tend to abandon my online shopping cart when I have to wait for more than 10 seconds for a web page to load.
- I tend to abandon my online shopping cart when it takes more than 10 seconds for the site to process my order.
- I tend to abandon my online shopping cart when it takes a while to confirm my online purchases.

Perceived Risk/Privacy Security Concerns

There is an increase in concerns over privacy and security, especially when consumers are asked to provide their financial information. If consumers are concerned over security, that could lead them not to complete their orders and to abandon their shopping carts. There were a few studies we analyzed that used perceived risk and security concerns as a variable. One of them was Kukar-Kinney & Close (2010). They conducted an online survey with both students and adults. Among the answers for cart abandonment were concerns over online security. Another study with this variable was Rajamma et al. (2009). The study found that perceived risk was the second most common reason why people abandoned their cart. To measure the perceived risk/privacy

security concerns construct, we modified three items from Kukar-Kinney & Close (2010) as follows:

- I am concerned that someone will steal my identity.
- I am concerned that the retailer will share my information with third parties.
- Internet privacy is important to me.

Transaction Inconvenience

Transaction inconvenience occurs when customers of e-commerce websites do not receive the fast and efficient service that they expect when using an online shopping source. When situations arise that cause consumers to be inconvenienced during transactions, they are more likely to abandon their shopping carts. Rajamma et al. (2009) discussed multiple variables in addition to transaction inconvenience. A survey was conducted in which undergraduate students in the business schools at two different universities volunteered to complete the questionnaire. Perceived transaction inconvenience was found to be the most common reason given for shopping cart abandonment. Another study to use this variable was Kumar & Thakur (2016). To measure the transaction inconvenience construct, we modified three items from Rajamma et al. (2009) as follows:

- I tend to abandon my online shopping cart when the online shop requires me to register before making a purchase.
- I tend to abandon my online shopping cart when order forms are lengthy.
- I tend to abandon my online shopping cart when technical glitches occur on the website.

Entertainment Value

Entertainment value is what some consumers get out of the process of online shopping. Studies have shown that some individuals shop online for fun or to dissipate boredom. Typically, these shoppers have no intention of purchasing a product. Therefore, they leave their shopping cart unattended when done. Using an online shopping cart as entertainment value was a construct that appeared in both Kukar-Kinney & Close (2010) and Huang et al. (2018). Essentially, they found that the more items added to a cart for entertainment purposes, the greater the chance that the

same cart will be abandoned. To measure the entertainment value construct, we modified three items from Kukar-Kinney & Close (2010) as follows:

- I select and place items in my shopping cart for fun.
- I select and place items in my shopping cart when I am bored.
- I enjoy online shopping.

Research Tool

Using online shopping carts as a research tool, consumers can easily gather information about the various products they are interested in. Their cart allows them to compile a list of the products in question, allowing them to quickly identify the key information about them. The more research a consumer does, the likelier the chance of them finding a better place to buy the product and to abandon the shopping cart. Kukar-Kinney & Close (2010) focused on shoppers using their carts as a research tool. An online survey was conducted that mimicked characteristics found in the U.S. population. Using the online cart as a research tool was among the responses given by consumers. To measure the research tool construct, we modified three items from Kukar-Kinney & Close (2010) as follows:

- I place items in my shopping cart so I can more easily evaluate a narrowed-down set of options.
- I use the shopping cart as a form of information gathering.
- I use the shopping cart as a shopping research tool.

Intention to Wait for a Lower Price

Similar to using an online shopping cart as a research tool, consumers also hold items in their cart as they wait for a lower price. When they have all of the items in the cart, the total price of all the items may discourage them from continuing. If they are concerned with the overall price, they are more likely to wait for sales or a discount. This can lead to a shopping cart being abandoned. Kukar-Kinney & Close (2010) also looked at additional constructs for why shoppers may abandon their carts. They found that many people added items to their carts with the intention of waiting for a lower price. They would wait for sales for products in which they were

interested, and, if it did not happen, then they would abandon their carts. To measure the intention to wait for a lower price construct, we modified three items from Kukar-Kinney & Close (2010) as follows:

- I decide to wait for the item to come on sale before buying it.
- I decide that I may be able to find better sales at another online store.
- I decide that I may be able to find better sales at a land-based store.

Lack of Physical Examination

Lack of physical examination is when a consumer does not have the ability to physically examine a product before purchasing it. Cho (2003) researched whether this impacted consumers from abandoning their shopping carts if they were unable to physically examine products before purchasing. The study determined that a lack of physical examination led to a high likelihood that a shopping cart would be abandoned. Cho (2003) focused on apparel retail shopping. Three sections of a focus group were interviewed and asked to rank various scenarios. From there a questionnaire was developed and sent to 1,000 randomly selected people. One of the reasons the sample population gave for abandoning their carts was the lack of physical examination when shopping online. To measure the lack of physical examination construct, we modified three items from Cho (2003) as follows:

- I worry that the product I receive will not perform the way I expected.
- I worry the product I receive will not be the one I ordered.
- I am unable to judge the quality of a product by actually examining it.

Shopping Cart Abandonment

This is when consumers place items in their online shopping carts and then right before moving forward with purchasing the item(s), consumers will close out of the website and not complete the transaction. The studies we have analyzed have all proposed numerous reasons as to what causes shopping cart abandonment. In our paper, we hope to expound upon those variables to further determine how they can cause abandonment. To measure the shopping cart abandonment

construct, we modified two items from Kukar-Kinney & Close (2010) and one item from Cho (2003) as follows:

- I tend to leave items in my online shopping cart without buying them (Kukar-Kinney & Close, 2010).
- I often close out of webpages before purchasing items in online cart (Cho, 2003).
- I often hesitate when it comes to purchasing the items in my online cart (Cho, 2003).

Analytics Model

We will build regression models for this sample data. This research employs a multiple regression model. In the model, the dependent variable is "Shopping Cart Abandonment". Independent variables are "Perceived Waiting Time", "Privacy Security Concerns", "Transaction Inconvenience", "Entertainment Value", "Research Tool", "Intention to Wait for a Lower Price", and "Lack of Physical Examination".

$$Y_1 = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7$$

where Y_1 = Shopping Cart Abandonment

X_1 = Perceived Waiting Time

X_2 = Perceived Risk/Privacy Security Concerns

X_3 = Transaction Inconvenience

X_4 = Entertainment Value

X_5 = Research Tool

X_6 = Intention to Wait for a Lower Price

X_7 = Lack of Physical Examination

Results

Sample Data and Descriptive Statistics

We received 124 viable survey responses from about 2,000 students taking undergraduate level business courses from a Northeast public university. The survey was distributed to students by the course instructor. If a sample was incomplete with missing values, it was discarded.

Males accounted for 52.4% of the respondents, females 45.2% and other .8%. Of the respondents, 103 selected that they are between the ages of 18 to 24. This accounts for 83.4% of those who participated in this survey. Fifteen people, 12.1% of respondents, selected that they are between the ages of 25-34. Three people, 2.4% of respondents, selected that they are between 35 to 44 years of age. One person, .8% of the respondents, indicated an age range of 45 to 54 years old. Of the respondents, 46% have completed some college, 12.1% have a 2-year college degree, 37.9% have a 4-year college degree and .8% have a doctoral degree. Of those who took this survey, 66.1% selected that their income is less than $25,000, 14.5% selected that their income is between $25,000 and $40,000, 2.4% selected that they made between $41,000 and $60,000, 3.2% selected that they made between $61,000 and $80,000, and 2.4% said their income is $81,000 or more. In summary, the majority of respondents were male, between the ages of 18 to 24, had some college completed, and made less than $25,000.

The mean for X1 (perceived waiting time) is 3.10±1.46 and the data is positively skewed. The mean for X2 (perceived risk/privacy security concerns) is 4.81±1.39 and the data is negatively skewed. The mean for X3 (transaction inconvenience) is 4.62±1.28 and the data is negatively skewed. The mean for X4 (entertainment value) is 4.26±1.65 and the data is positively skewed. The mean for X5 (research tool) is 4.35±1.63 and the data is negatively skewed. The mean for X6 (intention to wait for a lower price) is 4.67±1.09 and the data is negatively skewed. The mean for X7 (lack of physical examination) is 4.08±1.28 and the data is positively skewed. The mean for Y1 (shopping cart abandonment) is 4.37±1.53 and the data is negatively skewed. The majority of the variables were negatively skewed except for X1, X4 and X7.

Table 1. Descriptive Statistics of Constructs

	n	Minimum	Maximum	Mean	Std. Dev.	Skewness Statistic	Skewness Std. Error	Kurtosis Statistic	Kurtosis Std. Error
X1	124	1.00	7.00	3.1048	1.45599	.492	.217	-.179	.431
X2	124	1.33	7.00	4.8065	1.39304	-.259	.217	-.691	.431
X3	124	1.67	7.00	4.6156	1.27660	-.247	.217	-.313	.431
X4	124	1.33	7.00	4.2634	1.64142	.171	.217	-1.021	.431
X5	124	1.00	7.00	4.3468	1.62767	-.179	.217	-.681	.431
X6	124	1.67	7.00	4.6694	1.08907	-.327	.217	.020	.431
X7	124	1.33	7.00	4.0753	1.27911	.040	.217	-.427	.431
Y1	124	1.00	7.00	4.3710	1.53149	-.185	.217	-.744	.431

Pearson Correlation Analysis

Table 2 reports that Entertainment Value (X4) was the most closely related with our dependent variable of Y1, shopping cart abandonment (r = 0.515). This was followed by X5, Research Tool (r = 0.423). Therefore, we will include these variables in our regression analysis.

Table 2. Pearson Correlation Matrix 1

	Y1	X1	X2	X3	X4	X5	X6	X7
Abandonment (Y1)	1	.181	.154*	.129	.515**	.423**	.234**	.173*
Perceived Waiting Time (X1)		1	.288*	.447	.147	.021	.046	.125
Perceived Risk (X2)			1	.348	-.015	.104	.096	.395**
Transaction Inconvenience (X3)				1	.006	.036	.143	.359**
Entertainment Value (X4)					1	.593**	.172*	.114
Research Tool (X5)						1	.252**	.188*
Intention to Wait for Lower Price (X6)							1	.247**
Lack of Physical Examination (X7)								1

*p<0.05, **p<0.01 (2-tailed)

Regression Model

Our full regression model is not very strong as shown in Table 3. The adjusted R^2 is only 0.280. Additionally, only one of our variables, Entertainment Value (X4) is statistically significant (p<0.01). This indicates that we will need to create reduced models that remove different variables to identify which model is the strongest.

Table 3. Full Regression Model

Dependent Variable = Shopping Cart Abandonment				
	B	S.E.	Beta	t
Constant	.448	.726		.617
X1	.067	.095	.064	.712
X2	.102	.098	.093	1.038
X3	.035	.115	.029	.301
X4	.376	.092	.403	4.107**
X5	.125	.098	.132	1.270
X6	.147	.116	.104	1.267
X7	.019	.107	.016	.176

*p<0.05, **p<0.01 (2-tailed)

Reduced Models

We performed a reliability test of each variable using Cronbach's Alpha. Any variables with a rating of 70% above are considered reliable. To increase Cronbach's Alpha, we dropped one item from Perceived risk and security (X2), Entertainment value (X4), Intention to Wait for a Lower Price (X6), and Lack of Physical Examination (X7). While Transaction Inconvenience (X3) has a low Cronbach's Alpha, removing a variable would have a negative impact on the reliability rating. After the reliability testing was completed, we created four new variables, X2B, X4B, X6B, and X7B. With our new variables, we ran a new Pearson correlation. As Table 4 shows, variables X1 and X3 are not strongly correlated with the dependent variable of Y1. Since X3 also had a reliability rating below 70%, we chose to drop this variable from our reduced regression model.

Table 4. Pearson Correlation Matrix 2

	Y1	X1	X2B	X3	X4B	X5	X6B	X7B
Abandonment (Y1)	1	.159	.192*	.124	.541**	.442**	.236**	.215*
Perceived Waiting Time (X1)		1	.377**	.492**	.186*	.041	.015	.151
Perceived Risk (X2B)			1	.354**	.040	.086	.069	.420**
Transaction Inconvenience (X3)				1	-.009	.030	.120	.306**
Entertainment Value (X4B)					1	.553**	.161	.137
Research Tool (X5)						1	.276**	.215*
Intention to Wait for Lower Price (X6B)							1	.205*
Lack of Physical Examination (X7B)								1

*p<0.05, **p<0.01 (2-tailed)

Our first reduced regression model included the variables of X1, X2B. X4B, X5, X6B, and X7B. In this model, the adjusted R^2 increased to 0.327, and the overall model is significant. However, only one variable is statistically significant. That is again Entertainment Value (X4B). Since Perceived Waiting Time (X1) was the next variable that had the least correlation to our dependent variable, we will drop that variable from the regression model.

Table 5. Reduced Regression Model 1

Dependent Variable = Shopping Cart Abandonment				
	B	S.E.	Beta	t
Constant	1.193	.587		2.033*
X1	.018	.088	.017	.207
X2B	.115	.079	.129	1.463
X4B	.302	.066	.422	4.599**
X5	.147	.086	.159	1.701
X6B	.129	.096	.106	1.346
X7B	.048	.091	.045	.527

*p<0.05, **p<0.01 (2-tailed)

Our second reduced regression model included the variables of X2B, X4B, X5, X6B, and X7B. In this model the adjusted R^2 increased to 0.332 which is a slight improvement. Again, the overall model is significant. Still, only one variable is statistically significant. This is again Entertainment Value (X4B). This time Research Tool (X5) is marginally significant. Lack of Physical Examination (X7B) has the greatest p-value of 0.600. Since it seems to have the least impact on Y1, we will remove it from the regression model.

Table 6. Reduced Regression Model 2

Dependent Variable = Shopping Cart Abandonment				
	B	S.E.	Beta	t
Constant	1.223	.565		2.165**
X2B	.121	.073	.135	1.655
X4B	.305	.064	.426	4.775***
X5	.145	.086	.157	1.696*
X6B	.128	.095	.106	1.348
X7B	.048	.091	.044	.526

*p<0.10, **p<0.05, ***p<0.01 (2-tailed)

Our third reduced regression model included the variables of X2B. X4B, X5, and X6B. In this model, the adjusted R^2 increased to 0.337. Again, the overall model is significant. This time we found two variables were statistically significant. Perceived Risk/Security concerns (X2B) is now statistically significant in addition to Entertainment Value (X4B). Also, Research Tool (X5) is marginally significant. So far, this is the model that has the best-fit for our data.

Table 7. Reduced Regression Model 3

Dependent Variable = Shopping Cart Abandonment				
	B	S.E.	Beta	t
Constant	1.300	.544		2.389*
X2B	.136	.066	.153	2.058**
X4B	.306	.064	.427	4.806***
X5	.150	.085	.162	1.774*
X6B	.136	.094	.112	1.448

*p<0.10, **p<0.05, ***p<0.01 (2-tailed)

After running reduced regression models, it was determined that Reduced Model 3 was our best-fit model, as summarized in Table 8. Of all the models, the adjusted R^2s are in the same range. The Reduced Model 3 is the only model that has three variables with statistical significance.

Table 8. Summary of Regression Models

Model	Predictors	Adjusted R^2	F	t
Full	X1, X2, X3, X4, X5, X6, X7	0.280	6.983**	2.389*
Reduced 1	X1, X2B, X4B, X5, X6B, X7	0.327	10.791**	2.058**
Reduced 2	X2B, X4B, X5, X6B, X7	0.332	13.048**	4.806***
Reduced 3	X2B, X4B, X5, X6B	0.337	16.342**	1.774*

*p<0.05, **p<0.01

Discussion

In general, our results supported our hypotheses as to which factors lead to shopping cart abandonment. For our variable of perceived waiting time, our research showed that it had a positive relationship with shopping cart abandonment. This was in line with Liang (2016), but

not with the other (Rajamma et al., 2009). Because online shoppers are mostly time conscious, the consumer may leave the website all together if there is a lengthy checkout process. One caveat regarding Rajamma et al. (2009), is that it was so focused on the final stage of the shopping process that it did not consider consumer attitudes at the beginning of the process as well. Our hypothesis was not in line with this study. Even though Liang (2016) does not talk about shopping cart abandonment or online shopping, it addresses one of our identified variables: perceived waiting time. This study gives insight into how a store's waiting setting makes a difference in the results and how this is different from the setting of an e-commerce setting. One result from the survey concluded that 87.2% of the respondents would wait 30 minutes when making an important purchase. It is concluded that if a company improves their waiting setting, that customers are more likely to wait longer times in order to make the purchase. In these instances, their perceived waiting time could be shorter than the actual time they waited for the item.

Most of the articles we researched involving the variable of perceived risk/ privacy security concerns were found to have positive relationships to shopping cart abandonment. Our research supported these findings, showing a positive and statistically significant relationship to the dependent variable. Rajamma et al. (2009) concluded that transaction inconvenience would be the most significant to shopping cart abandonment. After this, perceived risk was determined to be the most significant to shopping cart abandonment. Consumers have fears that the website is not secure and does not have privacy settings that will keep their data secure. Kukar-Kinney & Close (2010) concluded that the hypotheses, such as using the cart as a research tool, waiting for a sale, concern over total cost, and concern over online security, all showed signs of leading towards shopping cart abandonment. The results of Egeln & Joseph (2012) showed that the most common risks in intended purchase behavior is the financial and psychological risk that consumers expect to experience. Results revealed that there is a positive significant correlation between the strength of perceived ownership in intended behavior and perceived ownership in actual behavior. Results from Moore & Mathews (2006) showed that the greatest risk associated with shopping online was performance and the financial risks associated with the purchase itself. However, there is variability in how participants view risk. Brand was determined as a sufficient factor to cause a participant to make a purchase. Some participants noted that price was a driver

in making a purchase decision. In some cases, design did have an influence, however not as much as brand and reputation. Reputation was identified as the strongest individual extrinsic cue that affecting performance evaluation. While not directly referencing shopping cart abandonment, Changchit et al. (2014) touches upon perceived security risk that shoppers can have with online shopping in general, and how it could impact their purchases. It found that Taiwanese shoppers were more likely to have had negative past experiences with online shopping, in addition to being more uncertain over the process in general and having security concerns.

For transaction inconvenience, past literature concluded that it had the most statistical significance in regard to online shopping cart abandonment (Rajamma et al., 2009). Kumar (2016) found that transaction inconvenience would have a positive relationship on cart abandonment. Our data reflected this variable had a positive relationship. However, our regression model did not show statistical significant for transaction inconvenience. We attribute this result to our questionnaire. It could have been worded more clearly. In certain situations, double negatives were used. This could have confused our survey participants. Rajamma et al. (2009) concluded that transaction inconvenience had the most statistical significance in regard to online shopping cart abandonment. Perceived transaction inconvenience is mainly derived from complicated order forms, website glitches, and lack of flexibility on the website itself. The results of Kumar, et al. (2016) indicated that information search and convenience both have statistically significant correlations with online shopping. The information search did have a stronger relationship with online shopping. It was found that information-search was a greater motivator for shoppers since they could quickly find information such as warranty, price and availability.

Changchit et al. (2014) detailed why consumers could potentially use their shopping cart for entertainment value. Kukar-Kinney & Close (2010) found this variable would have a positive relationship with shopping cart abandonment. Our findings supported the extant literature. Additionally, this was one of our most statistically significant variables. It was one of the only variables that was significant in each of the regression models we created. This could be because of the population we surveyed. Undergraduate college students are likely to have less income,

and therefore could use online shopping as a form of entertainment. The variables that Kukar-Kinney & Close (2010) included were entertainment value, research tool, intention to wait for a lower price, and privacy/security concerns. The study found that the results support 10 of the 11 hypotheses that were created. Essentially, they found that the more items added to a cart for entertainment purposes, the greater the chance that same cart will be abandoned.

We hypothesized that using online shopping as a research tool would have a positive impact on shopping cart abandonment. This was based on the findings of multiple studies (Changchit et al., 2014, Kukar-Kinney & Close, 2010). Our results corroborated this hypothesis. "Research tool" was one of our strongest variables. It was included in our best-fit regression model and was marginally significant to shopping cart abandonment. The variables that Kukar-Kinney & Close (2010) included were entertainment value, research tool, intention to wait for a lower price, and privacy/security concerns. Kukar-Kinney & Close (2010) concluded that the hypotheses, such as using the cart as a research tool, waiting for a sale, concern over total cost, and concern over online security, all showed signs of leading towards shopping cart abandonment.

Kukar-Kinney & Close (2010) and R. & Raveendran (2016) both found that there was a positive relationship between the intention to wait for a lower price and shopping cart abandonment. Our hypothesis went along with their past findings. Our data supported these findings. Intention to wait for a lower price had a positive relationship and was included in our best-fit regression model. Kukar-Kinney & Close (2010) concluded that the hypotheses, such as using the cart as a research tool, waiting for a sale, concern over total cost, and concern over online security, all showed signs of leading towards shopping cart abandonment. Sreya & Raveendran (2016) determined that online shoppers still hesitate about financial transactions over the internet. They noted that secure payment gateways could be established to help obtain consumer confidence. Cho (2003) had constructs that would influence attitudes towards e-commerce. These constructs were: product offering, control in the information search, attitude toward catalog retailing, effort saving, and time spent on the internet per visit. The study found constructs that lead to a likelihood of shopping cart abandonment. Those constructs were: lack of physical examination, concerns over delivery and return, the frequency of purchasing from catalogs, and past

purchasing experience online. These risk perceptions were confirmed to have a direct positive effect on abandonment.

We hypothesized that the lack of physical examination would have a positive impact on shopping cart abandonment. We found mixed results from this variable. While our data did show it to have a positive impact with shopping cart abandonment, the variable was not statistically significant. This could again be caused by our questionnaire. The lack of clear questions could have possibly clouded responses from our sample population. Sreya & Raveendran (2016) determined that online shoppers also still hesitate about financial transactions over the internet due to lack of physical examination. Clear product descriptions, zooming of product visuals and alternative images of the product are all options retailers can use to cut down on consumers perceived risk. Cho (2003) determined constructs that would influence attitudes towards e-commerce were product offering, control in the information search, attitude toward catalog retailing, effort saving, and time spent on the internet per visit. The study found constructs that lead to a likelihood of shopping cart abandonment. Those constructs were lack of physical examination, concerns over delivery and returns, the frequency of purchasing from catalogs, and past purchasing experiences online. These risk perceptions were confirmed to have a direct positive effect on abandonment.

Managerial Implications

The findings of this paper can help managers when making business decisions because this provides them with an understanding of what influences consumers to make online purchases. Knowing which factors make an impact in whether someone moves forward with online purchases or abandons a shopping cart can help businesses make decisions to help influence consumers to complete a transaction and help to decrease the number of items that are abandoned in an online shopping cart.

When companies better understand their consumers buying preferences and habits, it allows for businesses to better target and spend marketing dollars on the most profitable audiences. Some audiences may be more likely to abandon their carts compared to other consumers. Having that

information can save managers time, money, and allow them to make a larger profit using fewer resources.

Conclusion

This study has shown that entertainment value and perceived risk were statistically significant in relation to shopping cart abandonment. Using the shopping cart as a research tool was found to be moderately significant in regard to the dependent variable. Other factors including gender, age, income, and education have effect on the reasons why a shopper may abandon an online shopping cart.

Further studies on shopping cart abandonment should be investigated following this study. There were many limitations of this study that could be improved upon in a later study. Other directions for this study could be increasing sample size, revising the questionnaire to provide questions that are easier to understand, and extend the questionnaire to more than just college students (i.e. individuals with a substantial income). We also noted that using the EUCS model did not provide the results for which we were hoping. Using another model, such as factor analysis, likely would help a future study of shopping cart abandonment.

This research provides insight as to which factors lead an online shopper to abandon a shopping cart. The evidence shows that specific factors lead to abandonment more than others. Businesses can use this information in order to market their goods in an online setting better and to decrease the amount of shopping cart abandonment occurrences online. This information can lead to more online profitability for companies.

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OPERATIONS MANAGEMENT AND OPERATIONS RESEARCH - ABSTRACTS

ON THE ROTATING WORKFORCE SCHEDULING PROBLEM WITH VARIOUS CONSTRAINTS

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Abstract: In this paper, we study an actual problem faced by the operational manager from a small local medical equipment manufacturer. Workers are working on various workstations during the manufacturing process. All workstations are categorized into different groups based on their impact on workers. We want to setup a working scheduling that rotates workers on the different workstations to reduce repetitive injury. The goal is to quickly find a feasible working schedule that also meets a few additional constraints such as worker break requirements, machine impact balance, etc.

Key Words: Rotating Schedule, Linear Programming, Heuristics

SCHEDULING JOBS WITH Q-TIME PROPERTY

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Abstract

In this paper, a 2-stage hybrid flowshop scheduling problem with identical parallel processors in each stage is addressed. It is assumed that a queue(Q)-time of each job, which is a waiting time to be processed in the current stage, should be less than a predetermined time due to quality issue of the product in the field of state-of-art technology manufacturing systems. To minimize makespan of jobs, several methodologies to solve the scheduling problem are devised by using dominance properties developed here. The results of the simulation experiments of the suggested ones are also presented and show better performance than the existing ones.

Keywords: Scheduling, Hybrid flowshop, Limited waiting time, Time window

THE EFFECTS OF UNCERTAINTY IN THE CONTINUOUS TIME-COST-QUALITY TRADEOFF PROJECT SCHEDULING PROBLEM

Abstract

Quality is an important priority in managing a project, and so it should be explicitly considered in project planning and scheduling. This realization has led to a stream of research that addresses how to evaluate the tradeoffs between quality, cost, and time in project decision making. Previous research incorporated a quality function with a form related to the bivariate normal distribution into a nonlinear programming model to evaluate the tradeoffs between quality, time, and cost. In this paper we extend this research by considering how *uncertainty* affects the tradeoffs. Here, uncertainty is modeled by considering the quality function parameters to be stochastic. We propose a stochastic optimization model to determine the optimal levels of time, cost, and quality when the quality function parameters are uncertain. We introduce examples using real-world data from a translation agency and a software development firm, and solve the optimization using stochastic programming and simulation. Through these two examples we show how time and/or cost parameter uncertainty can affect project quality and the decisions on how much time and cost to allocate to project tasks. These examples show that uncertainty can have a substantial effect on project quality.

Index terms: project management, quality management, project planning, project scheduling, stochastic, stochastic optimization

OPERATIONS MANAGEMENT AND OPERATIONS RESEARCH - PAPERS

A HYBRID EOQ-EMQ MODEL WITH NONLINEAR HOLDING COST AND IMPERFECT QUALITY SUBJECT TO DISTINCT DEMANDS FOR PERFECT AND REWORKED ITEMS

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ABSTRACT

This paper presents a hybrid EOQ-EMQ model with imperfect quality subject to distinct demands for perfect and reworked items for which holding cost is a nonlinear function of the amount of time a piece is held in inventory. It is assumed that the vendor operates a process that is in statistical control and ships on a lot-for-lot basis to the purchaser. Purchaser applies a 100% quality inspection policy. We further assume that the purchaser's inspection process is precise and that all perfect items are utilized to satisfy demand in a primary market while all imperfect items are reworked at a fixed unit cost to satisfy demand in a secondary market. Inspection cost per lot is a linear function of the lot size and rework rate in units per unit time (year) is a known constant. Shortage costs for perfect items are assumed to be high. Hence, shortages are not allowed for perfect parts in the primary market while permitted for reworked items in the secondary market as lost sales. Therefore, shortage costs for reworked items are levied based on the number of units short, irrespective of the duration of shortage. We also assume that the relationship between demands for perfect and reworked items is such that there is no leftover reworked pieces at the end of each cycle. For the situation described above, along with the view that holding cost follows a relationship that is nonlinear in time, the present research fosters the underlying conditions leading to shortages or excess units of reworked items. The paper also develops explicit expressions for the optimal lot size and optimal total inventory cost incurred by the purchaser in both markets for the case of shortages of reworked items. It will be shown that the more general closed-form expressions of this paper will reduce to the corresponding results of the previous research when rework rate approaches infinity and unit rework cost is zero.

Keywords: Inventory Models, Nonlinear Holding Cost, Imperfect Quality

1. INTRODUCTION

The classical Economic Order Quantity (EOQ) and Economic Manufacturing Quantity (EMQ) relationships are the results of customary optimization of total relevant inventory costs under a series of highly restrictive and simplifying assumptions including deterministic demand and lead-time, constant holding costs across time, and perfect quality of replenishment items. However, despite their extreme simplicity, these models are still frequently used in industry in the present day [2].

For the purpose of this paper, let us look at the assumption of constant holding cost. This assumption presumes that stock can be stored indefinitely to meet future demand. While this is true for many items, certain types of inventories can undergo changes in configuration, alignment, structure, strength, potency, etc. which make them unfit for consumption. To account for these and other factors, researchers have developed a class of inventory systems that model holding cost as a function of the amount of time that an item is held in inventory. Such inventory paradigms are commonly studied under the class of perishable inventory models.

Nahmias [11] presents a review of the early work in the area of perishable inventory research. He classifies perishable inventory models into two classes: fixed lifetime and random lifetime. The fixed classification includes those cases where the lifetime is known *a priori* to be a specified length of time or number of periods. Of greater interest to the current research is the random lifetime classification which includes those cases where the product lifetime is a random variable.

Weiss [12] considers a product facing a constant demand rate, fixed replenishment lead-time, a constant ordering cost, and holding cost that follows a relationship that is nonlinear in time. Specifically, the unit holding cost exhibits an increasing function of time, t, and is given by $H(t) = C_h t^{\gamma}$, where C_h and $\gamma \geq 1$ are constants. He then develops an EOQ model that minimizes average combined ordering and holding costs over an infinite horizon. Ferguson et al [13] presents an approximation of the Weiss' optimal order quantity for perishable goods such as produce and dairy products sold in small supermarkets that do not receive daily deliveries.

The EOQ and EMQ models with time-dependent holding cost, such as the one developed by Weiss [12] and applied by Ferguson et al [13], implicitly assume that all items in a lot are of perfect quality. However, due to damages caused during transportation and/or deterioration of the production process or other factors, in real situations, the perfect quality assumption of these models is open to discussion. For these reasons, many researchers have studied more realistic models that allow for imperfect quality of ordered or manufactured items [3,4,5,6]. Other related studies that have appeared in the literature are as follows. Chung [7] investigated bounds for production lot sizing under machine breakdown conditions. Assuming that the deterioration of the production process follows a random process, Porteus [8,9] and Rosenblatt and Lee [10] investigated the effect of quality on lot sizes in Economic Order Quantity (EOQ) and Economic Manufacturing Quantity (EMQ) models, respectively.

While the above authors have relaxed the perfect quality assumption, they generally presume, either explicitly or implicitly, that the imperfect quality items go through a corrective process, at some cost, to satisfy demand. Paknejad, Nasri, and Affisco [14] present an EOQ model for a situation where two distinct demands for conforming (perfect) and non-conforming (imperfect) parts are placed on a stable production process with a known process capability, represented by the proportion of non-conforming items produced.

The papers cited above assume that the unit holding cost is proportional to the duration of time an item is kept in inventory to meet a future demand. In a more recent paper, Paknejad, Nasri, and Affisco [17] study the more realistic case where holding cost follows a nonlinear function of time for a scenario where the vendor operates a process that is in statistical control, generating a known constant proportion of non-conforming items, θ. They also assume that the vendor delivers on a lot-for-lot basis in response to orders from the purchaser. Under these circumstances and upon receiving the items from the vendor, the purchaser applies a 100% quality inspection policy. Furthermore, the authors assume that the purchaser's quality inspection process is perfect so that all non-defective items in a lot are accepted to satisfy demand in a primary market and all defective items are sent as is to a warehouse to satisfy demand for defective parts in a secondary market. Inspection cost per lot is assumed to be a linear function of lot size. In addition, shortage costs for

the non-defective parts are assumed to be very high. Hence, shortages are not allowed for perfect parts in the primary market while permitted for imperfect parts in the secondary market as lost sales. Therefore, shortage cost for imperfect items is levied based on the number of units short, irrespective of the duration of shortage. Leftover imperfect units at the end of each cycle, if any, are sold (or disposed of) all at once for a fixed price (or disposal cost) per unit.

In this paper, we extend the results in [17] by assuming that the purchaser can correct the imperfect parts at a finite rework rate per unit of time by incurring a fixed rework cost per unit before sending them to the secondary market. While shortages for reworked items may occur, the paper considers the relationship between demands at the primary and secondary markets to be such that no leftover of reworked items will occur. For the scenario described above, in the next section we present the structure of the inventory system and the underlying conditions leading to shortages or excess units of reworked items. We then present the explicit relationships for the optimal lot size and optimal total inventory cost incurred by the purchaser in both markets for the case of shortages of reworked items that may arise. Finally, we conclude the findings of this research with a brief summary in the last section.

2. MODEL AND ASSUMPTIONS

The key model considered in this research is the basic EOQ model with deterministic demand, constant setup cost, and nonlinear holding cost, developed by Weiss [12] and applied by Ferguson et al [13] for approximation of the optimal order quantity of perishable goods. Assuming that the cumulative holding cost for one (perfect) unit held during t interval of time is $H(t) = C_h t^{\gamma}$, where C_h and $\gamma \geq 1$ are constants, the average inventory cost per unit time, $AC_{Weiss}(Q)$, the resulting optimal lot size, Q^*_{Weiss}, and the corresponding optimal average inventory cost per unit time, $AC^*_{Weiss}(Q)$, for Weiss' model are given by

$$AC_{Weiss}(Q) = \frac{DK}{Q} + \frac{Q^{\gamma} C_h}{(\gamma+1) D^{\gamma-1}}, \tag{1}$$

$$Q^*_{Weiss} = \sqrt[\gamma+1]{\left(1+\frac{1}{\gamma}\right)\left(\frac{D^\gamma K}{C_h}\right)}, \tag{2}$$

and

$$AC^*_{Weiss}(Q) = \sqrt[\gamma+1]{\left(1+\frac{1}{\gamma}\right)^\gamma DK^\gamma C_h}\ , \tag{3}$$

where

D = demand in units (for perfect parts) per unit time (year),

K = setup cost per setup,

C_h = cumulative holding cost per (perfect) unit per unit time (year),

AC(Q) = average inventory cost per unit time,

Q = lot size per order.

Implicit in the above derivations is the assumption that all units produced by the vendor conform to specifications and are of perfect quality. Paknejad, Nasri, and Affisco [15] relax the perfect quality assumption of the EOQ model developed by Weiss [12]. Paknejad, Nasri, and Affisco [16] do the same for the case of Economic Manufacturing Quantity (EMQ) model in which holding cost is a quadratic function of the amount of time an item is held in inventory. In a more recent paper, Paknejad, Nasri, and Affisco [17] develop a perishable EOQ model with nonlinear holding cost subject to distinct demands for conforming and non-conforming items. They assume that the vendor's production process is in statistical control so that it generates a known, constant proportion of imperfect units, θ. Upon receiving the parts from the vendor, the purchaser conducts a full inspection of the entire lot at a cost of V dollars per lot, where V is a linear function of lot size. They further assume that the purchaser's inspection process is precise and that all perfect parts identified after inspection are used to satisfy demand of the primary market while the rejected

parts are sent as is to a secondary market to satisfy demand for imperfect parts in that market. In addition, they assume that shortages are not permitted in the primary market but are allowed in the secondary market. Finally, they assume that the leftover imperfect units, after demand of secondary market is fully satisfied, if any, are sold (or disposed of) all at once at the end of each inventory cycle.

Based upon the above scenario, Paknejad, Nasri, and Affisco [17] adjusted the behavior of the inventory system developed by Weiss [12] for two separate cases of shortages and excess units of imperfect (non-conforming) items in the secondary market. Using the basic framework of the expanded models in Paknejad et al [17], we now assume that the purchaser goes through a rework process to correct the imperfect pieces before sending them as reworked items to satisfy demand in the secondary market. We then present explicit relationships for the optimal lot size and optimal total cost at both markets for the case of shortages of reworked items. To do so, we use the following notations (most of which are the same or similar to those in [17]) as follows:

Let

$H'(t) = C_h' t^{\gamma}$, where C_h' and $\gamma \geq 1$ are constants,

C_h' = cumulative holding cost per reworked unit per unit time,

θ = proportion of imperfect parts in each lot,

$\rho = \dfrac{\theta}{1-\theta}$,

D' = demand in units for reworked items per unit time (year),

P = rework rate in units per unit time,

C_r = rework cost per imperfect unit,

V = k + vQ = inspection cost per lot,

π' = shortage cost per reworked unit short, irrespective of the duration of shortage,

I_{max} = maximum reworked inventory level

$$= \theta Q\left(1 - \frac{D'}{P}\right) = Q\left(\frac{\rho}{1+\rho}\right)\left(1 - \frac{D'}{P}\right),$$

T = cycle time = $\frac{(1-\theta)Q}{D} = \frac{Q}{D(1+\rho)}$,

$T_1 =$ rework time to correct imperfect units per lot $= Min\left\{\frac{\theta Q}{P}, T\right\} = Min\left\{\frac{\rho Q}{(1+\rho)P}, T\right\}$,

$T_2 =$ time needed to consume the maximum reworked inventory $= \frac{I_{\max}}{D'}$,

$$= \theta Q\left(\frac{1}{D'} - \frac{1}{P}\right) = Q\left(\frac{\rho}{1+\rho}\right)\left(\frac{1}{D'} - \frac{1}{P}\right),$$

$T_3 =$ time to build a lost sales position of B $= \frac{Q}{1+\rho}\left(\frac{1}{D} - \frac{\rho}{D'}\right)$,

B = Number of reworked parts short at the end of cycle, if any,

L = Number of reworked parts leftover at the end of cycle, if any,

C(Q)= Total inventory cost per cycle,

and

TC(Q) = Total inventory cost per year.

Simple algebra shows that shortages leading to lost sales for reworked units arise at the secondary market when $\rho < D'/D$ while excess units occur when $\rho > D'/D$. Finally, demand for reworked parts is fully satisfied when $\rho = D'/D$. Figures 1, 2 and 3 depict the three cases that may arise as follows:

Figure 1. Inventory System for Perfect and Reworked Items
Shortages of reworked items: $\rho < D'/D$

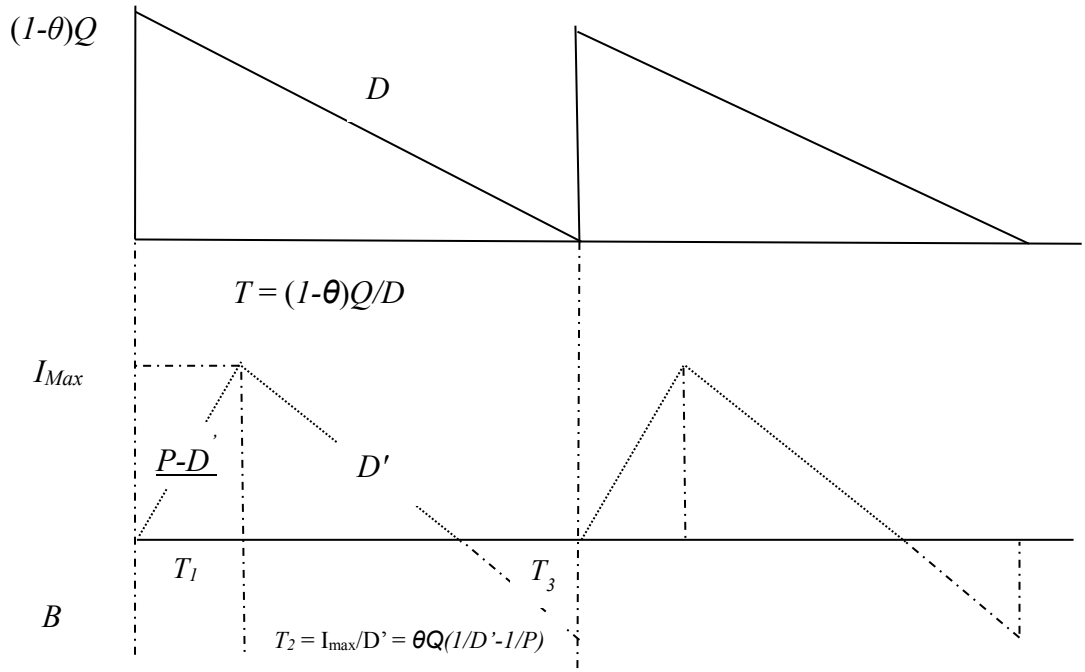


Figure 2. Inventory System for Perfect and Reworked Items
Demand for reworked items is fully met: $\rho = D'/D$

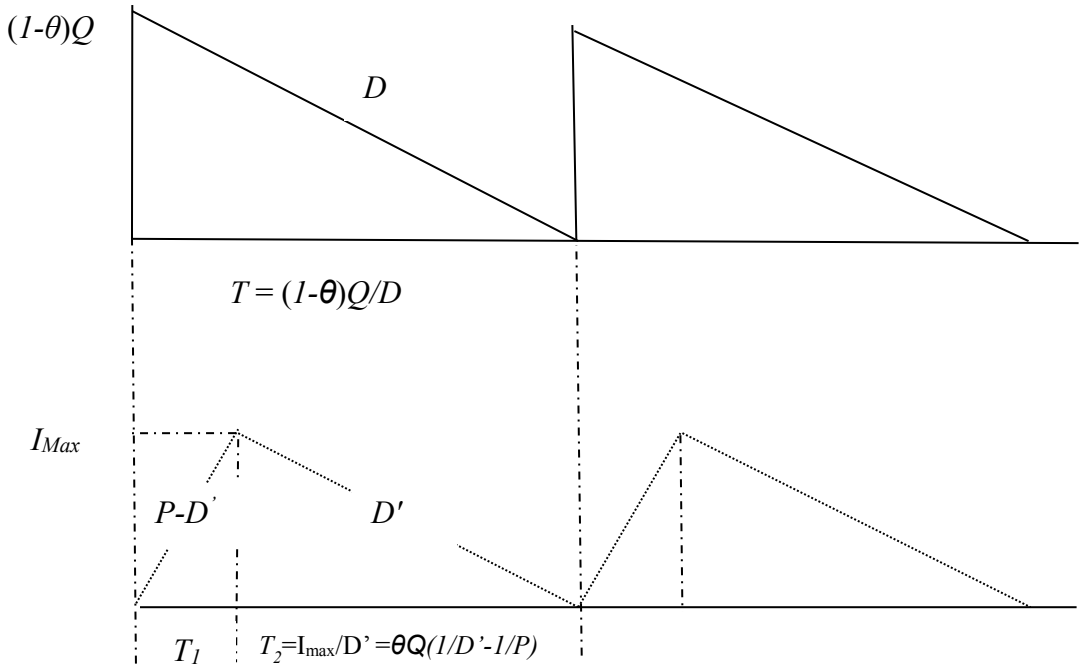
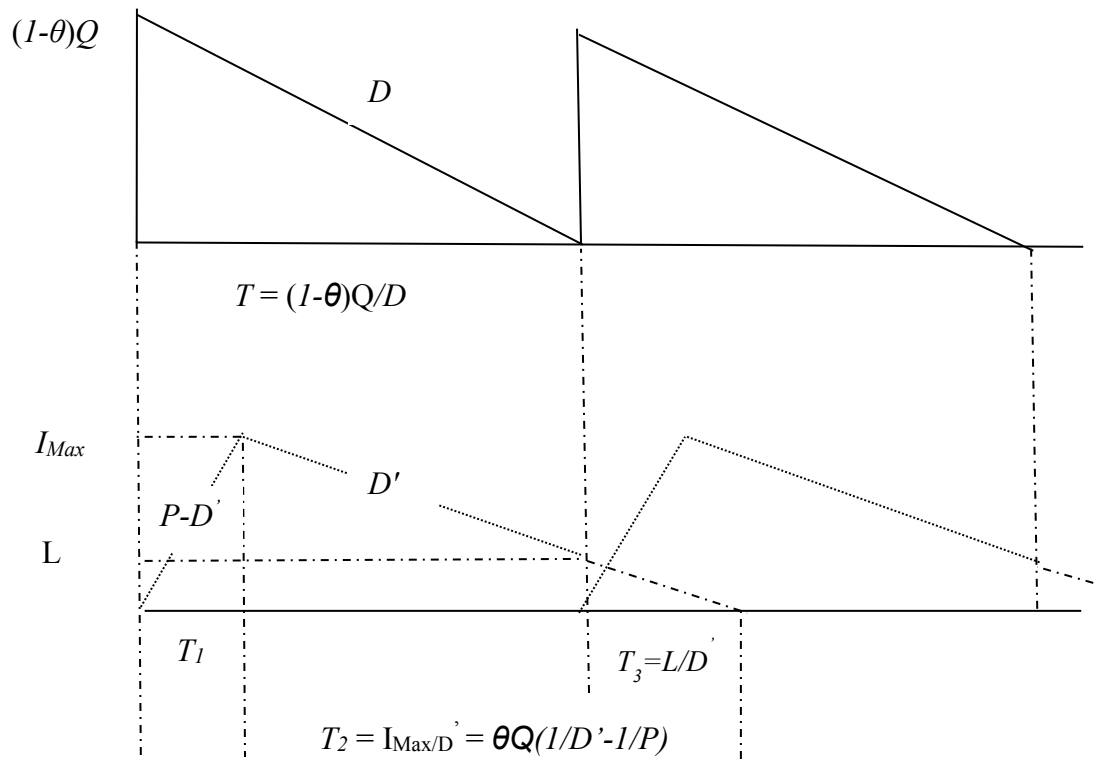


Figure 3. Inventory System for Perfect and Reworked Items
Excess units of reworked items: $\rho > D'/D$



Assuming that the relationship between demands for the primary and secondary markets is such that the case of $\rho \le D'/D$ applies, we use Figures 1 and 2 to develop the expression for the total annual cost for both markets as follows:

<u>Case of Reworked Parts Leading to Demand Satisfaction or Shortages (Lost Sales)</u>: $\underline{\rho \le D'/D}$

For one cycle of length $T = \dfrac{(1-\theta)Q}{D} = \dfrac{Q}{(1+\rho)D}$, the average holding cost per cycle for perfect items is given in [17] by

$$\int_0^{(1-\theta)Q/D} C_h \gamma \left[(1-\theta)Q - Dt\right] t^{\gamma-1} dt = \frac{C_h}{(1+\gamma)D^{\gamma}} \left(\frac{Q}{(1+\rho)}\right)^{1+\gamma}, \tag{4}$$

During a portion of the cycle $T_1 + T_2$ there is reworked inventory and inventory holding cost for reworked items are incurred. During the remainder of the cycle T_3 the system is in shortage condition and lost sales for reworked items are realized. The cumulative reworked holding cost if one unit is kept in inventory during the T_1 portion of a cycle $[0, T_1]$ is $\int_0^{\theta Q/P} C_h' \gamma t^{\gamma-1} dt$. Since P exceeds D', during the T_1 portion of the cycle, reworked inventory level increases with time as per $I'(t) = (P - D')t$. Therefore, average reworked holding cost during T_1 portion of a cycle is

$$\int_0^{\theta Q/P} C_h' \gamma (P - D') t^{\gamma} dt = C_h' \left(\frac{\gamma}{1+\gamma}\right)(P - D')\left[\left(\frac{\rho}{1+\rho}\right)\left(\frac{Q}{P}\right)\right]^{1+\gamma}, \tag{5}$$

Similarly, the cumulative reworked holding cost if one reworked unit is kept in inventory during the reworked inventory depletion time [0, T_2] is $\int_0^{\theta Q\left(\frac{1}{D'} - \frac{1}{P}\right)} C_h' \gamma t^{\gamma-1} dt$. During the T_2 portion of a cycle, the reworked inventory level decreases with time according to relationship $I'(t) = \mathrm{I}_{\max} - D't = \theta Q\left(1 - \frac{D'}{P}\right) - D't$. Hence, average reworked holding cost during T_2 portion of a cycle is

$$\int_0^{\theta Q\left(\frac{1}{D'} - \frac{1}{P}\right)} \left[\theta Q\left(1 - \frac{D'}{P}\right) - D't\right] C_h' \gamma t^{\gamma-1} dt = \frac{C_h' D'}{(1+\gamma)}\left[\left(\frac{\rho}{1+\rho}\right)\left(\frac{Q}{D'}\right)\right]^{1+\gamma}, \tag{6}$$

Combining equations (5) and (6) yields the reworked holding cost per cycle as follows:

$$C_h'\left(\frac{\gamma}{1+\gamma}\right)\left[\left(\frac{\rho}{1+\rho}\right)Q\right]^{1+\gamma}\left[\frac{(P - D')}{P^{1+\gamma}} + \frac{1}{\gamma D'^{\gamma}}\right], \tag{7}$$

It can also easily be seen that

$$B = \left[\frac{(1-\theta)Q}{D} - \frac{\theta Q}{D'}\right] D' = \frac{Q}{1+\rho}\left(\frac{D'}{D} - \rho\right) \tag{8}$$

Therefore, the total average inventory cost per cycle, equals

$$C(Q)=K+\frac{C_h}{(1+\gamma)D^{\gamma}}\left(\frac{Q}{(1+\rho)}\right)^{1+\gamma}+$$
$$C_h'\left(\frac{\gamma}{1+\gamma}\right)\left[\left(\frac{\rho}{1+\rho}\right)Q\right]^{1+\gamma}\left[\frac{(P-D')}{P^{1+\gamma}}+\frac{1}{\gamma D'^{\gamma}}\right]+\frac{\pi'}{1+\rho}\left(\frac{D'}{D}-\rho\right)Q+k+vQ+\frac{C_r}{1+\rho}Q \tag{9}$$

Multiplying (9) by the number of cycles per year, $\frac{D(1+\rho)}{Q}$, after some simplifications, we find the total average annual cost, TC(Q), as follows:

$$TC(Q)=\frac{D(K+k)(1+\rho)}{Q}+$$
$$\frac{D}{(1+\gamma)}\left(\frac{Q}{1+\rho}\right)^{\gamma}\left[\frac{C_h}{D^{\gamma}}+C_h'\rho^{1+\gamma}\left(\frac{\gamma(P-D')}{P^{1+\gamma}}+\frac{1}{D'^{\gamma}}\right)\right]+\pi'(D'-D\rho)+vD(1+\rho)+C_rD \tag{10}$$

When $\rho \le \frac{D'}{D}$, the optimal values for the order quantity, Q*, and the total average annual cost, TC(Q*), are found by using classical optimization and algebra as follows:

$$Q^*=(1+\rho)\sqrt[1+\gamma]{\frac{\left(1+\frac{1}{\gamma}\right)D^{\gamma}(K+k)}{C_h+C_h'\rho^{(1+\gamma)}\left[\gamma\left(\frac{D}{P}\right)^{\gamma}\left(1-\frac{D'}{P}\right)+\left(\frac{D}{D'}\right)^{\gamma}\right]}}, \tag{11}$$

and

$$TC(Q^*)=\sqrt[1+\gamma]{\left(1+\frac{1}{\gamma}\right)D^{\gamma}(K+k)\left[\gamma\left(\frac{D}{P}\right)^{\gamma}\left(1-\frac{D'}{P}\right)+\left(\frac{D}{D'}\right)^{\gamma}\right]}+\pi'(D'-\rho D)+vD(1+\rho)+C_rD \tag{12}$$

When $\rho=\frac{D'}{D}$, equations (11) and (12) will lead to the following results:

$$Q^* = (1+\rho)\sqrt[1+\gamma]{\frac{\left(1+\frac{1}{\gamma}\right)D^{\gamma}\left(K+k\right)}{C_h + C_h{}'\rho\left[\gamma\left(\frac{D}{P}\rho\right)^{\gamma}\left(1-\frac{D'}{P}\right)+1\right]}}, \tag{13}$$

and

$$TC(Q^*) = \sqrt[1+\gamma]{(1+\gamma)D^{\gamma}\left(K+k\right)\left\{C_h + C_h{}'\rho\left[\gamma\left(\frac{D}{P}\rho\right)^{\gamma}\left(1-\frac{D'}{P}\right)+1\right]\right\}} + \pi'(D'-\rho D) + vD(1+\rho) + C_r D \tag{14}$$

Please note that equations (11), (12), (13), and (14) simply reduce to the corresponding results of the EOQ model with nonlinear holding cost and imperfect quality subject to distinct demands for conforming and non-conforming items developed by Paknejad et al [17] when P → ∞ and the unit rework cost (C_r) is zero. Furthermore, they reduce to Weiss' EOQ model [12] with non-linear holding cost represented by equations (2) and (3) when the quality of the ordered items is perfect ($\theta = \rho = 0$), no inspection takes place ($v = 0$, $C_r = 0$, and $k = 0$), and P → ∞. Finally, they simply reduce to the corresponding results of the classical Wilson's EOQ model [1] when P→∞, $\gamma = 1$, quality is perfect ($\theta = \rho = 0$), and no inspection or rework is needed ($v = 0$, $C_r = 0$, and $k = 0$).

4. SUMMARY

A new Economic Order Quantity model has recently appeared in the literature for a situation where two distinct demands, (one for conforming (perfect) parts in a primary market and another for non-conforming (imperfect) parts in a secondary market), are placed on a stable production process with a known process capability. Assuming that the holding cost is a nonlinear function of time, the authors applied classical optimization techniques to derive closed form relationships for the optimal lot size and optimal total relevant inventory cost for two separate cases of shortages and excess units of non-conforming parts in the secondary market. Implicit in the results developed is the assumption that imperfect items go to the secondary market as is, without any rework performed on them to correct the defects - which is not always the case.

This paper extends the results of this recent EOQ model to the case of a hybrid EOQ-EMQ paradigm where all perfect items are used to satisfy demand in a primary market and all imperfect items are reworked at a constant rework rate, with a fixed unit rework cost, to satisfy demand in a secondary market. Assuming that the holding costs for perfect and reworked items are nonlinear functions of time and based on a scenario similar to the previous work, this paper presents the underlying conditions leading to shortages or excess units of reworked items in the secondary market. The paper then develops explicit expressions for the optimal lot size and optimal total inventory cost incurred by the purchaser in both markets under the assumption that the relationship between demands for the two separate markets is such that excess units of reworked items at the secondary market do not occur. We show that the more general results of this paper lead to the corresponding results of the previous work when rework rate approaches infinity and rework cost is zero.

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EXELON CORP: IMPLEMENTING TECHNOLOGY TO OPERATE A MORE EFFECTIVE AND EFFICIENT BUSINESS

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Key Words: *catastrophic events*

Abstract

This case concerns Atlantic City Electric Company, a subsidiary of Exelon Corporation, and the need for cohesive utilization on available technologies to save time and money during unplanned outages. The primary issues of this case study will touch upon the need for improved restoration times during catastrophic events, and how unifying technology between subsidiaries will assist with these improvements in both time and efficiency. The secondary issues of this case study will touch upon how using technology to improve efficiency measures will also increase productivity from support staff being sent from outside areas, and how technology can assist with cutting substantial costs during catastrophic events. This case will touch upon how consolidating technologies into one uniform system, although costly initially, will be financially more beneficial in the long run. This case will also show the importance of a unified system for safety reasons for both customers and employees.

Introduction:

Exelon Corporation is the largest utility services holding company in the United States. The Company, through its subsidiaries, Commonwealth Edison Company (ComEd), PECO Energy Company (PECO), Baltimore Gas and Electric Company (BGE), Pepco Holdings LLC (PHI), Potomac Electric Power Company (Pepco), Delmarva Power & Light Company (DPL) and Atlantic City Electric Company (ACE), are all a part of the energy delivery businesses (Reuters, 2018). Exelon operates through 12 segments: Power Generation's six segments: Mid-Atlantic, Midwest, New England, New York, ERCOT and Other Power Regions; ComEd; PECO; BGE, and PHI's three Power Utility segments: Pepco, DPL and ACE. Generation,

ComEd, PECO, BGE, Pepco, DPL and ACE participate in energy markets that are administered by regional transmission organizations (RTOs) and independent system operators (ISOs)(Reuters, 2018). Atlantic City Electric (ACE) was acquired by Exelon in March of 2016 as part of a $6.83 billion merger which enables their parent company Exelon to perform power generation, transmission, and distribution functions all across the country. ACE's energy delivery business consists of the purchase and retail sale of electricity, and is responsible for electricity transmission and distribution services to retail customers in portions of southern and central New Jersey (Reuters, 2018). While the grand scale consolidation of operations of all the disparate business units have assisted Exelon in providing overall sustainable power delivery, there are still some major shortcomings when it comes to their most important measure of operational success: reliability.

The Importance of Reliability:

Reliability can be defined in general terms as the "quality of performing consistently well". Atlantic City Electric is responsible for providing sustainable power services to their customers, or reliability of services, and are regulated to do so by the Board of Public Utilities, or BPU. For ACE, the Board of Public Utilities is the state agency with authority to oversee the regulated utilities, which in turn provide critical services such as natural gas, electricity, water, telecommunications and cable television. The law requires the BPU to ensure safe, adequate, and proper utility services at reasonable rates for customers in New Jersey (bpu.state.nj.us). ACE has accountability provisions in place to make sure they are meeting the BPU mandates, including CADI (Customer Average Duration Interval), SAFI (Suggested Average Frequency Interval), and SADI, which is an average of CADI and SADI. These numbers are derived from customers who report back frequency and durations of outages of service. Exelon as a whole has maintained excellent CADI and SAFI numbers, which helps when rate increases are petitioned to compensate for investments made in replacing and updating infrastructure to keep outages to a minimum. The BPU uses these numbers as a basis to assure that customer's demands are efficiently met at cost effective rates. Although Exelon and ACE have these reliability measures in place and are reporting well within the range of accepted outage times and service interruptions as per the BPU, one area of reliability that has not been able to meet these criteria margins is average restoration times reported during catastrophic events.

Deficiencies in the Current System:

Catastrophic events, otherwise known as "Acts of God", can strike at any time and in any area. Although ACE has been implementing infrastructure replacement programs prior to the acquisition by Exelon to increase reliability when storms occur, there is no way to predetermine how much these events will negatively impact service territories based on damage that occurs to existing infrastructures. One of the huge assets of ACE now being part of a Fortune 100 company is the access to both monetary and human capital that was not available previously when storms have impacted the territory in the past. The new availability of financial and human capital should make restoration times during catastrophic events much more cost effective and time efficient, but as reported during the few recent storms, this is unfortunately not the case. Although large amounts of capital and employee assistance are readily available before, during, and after a catastrophic event occurs, reliability and restoration rates are not improving as substantially as they should be. This result begs the question; if there is more money and man power available, why are restoration times and productivity decreasing while costs are increasing?

Typical Process for Outage Restoration Currently:

When a catastrophic event is forecasted, all Exelon business units are made aware of the details: when the storm is expected to hit, how long the duration of the event is anticipated to last, and where the largest negative impact is anticipated to occur for service disruptions. Work crews are prepared to be dispatched from unaffected areas to the areas anticipated to be hardest hit; these crews can come from local areas if the storms effects are not that widespread, or from across the country for more outside assistance. During the last few storms this past March, crews were dispatched from Chicago based ComEd to assist with the potential restoration efforts due to the length of the storms; there were three storms in a row that impacted the service area within a three week period, which was a highly unusual series of events. The Chicago based crews were instructed to drive to South Jersey in advance of the storm and were stationed in hotels before, during, and after the event; all corresponding expenses were paid for by Exelon, including but not limited to food, lodging, and overtime pay based on each crew's contractually decided upon pay rates. In the last few storms, although more man power and financial availability were present because of Exelon's resources, productivity declined and expenses increased

exponentially because of a lack of technical communication between ACE crews and the crews that were sent out from ComEd. Although both groups now work for the same company, each group still has their own internal technical systems that are not able to communicate with each other. The ACE crews received all the most current information about where they needed to be dispatched and what repairs were needed once they arrived on site, while the ComEd crews waited for hand written information packets to be dispensed to them so they could begin their restoration efforts. Initially, when the ComEd crews arrived, due to the hectic nature of catastrophic events, they were not able to be utilized in the restoration efforts because the information that they needed to assist was not physically available for them. Not only were the work packets not able to be prepared in advance, crews were having extreme difficulty navigating a service area they were not familiar with in dangerous weather and no maps or directions available to them. These ComEd crews sat for almost 24 hours with no work assigned to them because the dispatchers were unable to get the information directly to them. This lack in efficiency cost the company huge amounts of expenses in overtime payroll and negatively impacted the restoration and reliability scores mentioned previously.

Current Technology used by ACE Crews:

The Atlantic City Electric crews trucks are all equipped with a portable navigational system called NaviLink that visually links up all of the electrical infrastructure with the topography of the current service area of South Jersey. This is the system that the ACE crews use on a daily basis to troubleshoot basic outages within the territory, whether from a motor vehicle accident, equipment failure, or any disturbance that may occur on the grid. It displays in a map like formation all of the electric lines running from the distribution centers, all the way out to the transmission centers, and then to the individuals homes or businesses. When catastrophic events occur, these systems convert to “storm mode”, which allows all of the outages to be separated into a few categories of importance, including average outage duration time, number of customers affected, and system areas that need to be repaired. By focusing on these specific important parameters, it allows ACE’s productivity and restoration numbers to remain in the acceptable range when restorations occur. While there are a few extra NaviLink systems available for outside use, it is an extremely limited number, and a crew that has never used the system before or is not familiar with the territory would not be very adept at using them to their

full functional capacity. It is extremely difficult for crews that come from outside areas to navigate territories that they are unfamiliar with during regular service operations; it is almost impossible for outside crews to do this during catastrophic events.

Proposal for System Consolidation:

With all of the business units now a part of Exelon's make up, it is essential for all crews to be on board with the same NaviLink system that ACE currently uses. Before the Exelon acquisition, PECO Energy Company (PECO), Baltimore Gas and Electric Company (BGE), Potomac Electric Power Company (Pepco), Delmarva Power & Light Company (DPL) and Atlantic City Electric Company (ACE) were all under the Pepco Holdings LLC company. All of these companies are currently using the NaviLink system, which is a substantial portion of the Exelon family. All of these subsidiaries would not need the training on the new system, nor would they need the initial cost outlay because NaviLink is already in place. The only remaining subsidiary that would need to convert to the new system would be Chicago based ComEd. Training should be provided by NaviLink's current users, and should be done in Chicago to save on the expense of having to bring all of the ComEd staff to the East Coast. Since Exelon will continue to dispatch crews as necessary during catastrophic events, once all of the new users are proficient with the new system, they can get their assignments before they even arrive to the affected area, cutting down on restoration lag time and lack of initial productivity. Crews can also become familiar with the territories they will be working in because NaviLink allows crews to see topographically what areas they will be working in, and what types of equipment crews will be working around. This will also allow crews being dispatched to storm ravaged areas to be prepared with the proper tools and equipment necessary to efficiently perform restoration activities. Implementing the NaviLink system for ComEd to use will also allow that service area to "get on the grid"; ComEd can now be privy to having the availability of outside crews to come and assist in restoration efforts when catastrophes occur, which they are more likely to do now anywhere in the country. Most importantly, all crews being on the same system will allow for clearer communication between them while working; it is extremely dangerous to be performing restoration work during storms not only due to inclement conditions, but because someone working on one portion of a line can easily endanger or even kill someone working on another portion of that same line. The entire electrical grid is all a part of the same network, so it is

extremely important that everyone is on the same page when altering any portion of that system. Crews that are using the same system can visually see what power lines are engaged and what repairs are being made so no mistakes are made either where they are, or in an area where someone else is.

Conclusion:

Although it may be costly to implement initially, getting ComEd on board with the NaviLink system as quickly as possible should be one of Exelon's top priorities. Reliability measures will only increase with the implementation of one uniform NaviLink system, and the safety of the crews and customer satisfaction are huge secondary benefits. The NaviLink companywide system implementation will substantially improve outage times and productivity across all subsidiaries, helping to improve all reliability scores companywide. ComEd crews can work with the other subsidiaries to get trained quickly on the NaviLink system, and in return can be guaranteed productive and cost effective assistance when catastrophic events hit the Chicago area. Implementing one uniform system across Exelon can also allow for information sharing between all of the subsidiaries; there are always things that are learned during catastrophic events that can positively impact the company for future restoration efforts.

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Health Information Exchange: Literature Review

Submitted by

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October 19, 2018

Introduction

Over the past decades, the increasing cost of health care system has highlighted the necessity for the adoption of health information exchange (HIE). The advantage of technological advancement, ultrafast connectivity through the internet have paved the way for adoption of HIE, and hence, sparked renewed interest in HIE research for sustainable, cost-effective, and improved health care system. HIE is the process of electronically sharing patient-level information between healthcare providers. In 2001, around $1.5 trillion were spent in health-related cost in the US and the ratio of healthcare spending to Gross Domestic Product (GDP) was 13.9% (Ramkumar Janaki Raman et al. 2017). The spending cost had been doubled to $3 trillion in 2014 and GDP increased to 17.5%. It's been estimated that the annual healthcare spending will almost double in 2024 with 20% GDP (Ramkumar Janaki Raman et al. 2017). Therefore, there has been widespread awareness for the adoption of HIE. The policymakers are also trying to motivate and influence health providers to participate in HIE by offering incentives (Pouyan Esmaeilzadeh et al. 2016). In this report, we discuss the benefits of HIE highlighting mainly on patient safety, precise exchange clinical information for impactful workflows with data accuracy, cost reduction, patient satisfaction, reducing mortality, improving care coordination, and work efficiency. We also discuss the background of HIE and different federal nationwide projects, such as ONC, NHIN, HITSP, HISPC, HITECH Act, and impact of federal incentives (Emre M. Demirezen et al. 2014). Furthermore, we analyze various factors that influence the strategic decisions of HIE participation such as funding, awareness, policies, data security, patient privacy, technical and non-technical barriers, lack of enforcement etc. Then we discuss previous studies on the sustainability of HIE that has been done using game theory model. Finally, we discuss some potential future works and conclude with a summary.

What is HIE?

Health Information Exchange (HIE) is the appropriate and confidential electronic transmission of healthcare-related information e.g. laboratory results, clinical summaries and medication lists between different organizations such as hospitals, physicians, clinics, labs etc. The primary goal of HIE is improving patient safety, care coordination, quality of care, work efficiency, and reducing healthcare cost and mortality.

History of HIE in the USA

In the early 1990s, healthcare industry set up community health information networks to share patient medical records among healthcare providers. The initiative has been hindered by the expensive, unreliable, slow speed internet connection. Some of the networks have continued and still in operation such as the Indiana Health Information Exchange (IHIE), the Utah Health Information Network (UHIN), and the Health Bridge in Cincinnati. The Department of Health and Human Services (HHS) has created the Office of National Coordinator (ONC) in 2004, which is the beginning current era of HIE. Ever since, the federal government has started so many nationwide projects like Nationwide Health Information Network (NHIN), Nationwide Health, HITSP (Health Information Standards Panels), HISPC (Health Information Security and Privacy Collaboration Projects) (Emre M. Demirezen et. al. 2014). In order to accelerate HIE usage and sustainability, The Health Information Technology for Economic and Clinical Health (HITECH) Act, part of the American Recovery and Reinvestment Act of 2009, has provided $29 billion funding through its "meaningful use" program to the participated providers in HIE and health providers. The HITECH Act has allocated an additional $563 million for investment by States or State-designated entities to set up HIE capability among health care providers and hospitals in their jurisdictions to provide the full potential of services (Ramkumar Janakiraman et al. 2017). The aims of HITECH are promoting the adoption and use of interoperable electronic health records (EHRs) and health information exchange (HIE) and updating the country's health IT infrastructure to follow new models of care delivery. According to Michael F. Furukawa et al. in 2014, the Centers for Medicare and Medicaid Services (CMS) offered incentive payments to eligible health care providers who actively involved in HIE system in 2009, for signifying the objectives and benefits of HIE to motivate others. The influence of HITECH and its incentives expedited the rate of HER adoption. From 2010 to 2012, the usages of basic HER systems increased rapidly among US ambulatory care physicians, especially those had less enthusiasm to adopt the system and worked in countryside area or area with high rates of poverty. In fact, about 65 percent eligible professionals who were actively involved in the "meaningful use of program" received $21.6 billion incentive till February 2014. Subsequently, around two-third of US hospitals and nearly half of physician were participated in HIE with outside organizations in 2013. Close to 7 in 10 hospitals (69%)

electronically exchanged health information with ambulatory providers outside of their organization, representing a 92-percent increase since 2008 and a 21-percent increase since 2013 (Results from the National Ambulatory Medical Care Survey, 2013). It indicates a sharp increase of adoption rate of HIE from 2008 when 41 percentage of hospitals and 17 percentage of physician directly or indirectly were engaged with HIE system (Saurabh Rahurkaret.et al. 2015). Based on eHealth Initiatives report, the number of HIE initiatives grew from dozens to 255 within 2004-2011 (Emre M. Demirezen et al. 2014).

Benefits of HIE

- **Cost reduction**

HIE can eliminate the cost of duplicate tests and services, reduce redundant test and radiology exams in the emergency department, and unnecessary admission to hospitals. It can also save money for paper, ink, printing, and documentation and reduce phone call bills and time for follow-ups with labs for test results (Emre M. Demirezen et al. 2014). It has been shown by William Hersh et al. in 2015 that averted radiologic testing in emergency departments saved approximately US $161,000 savings over 3 months, while a retrospectives case study found 453 duplicate radiology testing in 1488 patients. Moreover, HIE implementation reduce consultation costs approximately $3,990 over 3 months (William Hersh et. al.2015). Accessing HIE data through a web-based technology within 11 hospitals of ED approximately save annually US $800 K and a total of US$ 1.9 million annually for all regional hospital EDs (Mark E. Frisse et al. 2012).

- **Patient safety and precise treatment**

Due to insurance requirement and limitation, mobility, special care provider availability, Americans gradually look more for healthcare from various organizations. The procedure of requesting and retrieving clinical information from such distinct organizations is complicated, time-consuming, and often ineffective, especially when patients cannot remind different locations from where they have received care. This is even worse for the older patients since most of the time they cannot remember correctly their previous physical conditions and also

cannot maintain medical records properly. In such a case, it becomes difficult for the doctors in identifying health problems accurately. Moreover, in critical emergency situations, lack of previous health history may cause wrong diagnosis leading to even serious injury or death (Kevin B Johnson et. al. 2011). Up to 18% of the patient safety errors and as many as 70% of adverse drug effects could be eradicated if the right information about the right patient is available at the right time (David C. Kaelber et al. 2007). Hence, an HIE does not only forward clinical information precisely, but it also impacts the clinical work flows by forwarding proper data to doctors and nurses in their need to make accurate decisions. Thus, HIE contributes to improved patient safety and treatment through more complete data availability.

- **Improved communication between patients and providers**

HIE can provide better and effective communication to patients and providers through personal health records (PHRs). It can allow patients to check their medication history, add up important information if necessary, and follow up their own test result. Patients can review their medication lists and other health-related information and communicate with their providers quickly in their need as well. Health providers also can be in touch with their patients through PHR. According to the study conducted by David C. Kaelber et. al. in 2007, it is found that PHRs help preventing medical mistakes and can track medical records with updates and transfer patients details to the new providers.

- **Other factors**

According to William Hersh et al., HIE saves time in evaluating Social Security claims and improved general patient satisfaction and visit experiences in hospitals where this system has been implemented. Physicians prefer an electronic exchange of medical records than paper lab report. HIE improves follow up using electronic reports in ED and ambulatory care efficiency. HIE makes an improvement on other factors like public health reporting and monitoring, clinical outcomes, transitions of care, monitoring of patient movement and disease management.

Factors influencing the strategic decision of HIE participation

To understand the complex strategic business decision of whether to participate in HIEs by healthcare providers, we need to understand the factors that influence the decision. Some of the factors are described below:

- **Awareness:**

Awareness is considered to be the first phase in initiation. It's been mentioned that many of the health organizations are not still aware of HIE services and benefits. Once they are aware of the profits of HIE initiative such as quality improvement, cost reduction, patient care coordination, the perspective of those organizational decision will vary (Pouyan Esmaeilzadeh et al. 2016). Being aware of HIE efforts, the stakeholders will be motivated to adopt HIE. To raise awareness, various informative HIE conferences, integrating marketing programs etc. should be organized to highlight clinical, financial, organizational benefits of HIE, which will assist organizational decision makers and stakeholders to move the next step.

- **Funding**

Initially, healthcare organizations didn't have any real strategy to adopt HIE. Although the large health provider might have IT infrastructure and resources to adopt HIE, the regional or local health provider doesn't have these facilities. Therefore, federal incentives, the HITECH Act can motivate the organizational adoption decision and encourage healthcare providers to obtain the necessary organizational approvals and required resources to implement HIE. Once they acquire the necessary funding, they will move to the next step by sorting out financial, organizational obstacles (Pouyan Esmaeilzadeh et al. 2016).

- **Policies**

Although the federal government offered incentives, healthcare providers have not yet adopted and used HIE. In fact, they are less likely to adopt HIE due to implementation cost, lack of motivation or mandated programs. To sort out such problems, sufficient research and

encouraging policies are necessary to clarify the different phases of HIE assimilation and ease this system. Some of the health providers are positive to adopt HIE system, but some institutions may not be able to go further due to startup cost shortage, organizational readiness, uncertainty in return of investment, technical infrastructure set up the problem, resource allocation concerns, stakeholders unwillingness, patient privacy, and security concern. Effective and sustainable policies can resolve those issues for further participation in the system. On the other hand, physicians from renowned and multifunctional hospitals and other large organizations are more actively involved in adopting EHRs rather than solo practitioners and rural areas health care providers. Hence, the new policies need to elucidate for the design and allocation of incentive programs with additional attention to lagging healthcare organizations to ensure ubiquitous use of the system, enforcement of federal mandates for the sustainability of HIE systems.

- **Data security and patient privacy concerns:**

The actual use of the HIE system starts by exchanging clinical information electronically within inside and outside of healthcare organizations. These data are vulnerable to abuse and some sensitive data about patients such as HIV status or mental health records being lost or stolen can lead to serious consequences. Hence, this gives rise to a huge concern regarding the data security and privacy disclosure of the patients. Many surveys have shown that Americans are very worried about the privacy of their personal health information because they think that disclosure of such information may lead to harm in terms of denied employment, claims, and discrimination. On the other hand, healthcare providers face unexpected troubles in sharing information outside the organization due to trust issue and competition. Hence, more research to find a sustainable and effective model of HIE that addresses these security and privacy concerns need to be performed. Once these issues are resolved, the decision of participation in HIE will certainly increase. New policies should also apply on standard guidelines for execution and maintenance of the network system with protection of data security and patient privacy.

- **Technical and non-technical barriers**

Technical barriers such as shortage of standardized structure and layout of exchange activities, lack of resources for implementation, lack of technical assistantship, technical infrastructure setup problem make a huge impact in the decision making of HIE participation. Because of improper integration between workflows and the network (HIE) system, the HIE service will never be successful. New policies should offer technical support, additional individual incentives, and training courses for healthcare professionals and staffs who may be not fully aware of the HIE technical details.

On top of that, various non-technical variables (such as lack of cooperation and trust among providers, start-up cost shortage, uncertainty in return of investment, resource allocation concerns, stakeholder's unwillingness, shortage of incentives for institutionalization, limited manpower) may stop providers from participating in HIE (Pouyan Esmaeilzadeh et. Al 2016.). Policymakers should broaden their options and opportunities beyond technological details to influence in participation.

- **Other factors:**

There are many other important factors that influence the strategic decision whether or not to participate in HIE. For example, lack of leadership, ineffective communication from management, diversity, and complexity within and across HIE systems, Lack of sufficient engagement of participants and providers, trust and solidarity among HIEs and HPs can be other influential factors for the sustainability of HIE (William Hersh et al.2015).

Previous study evaluating HIE sustainability and participation:

The success and sustainability of HIE networks rely greatly on the decisions made by the HIE providers and the HPs. Enough researches have not done yet on discussing how those decisions and linked factors (such as participation by HPs, fees, the value offered, size of the

network, net value, incentives, benefits) make an impact on the sustainability of HIE. Sufficient research is necessary to elucidate the different phases of HIE assimilation and sustainability. Emre M. Demirezen et al. in 2014, used a game theoretic model to prove costs and value-added service influence on whether the HIE network will be established or not. They proposed three different strategies for policymakers and HIE providers that can help boost participation and sustainability HIE:

- provide value-added services and incentives
- offer additional values to low-gain HPs
- set up a second HIE in the region

Once the government fund will cease, the changes will effect involvement in the network, HIE subscription fee and fee for value-added service, requested number of HP for value-added service and the net value for HIE and HP. Therefore, in their main model, they examined the decisions of HIE based on value-added service and fee and number of requests of these services by HPs. Besides, they analyzed how value-added services help to increase participation in the system and hold sustainability.

Future Scope of work

To advance the sustainability and participation of HIE, future studies need to address some important points. First, details cost analysis for initial setup and additional services to provide a better understanding for decision makers. Second, developing HIE model with detail policies on how to increase the government's influence and active involvement. Third, risk analysis so that stakeholders can make precise and accurate decisions for participating in HIE. Fourth, effective way to resolve uncertainty in the usage of HIE and sorting out barriers that influence in the successful implementation and come up with a complete, feasible, efficient system. Fifth, addressing patient privacy and data security concern with technological updates. Finally, the use of different models, such as game theory, to analyze how various factors impact the decision making of participation in HIE.

Summary

In summary, one of the most key messages that we understand from the literature review is that HIE can have a revolutionary impact in the healthcare system in terms of cost reduction, better and accurate treatment, work efficiency etc. We have identified some potential barrier, such as data security, privacy concern, cost of implementation etc., that prevents health care providers to adopt HIE despite government incentive and programs. Therefore, we present previous studies that discuss solutions to these problems, and then also identified some of the potential future research that is required to help the strategic decision-making process of HPs in participating HIE.

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REPLENISHMENT POLICIES FOR MANAGEMENT OF PERISHABLE INVENTORY UNDER SUBSTITUTION: A COMPUTATIONAL STUDY

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ABSTRACT

In this paper we study the management of perishable inventory when there is separate demand for products at different ages via simulation. For a product that has two periods of lifetime, in our model, we allow substitution between old and new items while customer does not always accept a substitution offer. Heuristic policies are proposed in order to lower operational costs.

Keywords: perishable inventory, substitution, simulation

Introduction

Perishable products lose their value significantly in a relatively short period of time and discarded when they reach the end of their lifetime. Examples include fresh produce, dairy, meat and baked goods. Sometimes perishable goods at different ages can be in the market at the same time, and old and new products can experience customer demanded simultaneously. Perishable inventory management is challenging by itself, but it is especially difficult when products of different ages co-exist in the market and there is a substitution possibility between old and new products.

In this paper, there is a single perishable product that outdates in two periods in a multi-period, infinite horizon setting. The value of the product decreases in the second period. Both new and old items may have stochastic demand streams. New products are replenished without lead time. At the end of a period unsold old items are discarded, and unsold new items become old.

New product demand is fulfilled by new product inventory unless there is a stock-out; old product demand is fulfilled similarly. If there is inventory shortage, unsold new items may be used to fulfill old item demand and vice versa. *Downward substitution* denotes the case when a new product is sold to a customer who demands old, and *upward substitution* denotes the case when an old product is sold to a customer who demands new. If both downward and upward substitution are allowed then we call that *full substitution*.

In this study for two different order-up-to level type replenishment policies the effect of substitution on system costs is compared.

One of the policies brings the total on-hand inventory to an order-up-to level (S); we call this policy *TIS*. The other policy brings the new on-hand inventory to an order-up-level (S); we call this policy *NIS*. These two policies are compared based on operational costs.

We compare our heuristics when substitution is not always accepted. We do experiments with partial acceptance and probabilistic acceptance. In the partial acceptance model when substitution is offered a certain fraction of it is accepted by customer. Under probabilistic acceptance all of the offered substitution is either accepted or rejected (as a whole) by the customer. We assume each substitution acceptance is independent. We propose an additional heuristic to find the optimal NIS order level.

Related Work in The Literature

Due to the importance of managing perishable goods many interesting research problems were studied in the past. A comprehensive literature review of perishable inventory management research is written by Nahmias (1982) and Karaesmen et al. (2011). Most of the research on perishable goods management is about determining optimal or near optimal inventory ordering policies to minimize operational costs. Also, most research focuses on cases when only the oldest item is demanded (i.e. *single demand stream*) and demand fulfillment is done according to FIFO (i.e. oldest items sold first) avoiding any substitution related issues. However in our model there are two demand streams: one for old products and one for new products. Even for the single demand stream case, the problem is very difficult to solve. In standard inventory management literature, the only information needed is the inventory position. However in order to determine the optimal ordering policy for perishable goods you need to track the amount of inventory of every age. This makes the problem's complexity grow with the lifetime of the product. Nahmias and Pierskalla (1973) showed that the optimal order quantity is a non-linear decreasing function of on hand inventory for two-period life time (single demand stream) problem. Since the optimal policy is found via a hard-to-solve multi-dimensional dynamic program, heuristic methods were utilized by researchers. Nahmias (1976) and Chazan & Gal (1977) proposed an order-up-to policy that brings the total inventory (of all ages) to a certain level every period. TIS performs well compared to optimal under FIFO according to Nahmias (1976) and Nandakumar & Morton (1993). Using a Markov Decision Process method Haijema et al. (2005) came up with heuristics for replenishment of blood platelets under full substitution and showed order-up-to heuristics that replenish based on total inventory level (TIS) perform well, and those that take into account total and new inventory levels (i.e., a TIS-NIS hybrid policy) perform better in a multi-period lifetime (5-to-7 period) setting. Brodheim et al. (1975) introduced NIS first, and demonstrated that TIS performs better than TIS. Nahmias (1975) found that best TIS policy, performs better than two other heuristics – first one based on the non-perishable problem, and the other a combination of the first one with NIS. In a simulation study, NIS was found to be worse than TIS according to Prastacos (1984).

Multiple demand streams for perishable products are studied in a few papers. Nahmias and Pierskalla (1976) model a system consisting of a perishable and a non-perishable product with a one-way substitution of the non-perishable for the perishable. Parlar (1985) considers a perishable product with two-period lifetime, and a certain proportion of unmet demand for new items is fulfilled by any remaining old items and vice versa (i.e. full substitution). His results are only for a single period and do not extend to longer horizons. Goh et al. (1993) consider a two-stage perishable inventory problem with random supply and separate Poisson demand streams. They computationally compare a restricted policy (similar to our no substitution) and an unrestricted policy (similar to our downward substitution). Considering only shortage and outdating costs they show that the unrestricted policy is less costly, if the shortage cost for new items is not very high. Ferguson and Koenigsberg (2004) study a two period problem with pricing and competition between new and old products.

Another line of research related to our paper is inventory management of products that are substitutable. There are many papers in this area, we mention here a few that are most relevant. McGillivray and Silver (1977) provide some analytical results for management of two substitute products with similar costs. Parlar and Goyal (1984) study two products with a fixed substitution fraction and find properties of the expected profit function. Rajaram and Tang (2001) show that substitution between products always increases profits compared to the case when substitution is not allowed, and provide a heuristic for order quantities. Of course in this stream of literature all products are non-perishable.

Deniz et al. (2010) compare substitution options analytically in terms of their infinite horizon time-average costs for a product with two period lifetime, providing conditions on cost parameters that determine when one substitution option is better than the others. They also show that downward substitution leads to fresher inventory. Their analytical results are based on sample-path analysis with no assumptions on demand distribution other than ergodicity.

We consider an infinite horizon problem as opposed to single period or single replenishment problem which is common in analysis of substitutable products. We compare two replenishment policies, NIS and TIS, under more general demand distributions.

Problem Definition and Formulation

In our problem, there is a single product with a lifetime of two periods; the value of the product decreases deterministically as it ages, and there may be random demand for both new and old items. A single supplier replenishes new items periodically, with zero lead time. At the end of each period, any remaining old items are outdated, while any unused new items become old. We denote by X_i^n (i = 1, 2) the amount of product with i periods of lifetime remaining at the beginning of period n. The different demand streams for the items of different ages are denoted D_i^n (i = 1, 2). In any period, demand is fulfilled as follows: All demand for new (old) items is fulfilled from the inventory of new (old) unless there is a stock-out. In case of stock-outs, the excess stock of new (old) items may be used to satisfy the excess demand of old (new). We use the term downward substitution to denote the case where a new product is sold to a customer that demands old; upward substitution is the reverse. We assume only a fraction, denoted $0 \leq \pi_D \leq 1$ and $0 \leq \pi_U \leq 1$, of customers accept downward and upward substitution, respectively. Throughout the analysis, we assume any such substitution occurs only if needed. Based on this setting, we can define the following quantities at the end of period n, where x^+ denotes max(x, 0):

$ds^n = \min\{\pi_D(D_1^n - X_1^n)^+, (X_2^n - D_2^n)^+\}$ is the upward substitution amount;

$us^n = \min\{\pi_U(D_2^n - X_2^n)^+, (X_1^n - D_1^n)^+\}$ is the downward substitution amount;

$L_1^n = [(D_2^n - X_2^n) \quad , ds^n]^+$ is the amount of lost sales for old items;

$L_2^n = [(D_2^n - X_2^n) \quad , ds^n]^+$ is the amount of lost sales for new items;

$O^n = [(X_1^n - D_1^n) \quad , us^n]^+$ is the amount that outdates at the end of the period;

$X_1^{n+1} = [(X_2^n - D_2^n) \quad , ds^n]^+$ is the amount of inventory carried to the next period.

We consider two replenishment policies for the supplier:

TIS (Total-Inventory-to-S): At the beginning of every period the total inventory level (old plus new items) is brought up to S. That is, for all n,

$$X_1^n + X_2^n = \text{S}.$$

NIS (New-Inventory-to-S): At the beginning of every period S new items are ordered. Therefore, for all n,

$$X_2^n = \mathrm{S}.$$

In each period, the order of events is as follows: First inventory is replenished, then demand occurs and is fulfilled, with substitution occurring only if need be. Unsatisfied demand for both new and old items are lost. New products become old and old products perish. Finally, costs are assessed and the supplier places the order that will arrive in the next period.

We define *C(S)* to be the long-run time-average cost of the supplier as a function of the order-up-to level *S*:

$$C(S) = \lim_{T\to\infty} \frac{1}{T} \sum_{n=1}^{T} hX_1^{n+1} + p_1 L_1^n + p_2 L_2^n + mO^n + \alpha_U us^n + \alpha_D ds^n.$$

where α_U is the cost of upward substitution and α_D is the cost of downward substitution.

In order to analyze the relative benefit of different substitution patterns for the supplier, we consider four specific substitution options: *No-Substitution*, denoted $\mathcal{N}$, is the base case where items of a certain age are used to fulfill the demand for products of only that age. The inventory levels and total cost of this policy can be found in our model by setting $\pi_D = \pi_U = 0$. Under *Full-Substitution*, denoted $\mathcal{F}$, both downward and upward substitution can take place; this is the general model introduced above with $\pi_D > 0$, $\pi_U > 0$. There are two restricted cases which consider only one-way substitution: *Downward-Substitution*, denoted $\mathcal{D}$, is when $\pi_D > 0$ and $\pi_U = 0$; and under *Upward-Substitution*, denoted $\mathcal{U}$, only upward substitution is allowed (i.e. $\pi_U > 0$ and $\pi_D = 0$).

Comparison of TIS And NIS when Substitution is not Always Accepted

Partial Acceptance of Substitution

In order to observe performances of TIS and NIS with consumer choice we did a numerical study with partial acceptance. Substitution is offered but only a certain fraction of it is accepted by customers. We use π_D and π_U to denote the fraction of substitution that is accepted for downward and upward substitutions, respectively. Table-1 shows the cost comparison of the policies under partial acceptance. The simulations were done for 400,000 periods and only for one parameter setting ($p_1 = 5$, $p_2 = 9$, $h = 1$, $m = 5$, $\alpha_U = 7$, $\alpha_D = 6$). Proportions for acceptance of substitution (π_D and π_U) are varied over (0, 0.1, 0.2, ..., 1). The cost (per period) figures in the table is averaged across all proportions. Cost of $\mathcal{N}$ is given for the sake of completeness and as a reference point.

	$\mathcal{F}$	$\mathcal{D}$	$\mathcal{U}$	$\mathcal{N}$
NIS	48.86	48.96	43.83	44.10
TIS	58.80	61.18	57.72	61.75
% difference	20.34%	24.96%	31.68%	40.01%

Table-1: NIS vs. TIS when a proportion of substitution is accepted

Probabilistic Acceptance of Substitution

In this section we present the results of our numerical study with probabilistic acceptance of substitution. Acceptance probabilities are denoted by ϕ_D for downward, and ϕ_U for upward substitution. We assume each substitution acceptance is independent. Table-2 shows the cost comparison of the policies under probabilistic acceptance.

	$\mathcal{F}$	$\mathcal{D}$	$\mathcal{U}$	$\mathcal{N}$
NIS	48.86	49.08	43.71	44.07
TIS	60.26	62.84	57.90	61.73
% difference	23.34%	28.04%	32.46%	40.09%

Table-2: NIS vs. TIS when substitution is probabilistic

Again, the simulations were done for 400,000 periods and only for one parameter setting ($p_1 = 5$, $p_2 = 9$, $h = 1$, $m = 5$, $\alpha_U = 7$, $\alpha_D = 6$). Probabilities for acceptance of substitution (ϕ_D and ϕ_U) are varied over (0, 0.1, 0.2, ..., 1) whenever there is a chance of substitution. The cost (per period) figures in the table is averaged across all proportions. Again, cost of $\mathcal{N}$ is given for reference.

Table-1 and Table-2 show that the models produce very similar results. We observe that NIS outperforms TIS especially when substitution is offered/allowed less. The reason for this is as follows: New item inventory level is lower under TIS than under NIS. As new items are more valuable, penalty costs will be higher if substitution is not allowed. This would cause NIS to outperform TIS, particularly when substitution is allowed or offered less.

Comparison of TIS and NIS when acceptance probability of substitution depends on substitution costs

It is quite possible that the acceptance probability of a substitution offer depends on substitution costs. We conducted experiments and observed performances of TIS and NIS by modelling acceptance probability of substitution as a function of substitution cost as follows:

$$\emptyset_D(\alpha_D) = 1 - \frac{\alpha_D}{h + 2m + p_1}$$

$$\emptyset_U(\alpha_U) = 1 - \frac{\alpha_U}{m + p_2}$$

Table-3 summarizes the cost figures under TIS and NIS with probabilistic acceptance when the acceptance probability is a function of substitution.

	$\mathcal{F}$	$\mathcal{D}$	$\mathcal{U}$	$\mathcal{N}$
NIS	57.36	57.49	43.86	44.07
TIS	69.46	70.89	59.38	61.72
% difference	21.10%	23.32%	35.37%	40.06%

Table-3: NIS vs. TIS when acceptance probability depends on substitution cost

In the experiment we conducted, the cost parameter settings were as follows: $p_1 = 5$, $p_2 = 9$, h = 1, m = 5, $\alpha_D \in \{0, \dots, 14\}, \alpha_U \in \{0, \dots, 14\}$. The cost numbers in the table are averages across substitution costs and demand distribution is uniform between 0 and 25. Cost of $\mathcal{N}$ is given for the sake of completeness and as a reference point. The table shows that NIS outperforms TIS by at least 20%. For this example, the optimal substitution costs for NIS are found as α_D=2, $\alpha_U = 10$, providing an average cost of 42.83. Under TIS the optimal substitution costs are α_D=3, $\alpha_U = 7$, with an average cost of 55.97.

Search for a good NIS order-up-to level

In this section we propose and evaluate a heuristics for NIS's order quantity. We did the numerical study with the 32 parameter settings. The demand has the uniform distribution between 0 and 25. The results are averaged over these 32 cost parameters. In this heuristic we use $p_2 + p_1$ as the cost of understocking and $h + m$ as the cost of overstocking in the traditional news-vendor setting. Therefore the critical fractile (CF) is as follows:

$$CF = \frac{p_2 + p_1}{p_2 + p_1 + h + m}$$

The results, which are averaged across 32 parameter settings, are summarized in the following table (Table-4):

	$\mathcal{F}$		$\mathcal{D}$		$\mathcal{U}$		$\mathcal{N}$	
	Cost	S	Cost	S	Cost	S	Cost	S
Heuristic	42.65	15.75	42.94	15.75	35.77	15.75	36.87	15.75
Optimal NIS	36.99	21.69	37.17	21.84	31.47	20.50	32.10	20.78
% difference	15.31%	-27.38%	15.53%	-27.90%	13.67%	-23.17%	14.85%	-24.21%

Table-4: Heuristic vs Optimal NIS

Conclusion

Based on our computations NIS outperforms TIS in most of the cases. First we used various demand distributions while comparing TIS and NIS. We observed that if downward substitution

is viable and demand uncertainty is low than TIS outperforms NIS. In order to incorporate customer behavior in terms of acceptance of substitution we did two sets of experiments. First we assumed that customers accept only a proportion of the substitution offer (i.e. partial acceptance of substitution). Second we modeled the system such that acceptance of substitution is probabilistic in nature; that is, based on a probability a substitution offer is rejected or accepted as a whole. Our results show that both models yield similar results. We also present the TIS vs. NIS comparison when acceptance probability depends on substitution cost. As NIS is generally a better replenishment policy for our problem compared to TIS; finding a good NIS order-up-to level without using computational methods is important especially for the cases computations are time consuming. Therefore we developed a heuristic to find a good NIS order-up-level based newsvendor-type logic. The heuristic can be used in case computational solutions are not readily available.

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TWO-DIMENSIONAL RANDOM POINTS MAY NOT BE HOMOGENEOUS

ABSTRACT

The issue addressed in this article comes from an application of Monte Carlo method in which a sample of families is picked for a statistical study in a city and the families in the sample are required to be uniformly distributed. We simulated two methods of generating random points in a two-dimensional space. Our statistical analyses show that randomness of a method does not warrant a uniform distribution of the points generated. A random sample in a two-dimensional area may not be valid in terms of uniformness or homogeneousness, despite that random points on a one-dimensional segment do distribute uniformly.

Key Words: Probability theory, Uniform distribution, Simulation

1. INTRODUCTION

The problem to be addressed in this article comes from an issue in an application of Monte Carlo method in a statistical study. A random sample of families is to be selected in ab area of a city. The families selected for the sample are required to be random and uniformly distributed in the area. A valid sample must satisfy both 'randomness' and 'uniformness' in the area. The problem is: Does any random method select a valid sample? Particularly, for example, if we randomly pick a family on a randomly selected street each time, does it give us a sample whose elements are uniformly distributed?

This sampling issue is generalized to: How to select points in a two-dimensional area so that they are random and uniformly distributed? Will the points randomly selected by any method

distribute uniformly and homogeneously? If not, what methods are not valid, and what methods are valid?

In this article, we examine two methods of randomly generating points by simulations. We use a circle as the example of a two-dimensional area. If a method does not generate uniformly distributed points in a circle, then it will not generate uniformly distributed points in a two-dimensional space in general. We take thousands of points in the simulation as a sample for a method, and carry out statistical analyses on the uniformness of the points generated by that method.

Section 2 addresses the basic concepts and how we test the uniformness of a set of points in a circle. Section 3 describes the two methods of generating random point in a two-dimensional space, which are used in our simulations. Section 4 presents the results of our simulations and shows the statistical analyses.

2. TEST UNIFORMNESS BY SIMULATIONS

Uniformly distributed points are homogeneously distributed (Ross, 1985). In a one-dimensional system, uniform distribution is well defined. Let T denote a line segment [a, b], let t<T be a part of T. A set of random points are uniformly distributed over T if the density of points in t remains same statistically no matter where t is in [a, b].

For a two-dimensional area *S*, a set of random points in S is *uniformly distributed* if only if the density of the points in S remains same statistically everywhere in S. This is the statistical definition of uniformness or homogeneousness of the points in a two-dimensional space.

To test the uniformness or homogeneousness of a particular set of points in a particular area S, we need to check the point-density at any position within S. To do it, we use a square *q* which is much smaller than the area S. If the points in S are homogeneously distributed, then number of point in *q* would be same or similar no matter where *q* is placed in *S*.

In our simulations for testing uniformness of two-dimensional point, we use a round area for *S*. That is, we randomly generate points within a circle *S* with radius 100 and center at the origin (0, 0), and examine the homogeneousness of those points. The equation of the circle *S* is $X^2+Y^2=100^2$. The square *q* is of size 20×20, which is placed at various positions within *S*. Number of points in *q* at a place is compared to those at other places so as to see whether the points in circle S are uniformly distributed.

The area of the circle *S* is $\pi(100)^2$=31,416. The area of the small square *q* is 20X20=400. The ratio of the two areas is therefore 400/31,416 = 0.012732395. It means that if the points in the circle were homogeneously distributed, then the ratio between (number of points in square *q*) and (number of points in circle *S*) should be sufficiently close to 0.012732395.

The simulations are carried out in EXCEL Spreadsheets.

3. METHODS FOR RANDOMLY GENERATING POINTS IN AREA S

There are many ways of generating random points in the area within circle S. The two methods we will examine and the step-by-step procedures are as follows:

Method 1. Random points on random chords of S.

This method picks a random chord of circle S by randomly picking two points <u>on</u> S, then pick a random points on the chord.

Step 1. Randomly generate a point f <u>on</u> circle S;
Step 2. Randomly generate a point g <u>on</u> circle S;
Step 3. Draw a chord H of S by connecting f and g;
Step 4. Randomly pick a point on chord H between f and g.
Step 5. Repeat from Step 1.

Method 2. Random X and Random Y in S

This method randomly picks a point's X coordinate value and Y coordinate value independently, and the point counts only if the selected point is in circle S.

Step 1. Randomly pick x such that $-100 \le x \le 100$, and randomly pick y such that $-100 \le y \le 100$.

Step 2. If point (x, y) is not in circle S (i.e., $x^2+y^2>100^2$), then go to Step 1, otherwise go to Step 3.

Step 3. (x, y) is a point selected.

Step 4. Repeat from Step 1.

The points generated by any of these two methods are undoubtedly random. But are they uniformly distributed? Our simulations try to answer that question. For each method, we generated hundreds of thousands of points, and then check their uniformness by using the point-densities in the small square *q* placed at various positions within circle *S*, $X^2+Y^2=100^2$.

4. SIMULATION RESULTS AND STATITTICAL ANALYSIS

We use EXCEL to generate hundreds of thousands points in circle *S* by either of the above methods. We count number of points in the small square *q* placed at a certain place in *S*. Circle *S*'s radius is 100, so that its area is $\pi(100)^2$=31,416. Square *q* is of size 20×20, so that its area is 400. If the points in *S* are uniformly distributed, then no matter where the square *q* is, the following equation should hold, or statistically hold:

$$\frac{number\ of\ points\ in\ q}{number\ of\ points\ in\ S} = \frac{area\ of\ q}{area\ of\ S} = \frac{400}{31416} = 0.012732395$$

The number 0.012732395 is <u>the benchmark</u> in our simulations and analysis. It means that if the points in the circle *S* were homogeneously distributed, then the ratio between (number of points in square *q*) and (number of points in circle *S*) should be statistically equal to 0.012732395. If

somewhere in *S* the ratio between (number of points in square *q*) and (number of points in circle *S*) deviates away from 0.012732395 significantly, then the points in *S* are not uniformly or homogeneously distributed.

Table 1 below shows the simulation results and statistical analysis on Method 1, *generating random points on random chords of S*.

Table 1. Results and Analysis for *Method 1. Random points on random chords of S.*

Points on Chords Generated from two random points ON the circle									
	Circle	$X^2+Y^2=r^2$		r=100		Area:	31415.9265		
	Square	20*20				Area:	400		
	Average ratio between Square and Circle, AR:						0.012732395		
	20X20 Square with center on:	Total # of points generated in circle S:	# of points in square q	(number of points in q) / (total number of points in S):	Sample standard deviation	Errow margin E with alpha = 0.01 (confidence level 99%)	D: - Difference between sample proportion SP and average ratio AR:	Can reject hypothesis population proportion equals to avg proportion = AR = 0.01273?	p-value
	X=0, Y=0	400000	3177	0.0079425	0.088766	0.000361523	-0.0047899	Yes	<1E-65
	X=50,Y=0	400000	2883	0.0072075	0.08459	0.000344517	-0.0055249	Yes	<1E-80
	X=87,Y=0	400000	2051	0.0051275	0.071423	0.000290888	-0.0076049	Yes	<1E-80
	X=0,Y=50	400000	3271	0.0081775	0.090059	0.000366789	-0.0045549	Yes	<1E-80
	X=0,Y=87	400000	8509	0.0212725	0.144291	0.000587664	0.008540105	Yes	<1E-80
	X=30,Y=30	400000	3032	0.00758	0.086733	0.000353241	-0.0051524	Yes	<1E-80
	X=55,Y=55	400000	3803	0.0095075	0.097042	0.000395228	-0.0032249	Yes	1E-78

Table 2 below shows the simulation results and statistical analysis on Method 2, generating random points by independently selecting values of X and Y in *S*.

Table 2. Results and Analysis for *Method 2. Random X and Random Y in circle S*

Points Picked direct by selecting independent X and Y without using any chord									
	Generate a value between -100 and +100; if it is outside the circle, discard it and generate the next one.								
	Circle	$X^2+Y^2=r^2$		r=100		Area:	31415.9265		
	Square	20*20				Area:	400		
	Average ratio between Square and Circle, AR:						0.012732395		
	20X20 Square with center on:	Total # of points generated in circle S:	# of points in Square q	(number of points in q) / (total number of points in S):	Sample standard deviation	Errow margin E with alpha = 0.05 (confidence level 95%)	D: - Difference between sample proportion SP and 0.01273:	Can reject hypothesis population proportion equals to avg proportion = AR = 0.01273?	p-value
	X=0, Y=0	1201277	15174	0.012632	0.111678	0.000199708	-0.00010084	No	0.31
	X=50,Y=0	1201277	15260	0.012703	0.11199	0.000200266	-2.9247E-05	No	0.78
	X=87,Y=0	1201277	15192	0.012647	0.111743	0.000199825	-8.5853E-05	No	0.4
	X=0,Y=50	1201277	15181	0.012637	0.111704	0.000199753	-9.501E-05	No	0.22
	X=0,Y=87	1201277	15312	0.012746	0.112178	0.000200602	1.40402E-05	No	0.9
	X=30,Y=30	1201277	15399	0.012819	0.112492	0.000201164	8.64631E-05	No	0.4
	X=55,Y=55	1201277	15249	1.2694%	0.11195	0.000200194	-3.8404E-05	No	0.7

In the above tables, we show

- total number of points generated in *S*,
- total number of points in *q* at various positions inside *S*,
- ratios between (number of points in *q*) and (number of points in *S*),
- error margins with α=0.05 or α=0.01,
- *p*-values, and
- whether we could reject the hypothesis that the point-density in s is equal to the benchmark 0.012732395.

For Method 1, we can confidently reject the hypothesis that (the point-density in square *q*) is equal to 0.012732395, so that we can confidently reject that the points generated by this method are uniformly distributed. That is, the random points generated by this method are not homogeneously distributed. (!)

For Method 2, we cannot reject the hypothesis that (the point-density in square *q*) is equal to 0.012732395, so that we take the hypothesis that the points generated by this method are uniformly distributed. That is, the points generated by this method are homogeneous over the two dimensional *S*.

Both Method 1 and Method 2 randomly select points. But their outcomes are different in terms of distributions of the generated points. The simulation results alert us that when selecting points in a two-dimensional space, randomness does not guarantee uniformness. While randomness in the one-dimensional space guarantees uniformness, it doesn't in a two-dimensional space.

When randomly selecting a sample of families in a city, a convenient method is to select a street first, then pick a family on the street, which amounts to selecting a chord first then picking a point on that chord as in Method 1. Our simulations show that a sample generated by using such a method is not a homogeneous one. To guarantee the uniformness of a set of random points in a circle, we need to generate its X-coordinate value and its Y-coordinate value independently, as we did in Method 2.

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USE OF MULTIVARIATE CONTROL CHARTS WHEN THE PROCESS DATA IS LIMITED

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Abstract

The objective of this paper is to discuss the use of multivariate control charts, specifically T^2 charts, when the data collected is low/limited. The use of multivariate statistical process control (SPC) techniques to manage quality has been increasing, e.g., in a supply chain environment. Conventional multivariate SPC tools, such as T^2 charts, require a large number of data points to form subgroups. This is not an issue when there is a large amount of data available. However, if the data is limited, the use of T^2 charts would be challenging, and the sensitivity of the chart to the changes would be very low. The proposed method estimates the variance-covariance matrix by using mean square successive differences (MSSD), which will help overcome these difficulties.

Key words: T^2 control chart, low data, mean square successive differences, variance covariance matrix.

Introduction

Conventional statistical process control (SPC) techniques, both univariate and multivariate, generally rely on a large amount of data being readily available. With the help of internet technology, a large amount of data is available in many business processes. As a result, we see the increasing applications of univariate and multivariate SPC tools, such as in the supply chain environment (see, for example, Mele, et al (2005), Jarrett (2013), Morgan and Dewhurst (2007)).

As the supply chain becomes a critical part of any business operations, managing quality, in addition to issues like inventory, logistics, information, etc., plays a key role for the overall performance of the supply chain. However, there are processes where data is limited due to its nature, such as chemical processes or processes which operate on a short-run production format (i.e., very small batch size). Thus, in this paper we will discuss a methodology to revise T^2 control charts so that they can be used in a limited data setting with increased sensitivity. This will help extend the application of these charts in more areas. The approach uses the concept of Mean Square Successive Differences (MSSD) to estimate the variance-covariance matrix, which will be explained below.

Proposed Method

The original work in T^2 control charts was done by Hotelling (1947). For more information on multivariate quality control charts, see, for example, the work of Jackson (1980) and Alt (1985). The statistic T^2 is calculated using the following equation:

$$T^2 = (X - \overline{X})' S^{-1} (X - \bar{X}) \qquad (1)$$

In the above equation, X is the (px1) vector representing data on the p variables, $\bar{X}$ is the (px1) vector of the average of p variables, S is the (pxp) sample variance-covariance matrix, S^{-1} is the inverse of S, and p is the number of variables. In the T^2 chart, the upper control limit for the T^2 statistics is set using the F distribution (T^2 chart only has an upper control limit), as shown below with a given Type I risk level of alpha (α):

$$T^2_{p,n,\alpha} = \frac{p(n-1)}{n-p} F_{p,n-p,\alpha} \qquad (2)$$

where n is the number of observations of p variables.

A common practice is to use a set of historical data (i.e., a base period) to calculate the variance-covariance matrix without forming any subgroups. Of course, the drawback to this practice is that the control limit may be too wide, so that the changes in the process are not detected quickly. This is not an issue in univariate charts, since subgroups and within subgroup variation are used to estimate the process' overall standard deviation. A similar approach can also be used for the

T^2 chart, i.e., using the subgroup averages and the average of the subgroup variance-covariance matrices. However, this requires a large amount of data; i.e., the subgroups must be large to ensure adequate degrees of freedom in the subgroup matrix calculations. In addition, making the subgroups large reduces the sensitivity of the chart to process changes, since the time lag between the subgroups would be too wide. Thus, to avoid the subgrouping problem mentioned above, we propose that the (MSSD) approach be used to calculate the variance-covariance matrix. This will also help improve the sensitivity of the chart to process changes (Holmes & Mergen (1993)).

The proposed method is a multivariate extension of the MSSD estimator of variance, to the variance-covariance matrix (S). The MSSD estimator of variance, which is unbiased, is given by Hald (1952) as follows:

$$q^2 = \frac{MSSD}{2} \tag{3}$$

where MSSD is defined as

$$MSSD = \frac{1}{n-1} \sum_{i=1}^{n-1} (X_{i+1} - X_i)^2 \tag{4}$$

where n is the number of data points. See also Neumann, et.al (1941) for MSSD.

The multivariate equivalents to the average and variance are, respectively, a vector of variable means and the covariance matrix. The multivariate equivalent to the mean square successive difference variance is the mean square successive difference covariance matrix, which is discussed by Holmes and Mergen (1993). The elements of the MSSD covariance matrix are

$$Cov(X_j, X_k) = \frac{\sum_{i=2}^{n} (X_{j,i} - X_{j,i-1})(X_{k,i} - X_{k,j-1})}{2(n-1)} \tag{5}$$

If the processes j and k are random and have no cross-correlation other than at zero lag, these two estimates of the universe covariance will be similar. Otherwise, they will be different. The covariance matrix obtained using the MSSD approach and the regular covariance matrix can be

tested for equality using the test proposed by Kramer and Jensen (1969). See also Holmes and Mergen (1998) for this test.

Example

We will use a data set from Holmes and Mergen (1993) to show the application of the proposed method. The data set is comprised of the percentage of particle distribution on three screens from a refractory. Since percentages add up to 100%, we will use the first two columns (screen 1 and 2 percentages); otherwise the variance-covariance matrix will not invert. There are only 56 data points on the percentage of particle distribution on three screens. An example of the data set is shown below.

Screen 1	Screen 2	Screen 3
5.4	93.6	1.0
3.2	92.6	4.2
..	..	..

The full data set is available from the authors upon request.

The T^2 chart shown in Figure 1 below uses the variance-covariance matrix estimated using the MSSD approach, which is given in equation 5.

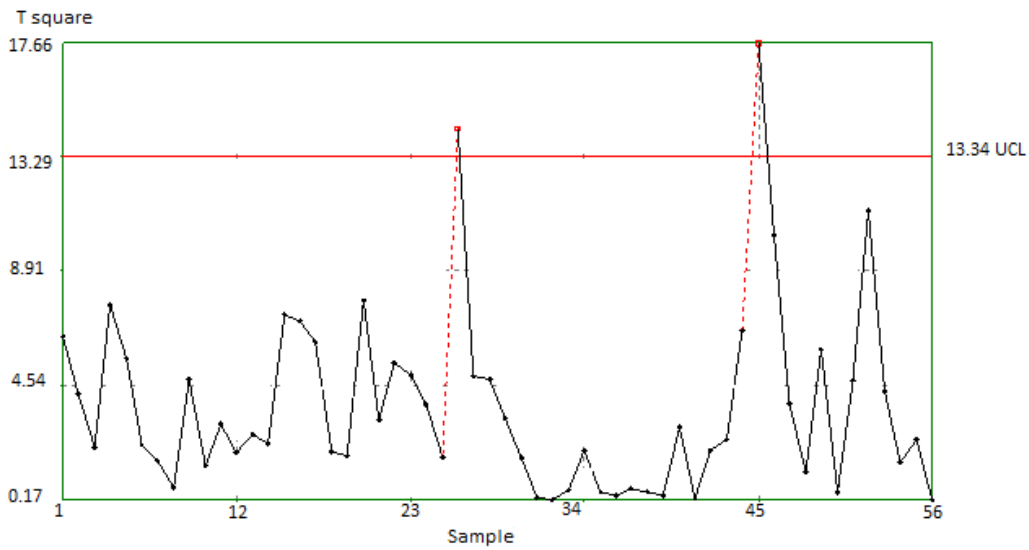

Figure 1. T square chart with MSSD variance-covariance matrix

The chart shows two out-of-control points: at points 26 and 45. On the other hand, the T^2 chart that uses the regular variance-covariance matrix, shown in Figure 2 below, misses these two out-of-control points. These two out–of-control points shown in Figure 1were not false signals, as verified by the refractory.

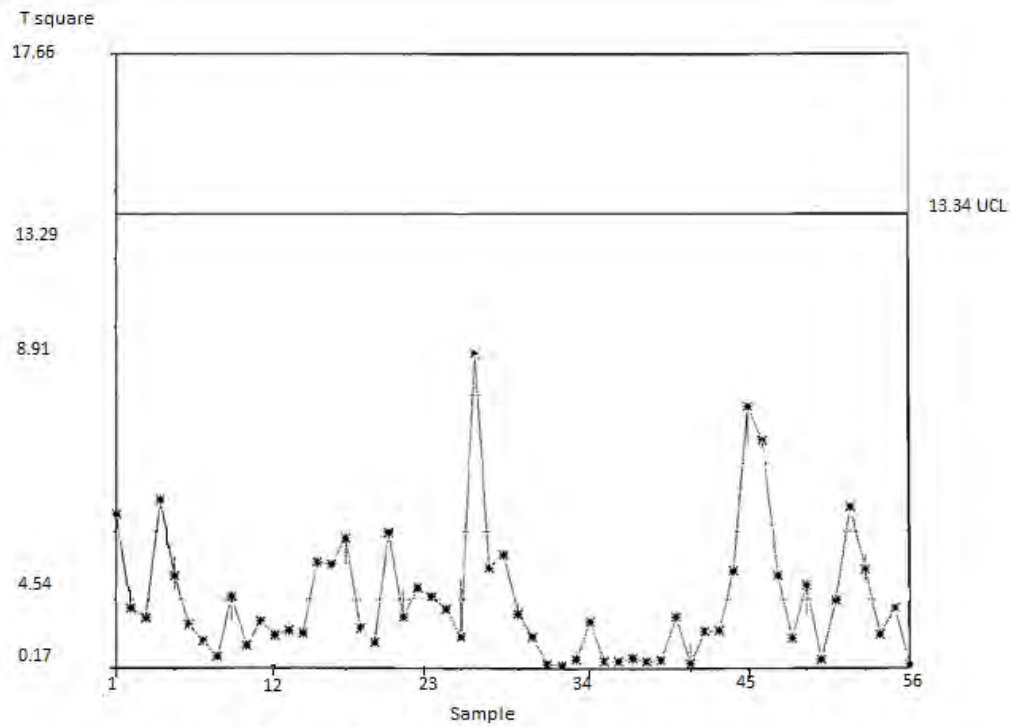

Figure 2. T square chart with regular variance-covariance matrix

As this example shows, using the MSSD variance-covariance matrix makes the use of the T^2 chart feasible when the data is limited and improves the sensitivity of the chart to detect changes in the process.

When a multivariate tool, such as a T^2 chart, is used, there is another step that needs to be completed: what has really changed in the process. An out-of-control signal on the T^2 chart indicates that one or more averages or the correlation structure between two or more variables might have changed. Several methods were discussed in the literature to find the variable(s) that triggered the signal(s), i.e., identified the cause of the out-of-control signal. See for example, Doganaksoy, et al (1991), Murphy (1987), Holmes and Mergen (1995).

Conclusion

In this paper, we proposed the use of a revised variance-covariance matrix to be able to use T^2 control charts when the data is limited. This approach not only makes the T^2 chart a viable tool

when data is limited, it also increases the sensitivity of the chart to detect process changes faster. Actually, this approach can be used in any process where the data is limited or abundant, i.e., it is not restricted to only a limited data environment. Given the increasing trend of using both univariate and multivariate SPC techniques, especially in supply chain management, this approach could be an additional tool for quality control practitioners.

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ORGANIZATIONAL THEORY AND BEHAVIOR - ABSTRACTS

IT'S ALWAYS LOYALTY TO THE ORGANIZATION? A STUDY OF THE RELATIONSHIP BETWEEN ORGANIZATIONAL IDENTIFICATION AND OUTCOME BEHAVIORS OF EXIT-VOICE-LOYAL-NEGELECT MODEL FOR THE PUBLIC SERVANTS IN TAIWAN

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Organizational identity refers to the members' awareness of organizational characteristics in the organization, which will affect the members' sense of organizational identification to the organization. Past accumulated empirical studies have supported the positive relationship between organizational identification and outcomes, including as satisfaction (Maria Karanika-Murray, Nikita, Halley, & Mark, 2015), job performance (Callea, Urbini, & Chirumbolo, 2016), organizational citizenship behavior (Jiang, 2010; Callea, Urbini, & Chirumbolo, 2016), and organizational commitment (Celeste, de León, & García, 2012). However, few study exploring the organization identity contents for Public agency and linking this to EVLN Model (Exit-Voice-Loyal-Neglect Model, Rusbult & Farrell, 1983). The study following Hinkin's (1995) method to develop an organizational identity scale for Public agency from Taiwan, and used this scale to test the relationship between four terms of organizational identification (e.g., identification, dis- identification, schizo-identification and neutral-identification of expanded model of organizational identification were used in the study which was proposed by Kreiner & Ashforth, 2004), and employees' four pattern outcomes of exit, voice, loyal, and neglect behaviors.

First, through grounded theory and content analysis, the study concluded 28 organizational identity contents and final briefly to 23 Public Agency Organizational Identity Scale (PAOIS) into empirical research. Secondly, the study used this PAOIS scale to test relationship between organizational identification and employees' outcomes. Data collection used convenience sampling method and final has 112 valid samples from public servants. Beside the organizational identify scale were developed in the study, all other scale were adapted from past valid scale.

The study results showed that two terms of organizational identification and organizational dis-identification are both significantly positive related to loyalty (β= .44, 31; p<.01, .01, respectively), and schizo-identification revealed significantly negative related to loyalty (β= -.42, p<.001). Further, schizo-identification showed

significantly positive related to neglect behavior (β= .372, p<.01), and exit behavior (β= .541, p<.01). Finally, it is pitiful that no any significantly pattern in the relationship between four terms of organization identification and voice behavior. The study prior linkage the organization identification and EVLN model in order to understand deeply what kinds of organization identification, which differ from past research only focus on one aspect of organization identification, final predict to different outcome behaviors.

The study finding has two practical implications. First, a well-developed PAOIS could be a useful tool for testing employees' organizational identification survey of human resource management in public agencies. Second, to develop higher organization identification, public agencies need to understand deeply about what kinds of identification to link different outcome behaviours for employees.

Past research have inter-exchange two constructs of organizational identify and organization identification, but the study try to develop a specific organizational identity contents for public agency and applying this to examine the relationship between organization identification and employees outcomes behaviours. This research finding has further contribution to the theory of organization identification and EVLN Model.

Keywords: Organization Identity、Organization Identification, Extended Model of Organization Identification、EVLN Model

SHINING A LIGHT ON PERSONNEL SELECTION MEASURES AND METHODS IN SEARCH OF THE IDEAL EMPLOYEE

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SHINING A LIGHT ON PERSONNEL SELECTION MEASURES AND METHODS IN SEARCH OF THE IDEAL EMPLOYEE

Freedman (2010) retells an old joke to suggest the "streetlight effect" in scientific research: Late one night, a police officer finds a man crawling around under a street light, searching for his wallet. The police officer helps him search, and after a while, asks the man if he is sure this is where he dropped his wallet, the man points to the dark alley across the street and says, "No, I think I dropped it over there." When the officer asks why they were searching under the streetlight, the man replies, "Because the light is better here!"

Human resource directors, executives, and hiring managers share responsibility for hiring employees who are a good fit with the organization and work setting, and it is important to understand their perspective regarding the employee qualities they prioritize and the ways they prefer to evaluate job applicants. A version of the streetlight effect may be applicable to personnel staffing research aimed at helping managers identify the best employees. Scholars advocate using carefully crafted methods and measures that have been studied for their reliability, validity, legality, and utility, but sometimes organizational leaders ignore this expert advice in favor of practices that they believe are better suit their personnel staffing needs. "In fact, many employers, both in the United States and throughout the world, are currently using suboptimal selection methods. For example, many organizations in France, Israel, and other countries hire new employees based on handwriting analyses by graphologists. And many organizations in the United States rely solely on unstructured interviews, when they could use more valid methods" (Schmidt & Hunter, 1998, p. 273). Although the goals of personnel selection scholars are not at odds with those of hiring managers, employers do not always screen applicants under the metaphorical streetlight that selection scholars have provided.

The present study investigates what organizational leaders look for in prospective employees and their attitudes toward traditional and web-based selection tools. Based on the analysis of structured interviews with fifteen European HR directors and senior executives, the "ideal employee" *shows enthusiasm* and is *open to new experiences*. Other important qualities include the *ability to adapt to new situations, global and/or intercultural experience, good multi-tasking skills,* and *honesty.* Some respondents also emphasized task-performance, creativity, and bringing diversity to a workgroup.

All interviewees expressed a strong preference for interviewing job candidates in a face-to-face format in order to subjectively measure these qualities. Despite the fact that the predictive validities associated with interviews tend to be much lower than the validities of more objective selection tests, most interviewees were not confident that formal tests or structured screening processes could adequately measure the qualities described above. Several interviewees commented that only interviews allow for both verbal and nonverbal information to be effectively perceived and subsequently evaluated by hiring managers. Given the strongly-held belief that "ideal employee" attributes are best found during face-to-face interaction, it is not surprising that the executives were skeptical of selection tools, methods, or formats that attempt to remove or limit communication between job candidates and hiring managers. Efforts to engineer the selection process in a way that minimizes human involvement and the expert judgment of experienced managers seem unlikely to be accepted, as such efforts attempt to remove what is viewed as the key ingredient in recipes for selecting ideal employees. Findings prompt several considerations for research and practice about the qualities organizational leaders want in their employees and the value of their judgment in the personnel selection process.

Keywords: Staffing, Selection, Organizational fit, Managerial judgment; "Ideal Employee"

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ORGANIZATIONAL THEORY AND BEHAVIOR - PAPERS

Differential Treatments in Team and Team Effectiveness: The Role of In-Group Members

Introduction

Influenced by Confucianism *guanxi*, in other words, human relationships in the Chinese society are differentiated in terms of respect and love rather than egalitarian. Therefore, during social interactions, people must observe the hierarchical order of respect and love, namely that they must love and respect those who should be loved and respected. This is the only way the benevolence, righteousness, and ritual of the Confucian spirit can be complied with (Yang, 2004). The value system of "Love" and "Respect" influences the thoughts and behavioral patterns of Chinese people day-to-day. In addition, it is perpetuated by virtue of the Chinese carrying the familial experience and habit over to other social groups, exerting significant impacts on organizational structure and management behaviors of Chinese Corporations (Cheng & Huang, 2000). Therefore, corporate leaders treat subordinates differently based on personalism or favoritism as a strategy to improve leadership efficiency. This differentiation is stemmed from Chinese culture and the leadership style is rooted in the personalism, that is when individuals make decisions *guanxi* or personal preferences influence decisions（Redding, 1990）. One important feature is differential leadership. Leaders expect to use differential treatment to improve in-group subordinates' loyalty and work efficiency. They also hope to motivate out-group subordinates to exhibit behaviors that comply with the leaders' expectations (Hsu, Cheng, & Huang, 2002; Jiang & Chang, 2010；Yuan, Li, & Li, 2016).

Differential leadership emphasizes treating different subordinates differently; it is a leadership style that relays favors to preferred subordinates, formed under the atmosphere of personalism (Jiang & Chang, 2010). However, as individuals of the organization exist in team units, leaders' preferential treatment of some subordinates might affect the interaction among team members and consequently team effectiveness. Therefore, to capture the derived

collective effect caused by leaders' differential treatment under the atmosphere of personalism, we must consider the potential impact of ensued within-group variation on team effectiveness.

Recent research on transitional leadership has developed the concept of differentiated leadership (Wu, Tsui, & Kinick, 2010). LMX (leader-member exchang) research has also extended its research level to the team level and found that LMX differentiation affects group-level outcome (Henderson, Liden, Glibkowski, & Chaudhry, 2009). Even though, in the existing research, Chinese-style differential leadership has been studied on a team-level, most studies directly use the team's average leadership behavior to predict team-level differential treatment. Regrettably, such a criterion cannot accurately determine whether a very preferential leader or a very non-preferential leader can affect team effectiveness differently. Studying how the extent of differentiation, formed by a leader, affects team effectiveness helps better capture the significance of differential treatment on a team level (Henderson et al., 2009).

Discussing team effectiveness on a collective level usually entails the inclusion of two main aspects, namely attitude and behavior (Cohen & Bailey, 1997). Therefore, this study uses team performance and team commitment as indicators of team effectiveness. Team commitment causes members to internalize team value and increases identification with team goals（Allen & Meyer, 1990）. Team performance, on the other hand, is the most important variable on a collective level in leadership studies (Bass, 1990; Yukl, 2002) and is the core criterion when evaluating leadership efficiency (Liden, Erdogan, Wayne, & Sparrowe, 2006). Through these two variables, we can predict the influence of the leaders' differential treatment on other team-related end result variables.

Moreover, the fact that a leader supports and cares for team members differentially, not only forms the hierarchical relationship of in-group and out-group but also implies that the leader intends to differentiate the status and role of different members (Slater, 1965; Stogdill, 1959), so that members can have a clear set of standards by which to play their roles. (Cheng,

2005a). Therefore, whether the team members are willing to perform their respective roles as dictated by the leader will be a circumstantial factor, which indirectly affects whether the leader's differential treatment can have positive influence on team effectiveness, and especially whether preferred in-group members can perform expected functions. Regrettably, few relevant researches have focused on the role function of in-group members.

Combining all the aforementioned factors, this research aims to discuss the influence of differential treatments on team effectiveness at a team level, and to better understand whether the exchange with in-group members and proportion of in-group members have a moderator effect on leadership differentiation and team effectiveness.

Theoretical and Hypotheses

Leadership Differentiation and Team Effectiveness

Differential leadership reflects a personalism leadership style that belongs to Chinese cultural. The concept of five ethics in Confucianism highlights the relationship of non-equivalence, and the two sides often have obvious differences in status, such as closeness and alienation, monarch and courtier, or father and son. At the same time, the unequal relationship also emphasizes that those with higher powers have the responsibility to take care of, and those with lower powers have the obligation to obey (Jiang & Cheng, 2008; Hwang, 1999; Wu, Hu, & Jiang, 2012). Each individual has their own role and its standard code of conduct must be followed, by individuals internalizing their roles, becoming one of the individual's obligations, and having a profound and extensive influence on the individual (Cheng, 1995; Jiang & Cheng, 2008).

Therefore, Chinese leaders, bound by Confucian ethics, do not interact with subordinates in a uniform manner but do so differentially, based on personal intimacy, closeness and seniority, as well as other role relationships; meanwhile, the leaders divide subordinates into

in-group members and out-group members, treating them differently (Cheng, 1995b). When subordinates perceive differential treatment, they will use it as a clue to judge the relationship position they have with the leader. Different relationship positions indicate that the leaders have different social relationships and a combination of personal favors and ethical responsibilities, all of which will be used as a guidance to their interactions (Hsu, Cheng, Kuo & Hu, 2006). Generally, in-group subordinates occupy operational and managerial positions and are personally close to the leader, receiving preferential treatment in terms of favors and allocation of resources. For out-group subordinates, leaders deem their relationship with them as purely contractual in rights and obligations, and treat them more strictly and distantly. Additionally, out-group subordinates usually occupy job positions that are purely executive and do not impact the organizational operation (Cheng, 1995b). When differential treatment by leaders takes place in a team, every subordinates will feel an overall differentiation of support and favors from the leader. Hence, the overall gap form an intra-group variation. In addition, it can be understood as an atmosphere of differentiation caused by different members' perception of the leader's differential treatment (Liden et al., 2006；Henderson et al., 2009；Kuo, Lin, Chou, & Cheng, 2015). That is, those who are treated well are in-group, and those who are treated badly are out-group.

According to the role theory (Mead, 1934), leaders provide team members with clear role objectives and role positioning by means of role differentiation, so that members can take actions that comply with the role's rules (Slater, 1965; Stogdill, 1959). In the case that differential leadership spurs team efficiency, when team members have clear hierarchical positions, arise out of members' competition for the same position can be avoided and team conflicts that might negatively affect team efficiency (Groysberg, Polzer, & Elfenbein, 2011). Therefore, differential leaders can reasonably allocate team members' characteristics and talents to corresponding tasks by means of differentiating members' roles and status, thereby

maximizing team efficiency (Jiang & Cheng, 2014).

On the other hand, that differential leadership interrupts team efficiency, leaders' preferential treatment can easily cause an uneven distribution of resources, and the team members might consider such treatment as unfair. Therefore, members might exchange a reduction of productivity and work quality for a psychological balance of fairness (Adams, 1965). Further, relative deprivation theory further elucidates that when people discover that they are at a disadvantage upon comparing themselves to others, they generate a feeling of deprivation that causes anger, grudge, or discontent (Crosby, 1984; Martin, 1981), thereby reducing the feeling of satisfaction in team members and causing team efficiency to dip (Colquitt, Wesson, Porter, Conlon, & Ng, 2001).

Based on the aforementioned arguments, to make role differentiation positive for team efficiency, the key is to make in-group and out-group members willing to accept their relative positions and to play their roles. This is the only way through which a team can run smoothly and create profits (Liden et al., 2006). For in-group members, since they belong to the preferred party, they identify highly with their role and team objectives and try their best to complete tasks. For out-group members, if leader chooses in-group members through objective criteria and the leader differentiation is not too great, they might have an easier time accepting a disadvantaged position. The reasoning is that leaders, in-group members, and out-group members work in the same team after all. For out-group members to survive in the team, they have to accept some degree of differential treatment aligned with the leader's preferences, in other words, play the appropriate role. What's more, they should cordially work with in-group members to complete team tasks. However, too great a leadership differentiation might cause out-group members to resist, thereby negatively impacting team efficiency.

The LMX research points out that differential treatment by leaders might cause subgroups to form within a team (Scandura, 1999; Sias & Jablin, 1995), thereby further affecting

relationships between in-group members and out-group members. When a leader clearly distinguishes the in-group and the out-group, he or she might cause resentment from the out-group members (Yukl & Fleet, 1992) and cause them to have negative opinions about the in-group members, thinking that these in-group members like to cajole the leader (Maslyn & Uhl-Bien, 2005). When leaders care for, ask about, and support team members to a varying degree, the likelihood of uneven distribution of resources and negative effect on team efficiency is higher (Liden et al., 2006).

H1a: leadership differentiation in team will negative related to team performance.

H1b: leadership differentiation in team will negative related to team commitment.

The Moderator effect of the proportion of in-group members

For differential leadership to be effective, first the employee categorization criteria must be related to individual effectiveness; secondly, the leader's differential treatment requires a rewarding and superior function (Cheng, 2017). Cheng (1995a) claims that to reduce cognitive burden in managerial work, leaders will categorize employees based on their own value systems and preferences. The criteria for categorization is g*uanxi*, loyal and talent. *Guanxi*, refers to blood, in-law relationship or special social connection. Loyalty, in order to regulate the internal order of the organization, the subordinate must be completely obedient and identified with the leader. In terms of the talent, employees' intelligence, ability, and performance as criteria for categorization. Next, the leader will have different degrees of trust in the subordinates based on the weighted value of the three criteria and a certain level of in-group consciousness. When the leader have a high in-group consciousness, they are insiders; if not, they are outsiders. This is exhibited in the differential treatment of subordinates in management. Therefore, insiders and outsiders are a continuous concept rather than a binary, and they reflect the difference in terms of extent (Cheng, 1995a). Meanwhile, the conditions

after categorization are a dynamic process rather than static. This means that when out-group members perform efficiently, they have a chance to be an in-group member (Cheng, 1995a).In short, at times, there could be just one insider in the team, and at other times, there could be more. Although the leader signals the categorization, the leader's categorization perceived by subordinates is highly similar to the leader's actual categorization (Hsu et al., 2006).

Through the role theory, we understand that in-group members understand leaders' expectations and have higher role cognition (Gerstner & Day, 1997). Therefore, they have a higher identification and sense of mission with the organization and are willing to internalize the organization's goals (Wang et al., 2005). In this situation, these subordinates are willing to accept more work tasks and take on more responsibilities (Liden, Wayne, & Stilwell, 1993). Therefore, to improve team performance, leaders should increase their number of in-group subordinates (Cheng, 2005b).

More than reflecting on in-group members, the expansion of in-group members helps one understand possible attitudes held by out-group members via the coattail effect. To avoid becoming the few marginalized members in the team, out-group members become more motivated to become one of the in-group members when the latter are larger in number. Additionally, based on the law of similarity-attraction, we can defer that, when there is a high proportion of in-group members, out-group members have a higher chance of finding similar minds with the in-group members. Two parties that are attracted to each other are more willing to learn from one another. Through the process of observation and learning, out-group members are more likely to become in-group members.

When most of the team members comprise the leader's in-group subordinates, they can obtain more support, care, and resources, and achieve an atmosphere of harmony and warmth. This helps members to work in harmony and communicate, and the interactive process will form a shared collective identification (Chou & Cheng, 2014). Therefore, if the in-group

members outnumber the out-group members in a team, the team's efficiency is higher (Graen & Cashman, 1975).

H2a: The proportion of in-group members will moderate the relationship between leadership differentiation and team performance. The negative pattern between leadership differentiation and team performance will weak when the proportion of in-group members is high.

H2b: The proportion of in-group members will moderate the relationship between leadership differentiation and team commitment. The negative pattern between leadership differentiation and team commitment will weak when the proportion of in-group members is high.

The Moderator effect of exchange with in-group members

Western organizations emphasize on an egalitarian order, and researchers usually adopt the theory of social exchange and consider the exchange between leaders and subordinates, or the exchange among team members, to be a mutually complementary function. Therefore, out-group members not preferred by leaders can improve work efficiency through the exchange with other subordinates (Heller & Rook , 2001). In Chinese companies where vertical order is of greater emphasis than horizontal order and power differentiation is relatively large, team efficiency might also be affected by the exchange among subordinates (Shen, Huang, Jiang, 2014).

The dilemma caused by differential treatment seems to be the structure of a circle within a circle formed by the leader, the leader, the in-group, and the out-group, which places a gap between the leader and the out-group. Therefore, if the in-group members can become a bridge for the communication between the leader and out-group members and assist the out-group members, they can reduce the leader's workload and provide out-group members with an opportunity to understand the leader's requirements. At the time, the out-group members may

be willing to work with the in-group members because they perceive goodwill from the in-group members. Through the process of collaboration and interaction, emotional connection can be established to increase trust and form a high-quality exchange relationship. This is when the leader, in-group members, and out-group members form a tight and solid team structure, maximizing work efficiency of all three parties and increasing overall work efficiency (Hsu et al. 2006）.

According to the role theory (Mead, 1934), in-group subordinates have higher role cognition and role responsibilities (Gerstner & Day, 1977), which can propel in-group members to exhibit organizational citizenship behavior and actively provide out-group subordinates with assistance. Based on the mutually beneficial principle of personal relationships, those who have received help will probably want to return the favor (Yang, 2004). Therefore, out-group members might want to coordinate with in-group members after receiving their help. The mutually beneficial relationship between the groups will result in a mutually trusted interaction model and a dependence relationship, inspiring the members to truly identify with the organization or the group (Hsu & Cheng, 2002). Furthermore, teams with positive exchanges, through mutual support between members, can not only regulate the mood of individuals and the team (Sheif & Sherif, 1964), reducing members' work pressure, but also increase employees' organizational commitment (Liden, Wayne, & Sparrowe, 2000), improving the team's self-identification and solidarity (Seers, 1989) and consequently improving the team efficiency (Frazier, 2009).

H3a: The exchange with in-group members will moderate the relationship between leadership differentiation and team performance. The negative pattern between leadership differentiation and team performance will weak when the exchange with in-group members is high.

H3b: The exchange with in-group members will moderate the relationship between

leadership differentiation and team commitment. The negative pattern between leadership differentiation and team commitment will weak when the exchange with in-group members is high.

Method

Procedure

The participants of this research are workplace teams consisting of 3 to15 members under the same direct supervisor in Taiwanese companies, including sole proprietorship company or departments of product R&D, product sales, product services, or accounting, HR, overall management, and administrative departments. To improve the applicability of the research results, we adopted a questionnaire model of relationship networks, with the procedure as follows. (1) We enquired whether friends and families are willing to assist, and after explaining the definition of team and other relevant concepts, we invite them to find appropriate teams that are willing to be measured. (2) After confirming that they are qualified for the study, we required their assistance in providing a list of team members, the names of whom will be pasted onto each questionnaire. (3) We packaged and numbered the questionnaires and reply envelopes based on the number of members in a team. (4) We informed each participant that they must respond to the questionnaires labeled with the names. After completing the questionnaire, they could tear off the name slip and put the response in the reply mail. The security and privacy of interviewees were protected.

Participants

After removing responses that had too much missing or were filled out carelessly, we selected 94 teams from 62 organizations, totaling 487 people. The analysis result of descriptive statistics shows that 187 entrants are male (38.4%), and 300 are female (61.6%); most of the

entrants aged 45 or below 45 (71.3%); and most have an associate/undergraduate degree (65.1%); most of the entrants' job positions are non-managerial (68.6%); and those who worked in the same company for nine years and above occupy the largest ratio (41.5%); in terms of team characteristics, most teams are in marketing communications/sales departments (42.3%); military, public services, and education occupy the highest ratio of industries (25.9%); most have worked for three years or less with their current leader (48.2%); and most of the participating departments have 10 people and below (59.9%); most of the participating teams have five people and below (50.1%).

Measures

Given that many Chinese people tend to choose an in-between answer when filling out questionnaires (Chiu & Yang, 1987), all the scale questions adopt the Likert type, divided into six extents, from "Strongly Disagree" (1) to "Strongly Agree" (6) or six frequency levels, "Not at all" (1) to "Frequently, if not always" (6). For the measurement tools to apply more accurately to the questions, we modified some options to suit the purpose of the research.

Leadership Differentiation. Since a leader's differential treatment reflects the difference in the leader's behavior perceived by team members, this concept applies to Chan (1998)'s dispersion model. Therefore, the current study used the standard deviation of members' scoring of perceived differential leadership behaviors as the score that measures the team leader's differential treatment. Regarding choosing questions, we adopted Jiang and Chang (2010)'s Leadership Differentiation Evaluation Questions for Chinese People. The rule of the adaptation is to change the subject of in-group subordinates to me, such as: "The leader often asks how I am doing," "The leader gives me relatively size-able bonus and rewards," "The leader gives me relatively light punishment."

Proportion of in-group members. This research adopted the method of Liden et al. (2006) and used the median value of the scores provided by leader regarding leadership differentiation as the central leadership tendency of each team leader. Entrants with scores higher than the median value were deemed as an in-group member. This is because the median value reflects the middle level of scores within a team and is not affected by extreme outliers. In addition, the present study adopted Jiang and Chang (2010)'s Leadership Differentiation Evaluation Questions for Chinese People, with questions changed to "I often ask him how he is doing."

Exchange with in-group members. This questionnaire adopted questions made by Seers, Petty, and Cashman (1995), with 10 questions in total. After deleting questions that had the same meaning, seven questions remained. The questions are, for example, "When I am busy, he volunteers to help me." In-group members are also determined with the median value of scores from the Leadership Differentiation Questionnaire which score by the leader. Then, we calculated the score that measures the exchange between subordinates and in-group members. Subsequently, we calculated the average exchange score of every team as the score that measures the exchange between team members and in-group members.

Team Commitment. The Team Commitment Questionnaire was adapted from Meyer, Allen, and Smith's (1993) Affective Commitment Questionnaire. The rule of the adaptation is to change the subject of commitment from organization to team, such as: "I'm very willing to work in the company long-term" is changed to "I'm very willing to work in the team long-term." There are six questions in the questionnaire. Since team commitment has an aspect of shared perceptions, calculation based on the consensus model was considered appropriate. Regarding the determination criterion when compiling the data, the median value of *rwg* is .73, $ICC_{(1)} = .14$, $ICC_{(2)} = .40$.

Team Performance. The Team Performance Questionnaire is adapted from the questionnaire developed by Edmondson (1999) and contains five questions. This questionnaire was filled out by leaders, with questions such as "The team's recent performance is better than the anticipated level," "the team's work quality has been continuously improving," "the team rarely makes mistakes or commits negligence."

Control variables. As this research collected data in units of teams, it includes factors that might be relevant to perception of leadership behaviors such as gender, age, educational background, job position level, service years, and time of working with the leader as controlled variables. Additionally, years in the team, task dependence factor, and team size are also included as controlled variables to avoid disturbance of end results (Liden et al. 2006).

Data Analysis. We used the SPSS software series to conduct descriptive statistical analysis on demographic variables, research variables, and controlled variables. Next, we calculated the frequency distribution and percentage of demographic variables to obtain a preliminary understanding of the sample makeup. Through further analyses, we understand whether the correlations among variables are in accordance with our theoretical predictions. Then, with hierarchical regression, we conducted hypothesis testing. Finally, compiling graphs as per Aiken and West (1991)'s recommendations, we inspected the interaction patterns.

Results

Descriptive Statistics

Table 1 shows the average value, standard deviation, reliability and relevant coefficients, etc. of each variable. The reliability of main variables is higher than .87, except for team commitment, which is .83. Among them, there is no significant correlation between leadership

differentiation and team performance or team commitment ($r = -.12$, $p > .05$; $r = -.16$, $p > .05$); regarding the moderate variables, exchange with in-group member and proportion of in-group member have significant positive correlation with team commitment ($r = .30$, $p < .01$; $r = .29$, $p < .01$).

Table 1. Correlation analysis

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Gender	.33	.22														
2. Age	4.15	1.42	.01													
3. Education	2.03	.54	.15	.06												
4. Grade level	1.64	.45	.42**	.17	.19											
5. Org tenure	4.14	1.21	.00	.75**	.01	.14										
6. Group tenure	3.39	1.27	-.04	.61**	-.13	.18	.80*									
7. Length of Co-work with leader	2.82	1.33	-.13	.47**	-.19	.13	.66**	.86**								
8. Task Interdependence	4.70	.54	.12	.13	.09	.21*	.08	.09	.06							
9. Group size	5.18	1.72	-.40**	-.07	-.16	-.44**	-.05	-.07	-.03	-.18						
10. Leadership differentiation	.75	.35	-.06	.04	.13	-.12	.01	-.04	-.04	-.11	.30**	(.93)				
11. Exchange with in-group member	4.13	.80	.09	-.21*	.02	.16	-.23*	-.07	-.02	.40**	-.39**	-.16	(.97)			
12. Proportion of in-group member	4.15	.83	.07	-.19	.03	.17	-.19	-.02	.02	.42**	-.35**	-.16	.95**	(.87)		
13. Team performance	4.34	.80	-.04	.08	-.01	.04	.06	.13	.19	.29**	.02	-.12	.14	.20	(.83)	
14.Team commitment	4.55	.55	.07	.16	.04	.22*	.17	.11	.11	.71**	-.21*	-.16	.30**	.29**	.13	(.94)

Note ：*N*=94

* *p*<.05，** *p*<.01

Hypotheses Testing: Leadership differentiation and team effectiveness

Table 2 presents the results of our hypotheses testing, regarding the main effects, there is no clear correlation between leadership differentiation and team performance or team commitment (β = -.0.3, p > .05; β = -.03, p>.05), and therefore hypotheses 1a and 1b are not supported.

Table 2. Hypotheses testing: Leadership differentiation and team effectiveness

Variable	Team performance	Team commitment
	M1	M2
Gender	.01	-.07
Age	.11	.02
Education	.04	-.04
Grade leve	-.02	.07
Org tenure	-.10	.22
Group tenure	-.09	-.26
Length of Co-work with leader	.27	.13
Task Interdependence	.36	.73
Group size	.12	-.06
Leadership differentiation	-.03	-.03
R^2	.17	.61
$adj\text{-}R^2$	.07	.56
ΔR^2	.00	.00
df	10.00	10.00
F	1.68	12.66***

Note：N=94

* p<.05，** p<.01，*** p<.001

Hypotheses Testing: The moderating effect of exchange with in-group members and the proportion of in-group members

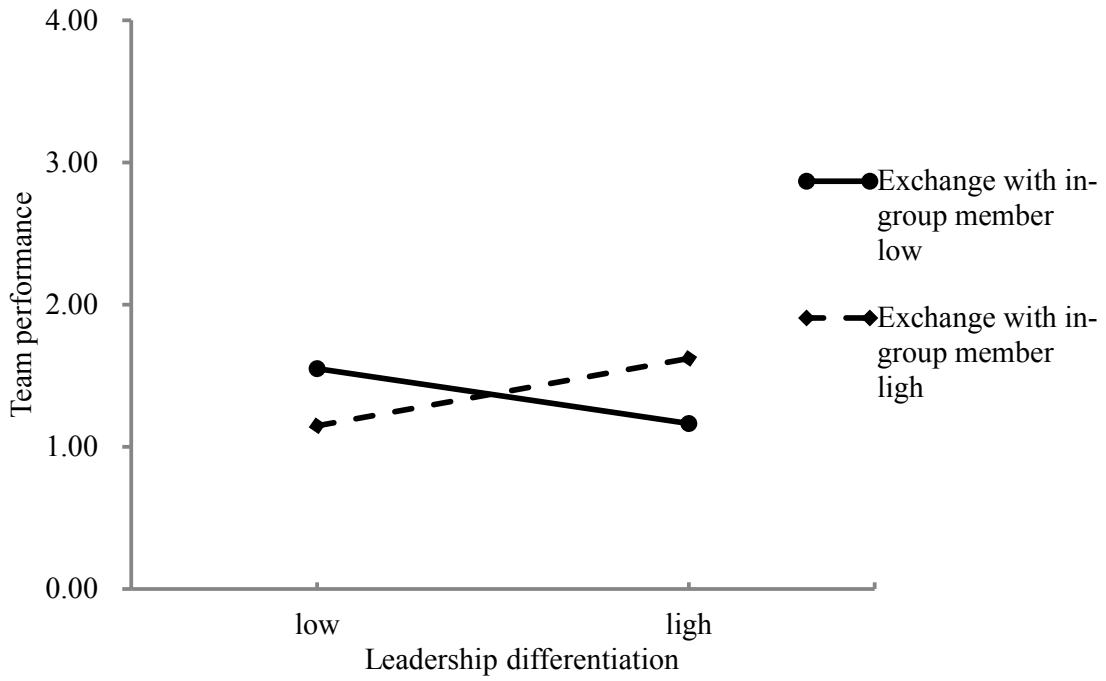
The main purpose of the testing of moderator effects is to determine whether the interactive effects are visible. We learn from table 3 that the correlation between leadership differentiation and team performance is positively by the exchange with in-group members and the proportion of in-group members (β = .29, p < .01; β = .23, p < .05). Therefore, hypotheses 2a and 3a are supported.

Table 3. Hypotheses testing: Moderating effect of proportion of in-group member and exchange with in-group member

Variable	Team performance		Team commitment	
	M1	M2	M1	M2
Gender	.00	-.03	-.07	-.06
Age	.12	.08	.03	.05
Education	-.01	.03	-.03	-.05
Grade level	-.04	-.02	.08	.07
Org tenure	-.20	-.06	.27	.20
Group tenure	.04	-.07	-.28	-.25
Length of Co-work with leader	.14	.20	.14	.11
Task Interdependence	.42***	.39***	.68***	.77***
Group size	.08	.06	-.01	-.08
Leadership differentiation	.03	.08	-.05	-.03
Exchange with in-group member	.02		.08	
Proportion of in-group member		.14		-.07
Leadership differentiation x Exchange with in-group member	.29**		-.06	
Leadership differentiation x Proportion of in-group member		.23*		.04
R^2	.23	.20	.61	.61
$adj\text{-}R^2$	.11	.08	.55	.56
ΔR^2	.07	.03	.00	.00
df	12.00	12.00	12.00	11.00
F	1.96*	1.63	10.50***	11.45***

註：N=94

* p<.05，** p<.01，*** p<.001



Figuge.1 Moderating effects of exchange with in-group member on the leadership differentiation and team performance

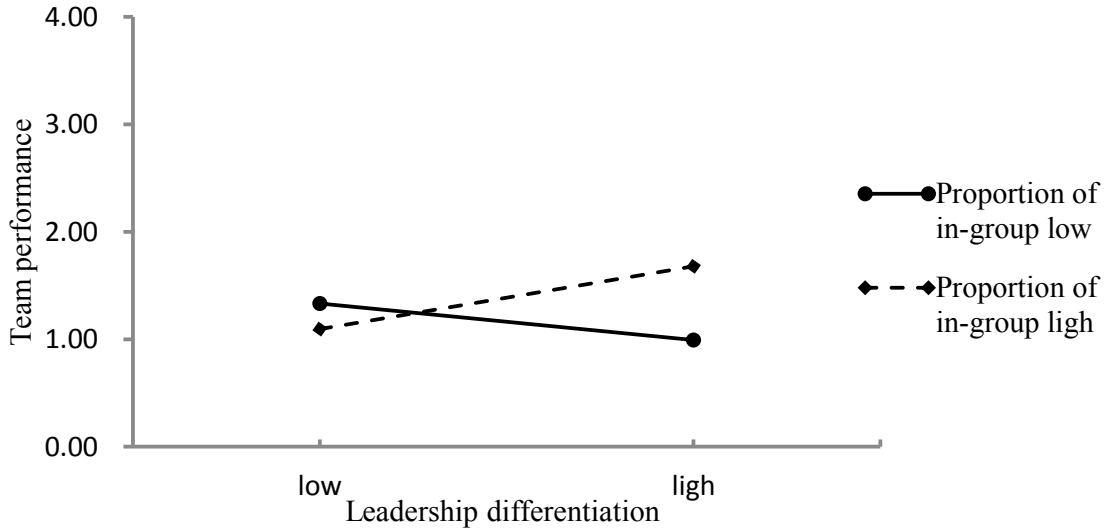


Figure.2 Moderating effects of proportion of in-group member on the leadership differentiation and team performance

Discussions

Main Findings of the Study

The research discusses the impact of leadership differentiation on team members and the role in-group members play between the two parties. The results show that leadership differentiation does not have a visible effect on team commitment and team performance. In other words, the impact of leadership differentiation on team effectiveness varies on a circumstantial basis. Although a leader's differential treatment cannot be used as a basis for prediction at the team level, it is regulated by the exchange with in-group members and the proportion of in-group members. First, neither the interaction between leadership differentiation and the exchange with in-group members nor the interaction between leadership differentiation and the proportion of in-group members can serve as a basis for predicting team commitment. Such results show that the correlation between leadership differentiation and team commitment might be affected by other more important factors, such as the emotional support from in-group members. Emotional support is defined by a person's perception of being accepted and cared about. Moreover, past studies have shown that the in-group members' support for out-group members can reduce the perceived distance between the two groups. Feeling accepted by the in-group is more likely to motivate out-group subordinates to identify with the team (DiDonato et al., 2011). This possibility is to be explored by future researches.

Second, when there is a high exchange with in-group members, leadership differentiation and team performance have a positive correlation. When there is a high proportion of in-group members, leadership differentiation and team performance also have a positive correlation. Further examination of the interaction graph shows that when there is a high exchange with in-group members, leadership differentiation predicts positively; meanwhile, when there is a high proportion of in-group members, leadership differentiation predicts positively as well. The effects are shown in Figure 1, Figure 2 .These results prove that in-group members preferred

by leaders have a positive role function in teams.

Theoretical Implication

Theoretically, the results obtained in this study have several contributions. First, although differential leaders prefer and focus on particular members among their subordinates, the impact of such preference will generate effects at a team level. Therefore, this study conveys the possible effects on leadership effectiveness by variation extent within a group owing to the differential treatment through leadership differentiation. Thus, it extends the theoretical level of differentiation leadership from dyad level to team level. This gesture responds to Kuo et al.'s (2015) study as they have stated that it is necessary to consider the possible influence of within-group variation in a group on leadership effectiveness when discussing leaders' behaviors. Testing the relationship variation at the team level so that the relationship difference between the leader and the subordinates can be revealed (Liden et al. 2006).

Moreover, this study finds that the main effect of differential treatment by leaders is not significant, and one must consider moderator effects in other scenarios. Thus, it might be necessary to define team scenario before discussing how differential treatment by leaders affects team effectiveness. Obviously, the exchange with in-group member and the proportion of in-group member create a team scenario for differential treatment by leaders, and thus they would affect team performance. When the proportion of in-group member is high or there is high extent of exchange between out-group members and in-group members, the effect of differentiation on team level would appear as positive. Such empirical findings also respond to an earlier statement of Hsu et al. (2006): if leaders could make the best of in-group members, the overall structure of the team would be enhanced, maximizing the efficiency of three parties, and thus the overall efficiency.

Practical Implications

Although many leaders are reluctant to admit that they treat their subordinates differently, differential leadership style does exist in organizations. Given the limited time and energy of leaders, it might be demanding to ask a leader to treat all subordinates equally. However, faced with behaviors of differential treatment from leaders, members of the same group will probably compare themselves with others. If they lose in the comparison, they can easily feel a sense of failure and deprivation. Such a result might cause the marginalized out-group members to feel they are unfairly treated. This study discovered that differential leadership, seemingly contrary to the principle of fairness, does not necessarily cause negative effects in the Chinese workplace. When leaders efficiently employ in-group members to assist out-group members, improving the exchange between the in-group and the out-group, the exchange becomes the key factor influencing team performance. When there is a positive exchange between in-group and out-group members, both parties have more opportunities to communicate and collaborate. Out-group members will become more motivated to learn from in-group members; subsequently, the number of in-group members might increase. Our research shows the importance of in-group members in a team, and reminds leaders to value and cultivate in-group members, and in-group member may also cultivate their altruistic. Perhaps Chinese subordinates can accept the leadership style of personalism. Leaders still should try to avoid making members feel unfair. Therefore, choosing an in-group member, should consider the talents of the subordinates, rather than from *guanxi*. In addition, out-group members should also think about why they are the marginal people of the team, and regard the team as a learning field to enhance their abilities. Leaders, in-group members and out-group members are interdependent, learning and growing together in the team to create organizational interests.

Limitations and future suggestions

This research is cross-sectional and all the data were collected at the same time. Therefore, it cannot make strict causal conclusions (Staw, 1975). Additionally, differential treatment by leaders might change dynamically based on subordinates' varying performance and reactions (Cheng, 2005). We suggest conducting a longitudinal study in future research, which carry out measurements at different times.

Based on the opinions put forth by the role theory, we believe that leaders' differential treatment propels role differentiation. Based on role cognition and rules on role tasks, when there is a high proportion of in-group members or a high exchange with in-group members, the negative impact of leadership differentiation on team commitment can be reduced. This conclusion might contain undiscussed circumstantial factors, and we recommend future researchers to include members' value systems and emotional support as moderator variables.

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THE GREAT DIVIDE: LACK OF RACIAL AND GENDER DIVERSITY ON NONPROFIT BOARDS

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January 4, 2019
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Abstract

There are many factors that contribute to the success and impact that a nonprofit organization has on the community it serves. One contributing factor is the strength and diversity of the board that leads the nonprofit's mission. Presently, there is a tense and conflicting sociopolitical climate in the United States, where racial, human rights, and gender equity issues are at the highest level of importance. It is, therefore, more important than ever that gender and racial diversity are present on nonprofit boards, which in turn will positively impact the communities they serve. The intent of this research paper is to explore the current state of gender and racial diversity on nonprofit boards, the various determinants for the lack of gender and racial diversity on nonprofit boards, the impact that said lack of diversity has on the communities that nonprofits serve, and how nonprofit boards can improve their racial and gender diversity moving forward.

Keywords: nonprofit, board, gender, race, diversity

Introduction

The United States is at a most interesting and challenging point in its hundreds of years of existence. The ever-evolving social and cultural landscape of this country has created diverse communities of individuals from every nation with the opportunity to pursue their greatest passions and move the country forward. With the rise of more corporations and entrepreneurial endeavors by these diverse citizens, the opportunity to make a social impact within a given community has also arisen. Nonprofit organizations have been an integral part of this social impact and have become the primary vehicle for social change to be implemented in America, especially in marginalized communities.

However, as the landscape of the country has changed, the nation's nonprofits have not quite caught up with this shift and the homogeneous makeup of nonprofit boards today reflect this. The predominately white and male members of nonprofit governance do not reflect the social and cultural intersectionality of the communities they serve. It is necessary, therefore, to analyze the current makeup of nonprofit boards and delve into the various determinants of this lack of racial and gender diversity in membership. By doing so, a light may be shed on how this disconnect remains present between nonprofit boards and the communities they must serve and represent, and ultimately give insight into the ways in which nonprofit boards can shift their practices in order to be more inclusive of racial minorities and women. In this way, the nonprofits can be more of a reflection of the diversity of this nation and be able to better connect with and support these unique communities.

Racial and Gender Diversity on Nonprofit Boards Today

In order to get to the root of the various determinants of the lack of racial and gender diversity on nonprofit boards, the current state of nonprofit boards in the United States must first be analyzed and assessed. "Earlier sociological studies…found that nonprofit boards were dominated by local elites [and therefore] local constituencies" were not considered when forming nonprofit boards (Abzug and Galaskiewicz, 2003). This meant that despite being concentrated in heavily populated and diverse geographical locations and serving individuals of all ethnicities, social classes and genders, a singular type of individual—usually one of a higher socioeconomic class—was chosen to represent many different constituencies within a given community while

serving on a nonprofit board. The reason for this domination by elite members was the external pressures put on "nonprofits [which] were influenced by funders, the state, trade and professional associations, and peers to adopt certain practices and policies", including keeping the exclusivity of the nonprofit board intact (Abzug and Galaskiewicz, 2003).

Over time, these ideals shifted as the phenomenon of globalization created "several communities containing pockets of homogeneous people living together based on common racial, ethnic, religious, or lifestyle characteristics" (Abzug and Galaskiewicz, 2003). With this drastic cultural shift in the urban communities of today, it became apparent that for "nonprofits…to be representative, they [needed] to represent [the] particular interests and identities" of those varying individual communities (Abzug and Galaskiewicz, 2003). As these homogeneous communities increased in numbers throughout various urban and densely populated cities in the country, their collective voices and sense of identity became more important to their way of life and the ways in which they moved through society. These "community members have intersectional identities [which call] into question traditional ways of approaching diversity in nonprofit organizations" (Weisinger, Borges-Méndez and Milofsky, 2016). Furthermore, the increasingly diverse and globalized nation has created communities with "intersectionality [that] extends beyond race and gender [and] also considers increasingly multiethnic and multiracial populations, gender fluidity, and a range of other intersectional identities" (Weisinger, Borges-Méndez and Milofsky, 2016). Knowing this drastic shift in culture, ethnicity, gender and socioeconomic class has spread throughout the nation at a rapid rate over the course of time, the question arises as to what this shift has meant in the representation of nonprofit boards in present day America.

With the cross-national effects of globalization and the cultural shift in communities of today, the hope is that nonprofit boards have moved away from the belief in a singular elite social demographic representing the community in favor of boards more representative of the various diverse communities present in America. However, the current state of nonprofit boards is surprising and disappointing in that "despite generally having an overall diverse staff of professionals" who serve nonprofits in any given capacity, "nonprofit organizations devoted to serving communities in need are led overwhelmingly by white non-hispanic individuals" with very little representation of women or individuals of color (Adesaogun, Flottemesch and Ibrahim-DeVries, 2015).

Indeed, when "Ostrower (2007) … did the first national survey of nonprofit governance in the United States, she found that 86% of board members in the country are White, non-Hispanic; 7% are African American or Black, and 3.5% are Hispanic/Latino" (Bradshaw and Fredette, 2013). To give a more direct picture of the impact of racial and ethnic divide in nonprofit leadership, a study of nonprofits in the very large and densely populated state of California revealed that "while minorities and women made up the majority of nonprofit employees in the state, only 25% of nonprofit organizations were minority-led" (Adesaogun, Flottemesch and Ibrahim-DeVries, 2015). Additionally, "though women are overrepresented in the nonprofit sector as a whole, they are at a significant power disadvantage relative to men in the nonprofit sector, and this is true for women in both roles as executive directors and as nonprofit board members" (LeRoux and Langer, 2016).

These findings illustrate that in the United States today, both women and "people of color are inadequately represented in decision-making roles within nonprofit organizations" and this reveals that nonprofit boards not only fail to reflect the diversity of the nonprofits themselves, but also the diversity of the communities they serve (Adesaogun, Flottemesch and Ibrahim-DeVries, 2015). Despite there being a vivid picture of sociocultural diversity present throughout all American communities, nonprofits have still not departed from their past singular views on nonprofit leadership. This is reflected by the findings presented which reveal that the racial and gender "composition of nonprofit organizations [have] fallen behind in being representative of the demographic shift happening in the United States" (Adesaogun, Flottemesch and Ibrahim-DeVries, 2015).

"Understanding the overall [racial and gender] composition of nonprofit organizations is integral to understanding the impact of… [racial and gender] stratification at the leadership level within the [nonprofit] industry" (Adesaogun, Flottemesch and Ibrahim-DeVries, 2015). It is difficult to understand how over time (even with globalization and the intersectionality of American communities), nonprofits have failed to reflect the diversity present in American societies today. However, it is important to reveal these findings in order to help answer the questions that now arise about the various determinants of the lack of gender and racial diversity on nonprofit boards.

Reasons for Lack of Gender Diversity on Nonprofit Boards

Over the years, gender equality has remained a consistent social issue within the United States. The discrimination that has plagued women can come from two distinct fronts, legal and social. The lack of gender diversity on nonprofit boards and organizations correlates to how our culture views gender roles. According to Siciliano (1996), "Men are viewed as more status worthy and competent overall and more competent at the things that 'count most'". (Siciliano, 1996). The predominately male membership of nonprofit boards is therefore evidence of the social belief that women are less competent.

One of the main reasons for the lack of gender diversity in nonprofit boards is the complexity involved in women's commitment to both their family obligations and to their work. According to Siciliano (1996), "current and longitudinal studies of gender stereotypes show that the core structure of these beliefs has not yet been dismantled by progress toward gender equity. Descriptive beliefs about the attributes of the 'typical' man or woman are still largely shared and largely unchanged since the 1970s" (Siciliano, 1996). Out of these factors, the one that carries the most importance is how women have the ability to reproduce. Gender roles have negatively affected how a woman's social power and status are weighed and viewed. Certain personality traits, behaviors, and even types of jobs have come to hold gender connotations. Due to the idea that men are stronger and more masculine, it has been believed that, men have a higher level of competence, which tends to overshadow woman's ability to be seen as skilled or competent. According to Freund (2017), a study was conducted with a population of 327 managers and there were more men that were married and established with a family with 92% of the surveyed male population reporting "married" as their marital status. While there were only 76% of women that reported their marital status as "married" (Freund, 2017). This shows that while almost all men in powerful positions can also have a family life, women in these same positions can not always have a family life as well.

Another reason that women in nonprofit organizations do not pursue upper level positions such as board membership or board chair is because of women's personal job of being a mother. It is believed that a woman who is a mother has less ability to perform up to acceptable performance standards and is not capable of being committed to her work and her family. According to Siciliano, (1996), "A phrase such as 'has a two-year-old child' to a woman's resume reduces evaluators' estimates of her competence, her suitability for hiring and promotion, and the wages she should be paid. It does not have this effect on evaluations of a man's resume".

(Siciliano, 1996). This stereotype compounds on the general gender role stereotypes to include whether women who are not mothers perform better than women who are mothers.

The pay gap between men and women who work similar jobs also continues to reflect the societal preference of men in leadership over women. Another study by Freund (2017), of a group that consisted of 202 of 327 returned surveys from an Israeli based community organization showed that the average monthly income level for men was NIS (New Israeli Sheqel) 5,000 while women were reporting significantly lower at NIS (New Israeli Sheqel) 4,000. (Freund, 2017). The pay gap between men and women at this Israeli non profit organization is at the 80% mark where it falls just about in line of that of the gender pay gap of 78-82% in the United States that women face on a day to day basis.

If a man and a woman are in a supervisory position and they exert a level of power and control, the genders are viewed extremely different in that same position. Men are believed to be strong and confident as leaders while women are believed to be bossy and threatening as leaders. According to Ridgeway and Cornell (2004):

> Competence implications of gender beliefs will implicitly bias coworkers', subordinates', and superiors' perceptions of women managers' competence and their legitimacy in the manager role compared to men. When a female manager asserts directive authority, as the manager role often requires, these implicit biases lead others to react with resistance and hostility. Managing such backlash reactions adds to the difficulties of women managers' jobs and is among the processes that constitute the glass ceiling they face.

In the nonprofit sector, leadership should match the mission and goal-oriented approach that is part of the purpose of nonprofit organizations. According to Ridgeway and Cornell (2004), “Every minute more that a woman spends on unpaid care work represents one minute less that she could be potentially spending on market-related activities, investing in her educational and vocational skills or leisure” (Ridgeway and Cornell 2004). Society has helped to mold a culture that has made women responsible for domestic activities as well as her employment responsibilities. There is not a lot of money to be made in the nonprofit sector to begin with, which is now compounded, with a lack of available opportunities.

This concept lends itself to how nonprofit organizations are structured. Unfortunately, because nonprofits are social entities, they are heavily influenced by external factors especially

by what is socially and culturally acceptable. According to Buse, Bernstein, & Bilimoria, (2016), "Mosley and Grogan (2013) noted that it is important to include women and other groups (ethnic, racial, etc.) in order to gain public trust and social legitimation for the organization as a whole". Women in managerial positions such as board member or CEO need to have the proper training in order to be able to succeed. For women on nonprofit boards they need to fight for themselves to be better represented and more involved in their organization's development.

There is a direct connection between bureaucratic success of organizations and males in positions of authority. The thought behind this is that it is believed men will have greater access to resources and stronger control of an organization's assets. According to Ferrant and Nowacka, (2015), "Babchuk et al. (1960) determined that men were more likely to be represented on boards of nonprofit organizations that were ranked as highly vital to the community". Nonprofits will continue to seek out men for their boards thus not allowing women the opportunity to prove themselves and succeed in the nonprofit sector.

Reasons for Lack of Racial/Ethnic Diversity on Nonprofit Boards

All stakeholders benefit from inclusion of a racially diverse population on nonprofit boards. Harris (2014) states that "both board member diversity and expertise are associated with better-performing organizations". Circumstances preventing participation of minorities on boards appear to be based in socioeconomic factors and challenges related to age. "Historically, nonprofit boards have been comprised largely of white upper- and middle-class citizens. This presents the question, what is preventing people of color from serving on nonprofit boards? Undoubtedly there are many contributing factors to the situations currently being presented. It would not be accurate to imply the only reasons for homogeneity on boards are discussed here. Socioeconomic factors as well as age demographics have to be considered when examining the lack of diversity in the membership of nonprofit boards.

Economic

Ostrower (2007) discusses the challenges in making a direct link between the income, wealth, class and nonprofit board membership because of the lack of specific data. Indicators can be taken from the for-profit sector and the wealth of information available related to people of color and systematic exclusion. "Black Americans have historically been much less likely than White Americans to organize, establish, and sustain new businesses across a wide variety of fields and industries. Contrary to popular belief, this finding is not due to a lack of desire,

inadequate role models, insufficient social networks, the absence of business expertise or entrepreneurship education, but rather to a shortage of financial capital" (White, 2018). White (2018) also goes on to state "that Black American households have on average less than one-tenth the net worth of White American households and, as a result, fewer aspiring Black American business entrepreneurs can come up with the money to organize, invest in, manage, and expand a business". The lack of wealth in black households impacts the ability to pursue philanthropic activities, because of the need to pursue subsistence activities takes priority.

Black Americans are not the only minority to be limited by wealth, class and nonprofit board membership; Latin Americans are also affected. "Despite the rising growth of business ownership within the Mexican American ethnic community, and additionally amongst members of the Hispanic and Latino racial community in the US, research indicates that both low educational levels and a lack of necessary financial capital continue to inhibit Mexican American, Hispanic, and Latino owned and operated businesses from expanding into other industrial sectors" (White, 2018).

Researchers are discussing the socioeconomic state of minorities and how it impacts their lives. Despite the attention that has been given to the for-profit sector there is still much work to be done. "There is a lack of research in the participation of minorities in the entrepreneurial activity in the non-profit sector" (White 2018). Additional research will create greater insight on the best course to take to improve diversity.

Age

The average age of board membership may exclude many minorities from participating. "Most nonprofit boards are composed of members between the ages of 36–50 (37 percent) and 50–65 (41 percent). On average, only 16 percent are older than 65 (the median is an even lower 8 percent), and an even lower 7 percent are under the age of 36 (median of 0)" (Ostower 2007). Considering the socioeconomic factors minorities in the age group that are most commonly part of boards (50-65). In the article "Race/Ethnicity, Socioeconomic Status, and Health" there is a correlation discussed between the failing health of elderly minority adults compared to their white peers. There are many factors that contribute to this health disparage but there is a demonstrated link between race and life expectancy (Crimmins, Hayward, & Seeman, 2004). During the time that white wealthy males are typically joining boards, many minorities are still actively engaged in subsistence activities. In 2016 The government of the District of Columbia

released a study done on the life expectancy of black men to be 68 years and white men in the same area to be 83 years (Sturdivant, 2016).

How Lack of Diversity on Boards Creates Disconnect within Community

There is a leadership crisis concerning minority representation on the boards that serve predominantly minority communities. "Nonprofits that serve higher percentages of minorities are far more likely to include board members from those minority groups on their boards, but even notable percentages of them include no corresponding minority group board members" (Ostrower, 2007). The same study shows that the percentage of minority board members as being far less than the population demographic. The implications of having a board that does not reflect the population it serves is indicative of a larger issue. It is vitally important that strategies to improve this critical issue are developed because "the need for [nonprofit board] diversity is an essential part of making effective decisions and delivering appropriate services to [both female and] minority clients" (Harris, 2014). In this way, board members are better able to directly respond to the needs of these groups of individuals and provide the tools for change that the community needs from a perspective of greater empathy, connection and understanding.

Ways to Improve Racial/Gender Diversity on Nonprofit Boards

"If agencies and their boards are to work successfully toward diversity, they must believe that diversity is important. Almost all board members speak of diversity as a good thing – a beneficial, fair, helpful, noble thing to achieve. But when board members are asked why diversity is good, many... are not sure why" (Daley, 2002). The first step to improving diversity is for nonprofits organizations and their boards to acknowledge that diversity is important. At the same time they must acknowledge that "experienced members may find it difficult to give up traditional ways" and "new and veteran members may view the early dynamics of the more socially diverse board as a struggle for power or control" (Daley, 2002). Daley and Kettner outline a five-step action plan to facilitate board diversity:

1. Considering antecedent and contextual conditions.
2. Preparing the board and organization for change.
3. Planning change.
4. Implementing change.
5. Assessing, adjusting, and stabilizing change residue, and celebrating accomplishments.

When utilizing these five phases to incorporate diversity on a board it is critical to have strong leadership that has a thorough understanding of the dynamics of the organization and the board, heading the charge. Preparing for the change and the incorporation of new members that bring diversity and skills is vital to the successful implementation of a fair, equal and diverse mix of board members that have the skills needed to successfully lead the organization.

The diversity matrix, identified by Mark Fox, is another approach to gaining board diversity. "The Diversity Matrix" provides "an at-a-glance status of how wide or narrow your [boards] scope is" (Fox, 2007). Interestingly, Fox points out that "diversity isn't just about demographic factors. It also involves valuing differences in thought, background, and experience" (Fox, 2007). However, he adds that "diversity will be associated with these things to some extent --- but not exclusively so" (Fox, 2007). Incorporating a broad set of skills as well as diversity on a board is important. Fox adds "you can avoid a narrow view of diversity by creating a diversity and skills matrix. Relating diversity to other efforts can mitigate perceptions that minority board members are being selected for their minority status, as opposed to other contributions they can make" (Fox, 2007). Adding skills to the diversity matrix allows for diverse members that are appointed for their skills, experience and for the value they can add to the nonprofit organization board.

Recruitment plays a key role in diversifying your board. Your governance committee needs to identify diversity needs in their process of board development and "make sure the board candidate pool is not filled with carbon copies of you or the existing board members" (Cook, nd). "Board development generally includes nine steps: identify the board's needs in terms of skills, knowledge, connections, and perspectives; identify and cultivate the interest of prospective board members to meet those needs; recruit new board members; provide new members with orientation, both to the board and the organization, etc." (Worth, 2017). The governance committee, [should be] working year-round to guarantee that that the board takes responsibility for its own development, learning, and behavior; sets and enforces its own expectations; and allots time, attention and resources to understanding its stewardship role" (Worth, 2017). They should be "expanding recruitment to board members of varying backgrounds, perspectives, ethnicities, professions, age groups and socioeconomic status" (Nonprofit HR, 2017). Again, diversity is not only based on demographics. It is important to have the right mix of gender, race, ethnicity along with skills and experience. After identifying the gaps, your governance

committees recruitment activities should be focused toward the board members you want to attract. Instead of recruiting by "word of mouth" but rather based on the board needs, you will be more likely to attract candidates that will fill the needs for diversity on your board.

In addition to changing the recruitment process, policies should be formalized to set the expectation of a diverse board. Diversity should become the norm in the organization not a goal that needs to be set and worked toward. According to Bradshaw and Fredette (2013), "nonprofits who want to increase the range of ethnocultural and visible minority representation on their boards, regardless of organizational age or size, benefit from embedding and institutionalizing formal diversity related practices (e.g., policies regarding representation of diverse groups on the board such as including diversity considerations when doing board self-assessments, and incorporating diversity goals into work plans of the board)". Their extensive research on several nonprofit organizations has revealed that "rather than suggesting a risk of bureaucratic rigidity from formalization... policies and practices that are formalized actually coincide with improvements in the range of boardroom diversity" (Bradshaw & Fredette, 2013). It is additionally found through their research that "with institutionalization, diversity comes to be seen as good board practice…[and] becomes 'just the way we do things around here,' as the policy is routinized. Embedding the policies and practices ensures that they continue and perhaps reduces the tendency to introduce personal bias and idiosyncratic approaches to boardroom processes" (Bradshaw & Fredette, 2013).

A board that is diverse makes for a successful organization because they are able to collaborate and encompass a broad spectrum of understanding and expertise. Diversity as far as race, gender, ethnicity, experience and skills are all key to having a well-rounded board. Strong leadership is critical to incorporate change to the dynamics of the board. Leadership/Governance committee both need to focus on educating the board/organization on why diversity is important, prepare them for change, work to recruit from outside of their comfort zone and incorporate policies/practices that encourages diversity. These are all actions that will move an organization toward creating a board that is diverse and capable of fully understanding the culture and needs of those they are serving.

Conclusion

One of the greatest depictions used to describe the United States is that of a melting pot. This country is recognized as a diverse nation with representation from many ethnic and racial

communities along with a promise for gender equality. Unfortunately, that diversity is not represented on many nonprofit boards today. In order to best impact people through their outreach, nonprofit boards need to represent the diversity in the communities they serve. Incidentally, a simple adjustment in the culture of any given nonprofit board could determine the potential for continued acquisition and retention of female and minority board members over time, which could positively affect the nonprofit board and consequently, the community the board serves. Minor changes in board diversity can make significantly positive impacts to the missions that these organizations set out to achieve. Gender, ethnic and racial diversity on a nonprofit board brings greater potential to serve the population at hand and build a foundation of diverse cultures, experiences and connections that best address the needs they are servicing.

Racial and gender equality are key factors since most boards are comprised of mostly white males. Minorities and women that are skilled and educated should not be punished for being competent and capable. It would be in the best interest of any nonprofit organization to develop a high level of organizational commitment toward its employees, no matter their race or gender. Both minorities and women tend to rise into mid-level managerial positions, but regardless of their positions, nonprofits need to be cognizant in creating opportunities for every type of person, regardless of their cultural or social demographic. If organizations are not going to express that women and people of color matter, these individuals will be more likely to leave the organizations and the nonprofits will lose out on quality talent, and the community will lose representation at the board level.

Additionally, the result of racial diversity at the top brings a better understanding to the complexities of the environment and its needs that may require more astute decision making. There is no doubt that diversity on a nonprofit board can achieve better results because each member offers a different perspective and moves the board away from “carbon copies” of each other. A diverse mix of gender, racial and ethnic background along with experience and abilities drives success and collaboration to achieve the most effective results.

Trust is a major component along with creating expectations of diversity among the board. To gain trust, a board must have diversity themselves and have diversity, practices, and policies in place. Building these expectations through policies and procedures is the first step in making diversity the norm and the expectation. Through procedural mechanisms, boards can influence the societal views of racial and gender inequality in cultures. Boards can also use their

practices and processes to push for further diversity within their organization and other nonprofit organizations. Change is never easy or easily accepted, however, it is achievable. Leadership that is strong and committed to long term change is key as an organization builds a foundation that demands diversity on their board and recruits individuals that add to the board instead of mirror its members.

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STRATEGY, NEW VENTURES AND ENTREPRENEURSHIP - ABSTRACTS

ARE DIGITALIZATION BENEFITS INFLUENCED BY BUSINESS PROCESS MANAGEMENT CAPABILITIES? AN EMPIRICAL INVESTIGATION

The entrance of new digital methods and devices into business and society has introduced new challenges for organizations to realize the potential benefits that these digital methods and devices may provide. This move towards a digital business has led to the growth of digitalization and the redefinition of traditional industry and market boundaries (Billon et al., 2010; Plummer, 2014). Digitalization is defined as the approach to developing new business models through the integration of products, services, processes and people based on the internet and emerging digital technologies (Plummer, 2014; McDonald, 2012). Despite the progress in analyzing the alignment of business processes with organizational strategy, the recent emergence and growth of digitalization introduces new challenges. In particular the inability to establish business processes that enable the full value of digitalization has led to calls for a more inclusive understanding of the relationship between digitalization and business process management (BPM). To response to this call, this exploratory study of 192 organizations worldwide, examined the relationship among BPM capabilities and the realized benefits of digitalization within organizations.

For the purposes of this study, BPM is defined as a management discipline that transfers business strategy into people and information technology-based execution (Kirchmer and Franz, 2015; Hill et al., 2006). Several studies have identified the BPM capabilities utilized to assess the effectiveness of an organization's BPM discipline (Harmon, 2004; Rosemann and deBruin, 2005; Melanovsky and Sinur, 2006; Hammer, 2007) showing that that a well-defined and managed business process discipline (BPM Discipline) has leveraged business value (Kirchmer and Franz, 2015). While these studies provide solid understanding of capabilities within the BPM Discipline and methods to analyze BPM effectiveness, the alignment of these capabilities with realized benefits of digitalization is still unclear. Therefore, as organizations begin to adopt and deploy digitalization methods, the question remains how to align business processes that leverage the business value of these methods into realized benefits. Prior research finds that a more mature business process discipline of a company reaps a higher level of business value to the organization (Kirchmer and Franz, 2015); therefore, it is imperative to understand the effects of digitalization as they are applied to business processes on the realized benefits of digitalization.

Drawing upon the capabilities perspective (Richardson, 1972; Helfat et al., 2007) from strategic management and the broader resource-based view of the firm (Penrose, 1959, firm activities or processes are a source of competitive advantage. Following Helfat and Peteraf, (2003), we define organizational capabilities as the ability to perform certain tasks using organizational resources since BPM relates to the integration of people and information technology to achieve organizational objectives. The capabilities perspective distinguishes between ordinary capabilities that represent the basic operational or functional activities of a firm (Winter, 2003, Collins, 1994), and dynamic capabilities that enable the firm to evolve and change (Winter, 2003, Collis, 1994, Teece et al, 1997). The ordinary and dynamic capabilities dichotomy provides a useful framework for organizing and exploring BPM capabilities in the effort to achieve a deeper understanding of the relationship among various BPM capabilities and the realized benefits of digitalization. Hence, this study explores the influence of ordinary and dynamic BPM capabilities on the outcome variable of digitalization realized benefits.

Keywords: Digitalization, Business Process Management, Organizational Capabilities

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Social Media use Among Women Entrepreneurs: the Case of the UAE

Research-in-progress

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ABSTRACT

Prior studies have shown that entrepreneurial activities contribute in creating employment opportunities and increasing economic growth. Despite the positive impact that women entrepreneurs (WEs) have on the world economy, studies on them in the Arab world is lacking. The Arab world comprises of Muslim countries, where Islam in particular is an under-researched component in the context of women entrepreneurship. There was limited studies on how being a Muslim woman entrepreneur (WE) creates (if any) limitation(s) in the use of social media (SM) for their businesses. And on the other hand, how SM has equipped the women in the United Arab Emirates (UAE) to become successful entrepreneurs; considering the many challenges they face in the Arab world. After all, SM is the new marketing tool that helps businesses to improve its profits and value, build customer relationship and gain competitive advantage. Therefore, this study will thus analyze how the two variables, WEs and SM, interact with each other when religion comes into play. The theoretical framework will discuss Institutional theory since it is the most relevant and fruitful lens to study WEs. It comprises of three pillars; cognitive, regulative and normative pillar that guides and promotes one's behavior, which is socially acceptable. In other words, the entrepreneurial activities revolve around a country's embedded norms, cultural beliefs and rules. The normative pillar is especially salient in relation to women entrepreneurship, where the career choices are selected by what the society believes is correct for one's gender. A qualitative approach was adopted to collect data and analyze with in-depth, face-to-face interviews with Muslim WEs in the UAE. Questions will explore different opportunities available to WEs in the UAE and the various challenges faced by them. The objective was to study how factors such as socio-cultural, educational level, access to the capital, family responsibilities, government support, family responsibilities/ household, training and education in regards to the use of SM come under the influence of the interpretations of Islamic teachings at different magnitudes.

THE IMPACT OF FINANCIAL SLACK ON CORPORATE POLITICAL ACTIVITIES

Keywords: Corporate Political Activities, Lobbying, Organizational Slack, Non-Market Strategy

Overview

Organizational theorists have been drawing on the behavioral theory of the firm (BTF) (Cyert and March 1963) to study the link between slack resources and organizational outcomes for decades (Bromiley 1991; Kim and Bettis 2014). Behavioral theorists assert that financial slack fosters goal congruence and harmony since it allows firms to offer employees perquisites to maximize retention, as well as resources that minimize group or sub-unit conflict (Vanacker Collewaert and Zahra 2017). Scholars also posit that slack provides firms with strategic flexibility during periods of economic stress and buffers stakeholders from sub-optimal managerial decisions (Bourgeois 1981; Cyert and March 1963; Fadol Barhem Elbanna 2015).

Scholars have studied the linkage between slack and a host of managerial decisions including R&D investment and experimentation (Nohria and Gulati 1996), sustainability programs (Boso, Danso, Leonidou, Uddin, Abeola, Hultman, 2017) and entry mode options such as exporting (Lin Cheng and Liu 2009), alliances (Bizzi 2017), and mergers and acquisitions (Uhlenbruck Hughes-Morgan Hitt Ferrier and Brymer 2017). The common thread in these studies is the assumption that slack alters the behavior of risk-averse managers, in that it encourages the continuing support of projects despite the inherent risks and uncertainty that accompany such initiatives (Bromiley, 1991: Shaikh, O'Brian, and Peters, 2018). In short, more ample resources act as a buffer when funds are allocated to more speculative, time-variant projects (Levinthal and March, 1981; Malen and Vaalar, 2017). Surprisingly, to the best of our knowledge, no studies have examined the direct link between slack resources and corporate political activities (CPA). This is surprising because investment in CPA exhibits many of the same project characteristics noted above, specifically, considerable risk and payoffs, which are uncertain in both time and magnitude. We address this gap by examining the

distinct impact of available, recoverable, and potential slack (Bougeois and Singh 1983) on CPA variables, namely lobbying.

Findings

In this paper, we examine how financial slack influences corporate political activities. Focusing on S&P 500 firms, over the period from 2001 through 2008, we find a positive relationship between financial slack and lobbying expenditures. Our results are supported in both fixed and random effect models and across continuous and binary measures of our dependent variables. Therefore, our findings suggest that financial slack is an antecedent to corporate political activities.

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STRATEGY, NEW VENTURES AND ENTREPRENEURSHIP - PAPERS

THE DEVELOPMENT OF A PROBABLE VENTURE SUCCESS MODEL AND IT'S IMPACT ON STRATEGIC MANAGEMENT

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Keywords: Strategic Planning, Entrepreneurial Investing, Strategic Management, Entrepreneurship, Management

Abstract

Utilizing Nobel Laureate, Daniel Kahneman's views on the psychology of decision-making and the experience of Amazon's founder, Jeff Bezos, the authors formulate an improved approach to understanding entrepreneurship by calculating the hypothetical *a priori* probability of a successful entrepreneurial venture. The model developed clarifies why the "prior to launch" probability of success is normally exceptionally low. Although extremely low, these probabilities of success can have a substantial impact on strategic planning within competitive firms. As a venture progresses through start-up phases and the probabilities of critical single events rise, the probability of venture success increases as a function resembling the shape of a "hockey stick."

Introduction

Amazon Inc., founded in July 1994, recently reached an economic value of $1 trillion. This economic evaluation is equal to "ten GEs". Certainly, Amazon qualifies as a "class-one," high rate of return, "gazelle," IPO-qualified entrepreneurial venture. Amazon's founder, Jeff Bezos gave a very candid interview in 2001 which was published online in 2017. His honest words lead to the first postulate of this paper as he stated;

> "… never lose track of the fact that there was a lot of luck involved in that… you know, there are a lot of entrepreneurs, there are a lot of people who are very smart, very hardworking, very few ever have, you know, the planetary alignment that leads to a tiny little company growing into something substantial."

He acknowledges the significant role of "luck" signifying non-causality leading to low probability of success and indeterminate predictability. Hence, our first proposition is stated… in competitive economic environments, luck is a dominate component to success. Bezos continues,

> "… that requires not only a lot of planning, a lot of hard work, a big team of people who are all dedicated, but it also requires that not only the planets align, but that, you know, you get a few galaxies in there aligning too. And that's certainly what happened to us…our timing was good, our choice of product categories, books, was a very good choice, and we did a lot of analysis on that, to pick that category, as the first best category for e-commerce online, but there were no guarantees that that was a good category. At the time we launched this business it wasn't even crystal clear that the technology would improve fast enough. That ordinary people, you know, non-computer people, would even want to bother with this technology. So, that was good luck. So, there are a whole bunch of things that have to sort of align to make it work."

Above, Bezos recognized important tasks and events must have successfully occurred for Amazon to be a success. Specifically, in the full interview, he noted the requirement of:

A dedicated team
Market entrance timing
Offering the correct product line
The technology works
The technology is appropriate
Infrastructure operation
Acceptance by the demographic market

Hence, our second proposition is certain critical events must be successful for a venture to be successful. Bezos, continues;

> "… and what you do with those early investment dollars, you know, so if you have $300,000 and then you have $1,000,000, what you do with those early, precious capital resources is you go about systematically trying to eliminate risk. So you pick whatever … you think where the biggest problems are, and you try to eliminate them one at a time."

Above, Bezos prompts our third postulate, he notes there exists limiting "lethal events" which must be "eliminated" for Amazon to survive.

Restating all postulates, we recognize:

1. The principal role of randomness and non-causality in new venture creation.
2. The existence of a set of Required Events (REs) that must successfully occur, and,
3. The existence of a set of potentially Lethal Events (LE) that must *not* occur.
   (Here, we employ $\overline{LE}$ as a symbol for probable lethal events not occurring.)

Discussion

Luck denotes randomness, chaos and lack of causation, wherein low causation implies low predictability, and low predictability may eliminate repeatability. Nobel Laureate in Economics, Daniel Kahneman (2011, p. 201) confirms this as he notes that luck, (randomness) not intentional causation played a large role in the Google launch. Kahneman stated, "Of course there was a great deal of skill in the Google story, but luck played a more important role in the actual event than it does in the telling of it. And the more luck was involved, the less there was to be learned."

The harmful effect of employing selectively-erroneous stories used to guide future managerial actions are clearly outlined by Cassver and Craig (2008) who emphasize the risk to entrepreneurship, "…individuals are at risk of overestimating their chances of success when starting future nascent activity." Kahneman's (2011, p. 256) research unmistakably demonstrates the innate human tendency to over-optimism and unsupported assessment of success, "The chances that a small business will survive for five years in the United States are about 35%. But the individuals that open such businesses do not believe that the statistics apply to them." Peter Drucker (1985, p. 191) comments on the ineffectiveness of most venture business planning when he noted, "One cannot do market research for something genuinely new."

A prime example of a "low probability" RE, was the financing of Amazon. By luck, Bezos floated $672 million in convertible bonds a few months before the Dotcom crash of 2000. Had he tried to gain the necessary financing after that date, there would be no Amazon.

The authors suggest an improved method for evaluating entrepreneurial efforts useful for evaluating the risks and likelihood of success of large market-driven, market-financed, IPO qualified ventures *prior* to, and post launch. The purpose of such calculation is not to promote fear of entrepreneurship, but to focus intent and sharpen entrepreneurial resolve.

Required Events (REs)

As Bezos noted, there exist various Required Events (REs) or events which must occur in order to produce entrepreneurial success. The list varies with each start-up. Example critical REs could be:

Demand generation
Resource acquisition
Market acceptance
Organizational efficiency
Skill acquisition

In early stage planning, each RE should be assigned a potential probability of success. Since all REs *must* occur, the *total a priori* probability of all critical REs occurring is derived by multiplication of the individual probabilities assigned to each RE. Certainly, probabilities should be updated as the launch progresses. It should be noted if any of the assigned individual Required Event probabilities become zero, then the probability of the entire probability chain is likewise zero, and the new firm fails.

The Probability
of 10 Required Events Occurring

For illustration, a series of 10 hypothetical, critical REs, occurring successfully with each individual event probability set at 20% is assessed as follows:

P (Required Event occurring) = 0.20

P (10 RE) occurring successfully = P (0.20^{10}) = 0.0000001024 = 0.00001024%

Lethal Events (LEs)

Likewise, for a new entity to be successful, many potentially harmful or Lethal Events, (LEs) must *not* occur. The list of critical events potentially harmful to a start-up is extensive. Examples LEs are:

A competitor firm entering the demographic market
A competitor firm occupying the market space
A competitor firm acquiring the knowledge or technology necessary
A severely damaging weather event
Failure of critical technology
The growth of a damaging corporate culture

All of the LEs which could occur, must fail to occur for the firm to survive. The *total* probability of all LEs not occurring is the mathematical product of the individual probabilities assigned to each LE not occurring. There exist many LEs in a competitive marketplace. The total mathematical product of all LEs *not* occurring serves as an effective limit on the possible success of the nascent firm. LEs "kill-off" most new firms and this fact is usually reflected in the low number of companies reaching maturity. A skillful management team should intentionally identify and mitigate each LE in a coordinated effort to promote the new firm.

Kahneman (2011, p. 259) cautions to consider unknowns, "We focus on what we want to do and can do neglecting the plans and skills of others. Both in explaining the past and in predicting the future, we focus on the causal role of skill and neglect the role of luck. We are therefore prone to an illusion of control. We focus on what we know and neglect what we do not know, which makes us overly confident in our beliefs."

The Probability of
10 Potentially Lethal Events
***not* Occurring**

Shown for illustration, here we arbitrarily assign a 30% chance of any individual LEs occurring (implying a 70% chance of any one LE *not* occurring), the probability of a set of 10 potentially LEs not occurring ($\overline{LE}$) is calculated as the mathematical product of each individual LEs not occurring:

P(LE occurring) = 0.30

P(LE not occurring) = $\overline{LE}$ = 0.70

P(10 $\overline{LE}$) = P (0.70^{10}) = 0.02825

Recognition of potentially lethal events provide an important list of events for the entrepreneurial team to monitor.

Market Entrance Timing
(A Major RE)

The time, window of opportunity, or a "fertile gestation" period allowing success is usually very short. Entrepreneurial success is only probable within this "fertile" period. Usually, the entrepreneur has little awareness of this window. If a new entrepreneur studied the historical daily actions of Amazon's creator, Jeff Bezos and re-enacted those actions sequentially and faithfully starting today, a new and equal Amazon would not be born. The existing Amazon, the existing involved logistical system (i.e. FedEx's exclusive contacts with Amazon) and invested capital would most likely leave insufficient and more expensive capital for any "new" Amazon. These temporal scenarios would produce a competitive disadvantage and most likely preempt any "imitator - new Amazon" from being successful. Hence, organizational success generates its own non-repeatability.

Bernstein (1998, p. 332) observes this phenomena as he quotes Dimitris Chorafas, "…an articulate commentator on chaos theory, [who] describes chaos as, "… a time evolution with sensitive dependence on initial conditions. And, even if cause and effect is truly operative…" Bernstein notes, "… [in] chaos theory…nonlinearity means the results are not proportionate to the cause…".

Kahneman (2011, p. 200) continues with his account about Google clearly showing even celebrated founders did not know of the future value of their own enterprise, "…there is a very

good story here. Fleshed out in more detail, the story could give you the sense that you understand what made Google a success; it would also make you feel that you have learned a valuable general lesson about what makes businesses succeed. Unfortunately, there is a good reason to believe that your sense of understanding and learning from the Google story is largely illusory. The ultimate test of an explanation is whether it would have made the event predictable in advance. No story of Google's unlikely success will meet that test, because no story can include the myriad of events that would have caused a different outcome. The human mind does not deal well with nonevents. The fact that many of the important events that did occur involve choices further tempts you to exaggerate the role of skill and underestimate the part that luck played in the outcome. Because every critical decision turned out well, the record suggests almost flawless prescience - but bad luck could have disrupted any one of the successful steps. The halo effect adds the final touches, lending an aura of invincibility to the heroes of the story."

Peter Drucker (1985, p. 189) agrees noting, "When a new venture does succeed, more often than not it is in a market other than the one it was originally intended to serve… brought in large part by customers it did not think of when it started… "

Taleb (2007) introduced the idea of "narrative misjudgment" in his book, The Black Swan: The Impact of the Highly Improbable, wherein he describes how flawed stories of the past shape our views of our world. Narrative errors occur naturally because of innate human cognition wherein humans strive to make sense of their world. People find short and easily understandable stories persuasive (i.e. Steve Jobs was a genius, hence his disposition caused Apple's success). Kahneman work clearly demonstrates humans show a strong tendency to focus on dispositional qualities rather than attribute success to luck (i.e. Steve Jobs was a maniacal genius) and they focus on notable events (his computer built in his garage) rather than on the high number circumstantial and potentially lethal events that failed to happen (i.e. IBM deciding not to manufacture personal computers). Any prominent event is a nominee to become the central plot of a causal story. Taleb suggests humans constantly fool ourselves by constructing these mostly fallacious stories, and then believing they are true.

To summarize a fundamental point, the role of leadership, the dispositional power of Bezos's personality, intelligence, knowledge and leadership skills were necessary factors but *not at all sufficient* antecedents to Amazon's success. For a more complete analysis, all critical factors should be identified and assigned individual probabilities and incorporated in the probable success calculation for the new firm.

The Probability of *Both*
"REs occurring" and "LEs *not* Occurring"
***a priori* to Amazon's Launch**

The exact probability of venture success can never be precisely assessed because of the unknown probability of completing each key factor, the large number of unknown factors causing outcomes and the unknown and temporal interaction of causation factors involved with start-ups. However, the approximate probability of success should be calculated and used in both venture and strategic analysis and as an ongoing venture-assessment tool.

Since a successful venture would require *both*, all critical REs to occur *and* all critical LEs to not occur, the probability of Amazon's successful venture computed *a priori* can be estimated by the mathematical product of both REs occurring *and* LEs not occurring. Here, assuming 10 important factors we have;

P (Successful Outcome) = P (REs) x P ($\overline{LE}$)s

P (Successful Outcome) = 0.0000001024 x 0.02825 = 0.00000000289 = 0.000000289%

Which is approximately 1 in 346 million.

These illustrative calculations are certainly informed conjecture but they are accurate enough to lead to the conclusion Jeff Bezos was correct when he commented the success and existence of Amazon was a "cosmically improbable" event.

A Generalized Venture Success Model

Generally, our Venture Success Model is:

$$P\ (\text{Success}) = P\ (\text{RE})^{n} \ \text{x} \ \ P\ (\overline{LE})^{m}$$

Where:

P(RE) is the probability of a critical Required Event (RE) successfully occurring.

P ($\overline{LE}$) is the probability of a Limiting or Lethal Event (LE) not occurring.

n is the number of individual Required Events

m is the number of individual Lethal Events

P(Success) is the aggregate probability of all REs occurring and all LEs not occurring.

Improving the Entrepreneur's Odds of Success

Shane (2008), notes, "There are far more entrepreneurs than most people realize. But the failure rate of new businesses is disappointingly high, and the economic impact of most of them disappointingly low, suggesting that enthusiastic would-be entrepreneurs and their investors all too often operate under a false set of assumptions." Improvement is needed. If the Entrepreneur strives to increase the chance of successfully completing each RE, the probability of the venture succeeding increases rapidly. Illustrated below, using ou previous example, if the Entrepreneur can increase the chance of successfully completing each REs to 60% (possibly accomplished by improving the management team or increasing resource allocation) the probability of a successful venture would rise dramatically to:

$$P\ (10 \text{ Required Events}) \text{ occurring} = P\ (\ 0.60^{10}) = 0.00604$$

If we assume the entrepreneur can't effect the possible lethal events, the previously computed P(10 $\overline{LE}$) remains unchanged at:

P 10 critical ($\overline{LE}$) = 0.02825

Hence, the total probability of improved venture success becomes:

P (Successful Outcome) = P(REs) x P($\overline{LE}$) =

P (Successful Outcome) = 0.00604 x 0.02825 = 0.00017 = 0.017 %

The vastly improved odds of success are now, 1 in 5,882.

Acknowledging and quantitatively improving the pre-start-up odds of success should be every entrepreneur's task and goal.

General Probability of Success
at
Various Probabilities of REs and LEs

Table 1 presents the results of a series of model calculations determining the probability of venture success, P(Success) at various probabilities of individual Required Events (RE) and significant Lethal Events assigned probabilities ranging from 0% to 100%. This model could be used to determine the pre-launch effect on the P(Success) as the probabilities of each RE or LE are assigned. Ongoing, this model could also be employed to estimate the P(Success) as the firm matures using updated probabilities of each RE and each mitigated ($\overline{LE}$) through time. Importantly, note the overall probability of venture success remains very low until the probabilities of individual RE or LE are greatly improved. In general, the prime goal of the entrepreneur is to ensure the probability of achieving each RE is greater than about 80% and the probability of each LE has been reduced below 20%. Only in that case, is the P(Success) sufficiently above 1%.

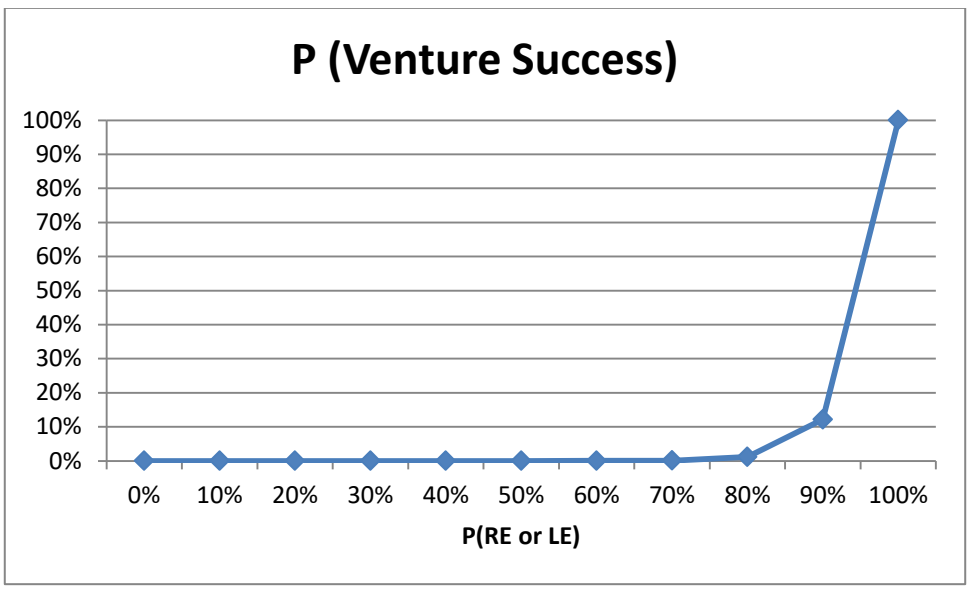
Table 1

RE & LE:	10			10	P(Success) =
P(RE)	P(all RE)	P(LE)	P(LE not)	P (all LE not)	P(10 RE) x P(10 LE not)
0%	0.00000%	100%	0%	0.00000%	0.0000000000%

10%	0.00000%	90%	10%	0.00000%	0.0000000000%
20%	0.00001%	80%	20%	0.00001%	0.0000000000%
30%	0.00059%	70%	30%	0.00059%	0.0000000035%
40%	0.01049%	60%	40%	0.01049%	0.0000010995%
50%	0.09766%	50%	50%	0.09766%	0.0000953674%
60%	0.60466%	40%	60%	0.60466%	0.0036561584%
70%	2.82475%	30%	70%	2.82475%	0.0797922663%
80%	10.73742%	20%	80%	10.73742%	1.1529215046%
90%	34.86784%	10%	90%	34.86784%	12.1576654591%
100%	100.00000%	0%	100%	100.00000%	100%

Graph 1 shows the probability of venture success as dependent variable progressively calculated as P(RE) rises and P($\overline{LE}$) falls. This progression demonstrates the chance of P(Success) curve, as each RE is increased and the probability of each LE is reduced (($\overline{LE}$) increased) for the venture to be a likely success.

GRAPH 1



The "hockey-stick" shape describing the probability of success of a new firm shows the probability of firm success remains exceedingly low until and unless the entrepreneur works to ensure the probability of successfully achieving each individual RE is high and the probability of each individual LE is minimized.

Kahneman

At first glance, the metrics presented above would seem to lack credibility as we are incorporating unknown events, unknown non-linear interactions, and the assessment of potential events which did not occur into a model. However, the credibility of this proposal is vastly enhanced by the work of economic behaviorist Daniel Kahneman, who (2011, p. 207) wrote.

"Because luck plays a large role, the quality of leadership and management practices cannot be inferred reliably from observations of success. And if you have perfect foreknowledge that a CEO has brilliant vision and extraordinary competence, you still would be unable to predict how the company will perform with much better accuracy than the flip of a coin." Kahneman (2011, p. 194) continues, "Extreme predictions and a willingness to predict rare events from weak evidence are both manifestations of [the human mind]. It is natural for the associative machinery to match the extremeness of predictions to the perceived extremeness of evidence on which it is based - this is how substitution works. And it is natural for [the human mind] to generate overconfident judgements, because confidence, as we have seen, is determined by the coherence of the best story you can tell from the evidence at hand. Be warned: your intuitions will deliver predictions that are too extreme and you will be inclined to put far too much faith in them."

Impact of the Venture Success Model on Strategic Planning

Importantly, the calculations shown above demonstrate why strategic planning is often ineffective. Highly improbable events (i.e. the rise of Amazon) are routinely ignored by competitive firms such as now defunct Toy's R-Us and Sears. But these low probability, competitive-market events can have devastating impact on a competitive firm. It is a mistake for strategic analysts to disregard low probabilities of occurrence events if the potential effect is the destruction of their business because , as the model demonstrates, low probabilities of organizational success are normal. Consider the Schumpeterian creative-destruction (Elliott, 2018) of Amazon "destroying" Circuit City, Tower Records, Musicland, Borders, Sears, JC Penny, Macy's, Staples, Barnes&Noble, etc. The prediction of statistically improbable events

should never be ignored and extremely low probabilities of competitor success may require pre-emptive strategic action. The potential harm/gain generated by the emerging existence of new competition and technology should be *well* considered in strategic plans.

Conclusions

The authors developed a venture probability of success computational model yielding a distinctive probability of success profile resembling an up-ended hockey-stick. This function visually explains why many new ventures fail and when success becomes probable.

The entrepreneurial success model incorporates Required Events which must occur, and the Limiting Events which can halt success. These concepts were integrated into a mathematical model capable of assisting the entrepreneur in assessing and enhancing the probability of venture success. Certainly, financing angels can use the model to assess the funding potential of a new project and calculate an expected rate of return.

Entrepreneurial business plans should include lists of important Required Events as well as identifiable Lethal Events. Using the model presented and assigning probabilities to each factor could move the field of entrepreneurial planning closer to a science. Additionally, any corporate strategic analysis should not ignore potential competitive start-ups merely because they are assigned exceptionally low probabilities of success as possible competitive effect may be extremely costly. Porter's 5-forces and standard SWOT-style "scanning" of the environment does not sufficiently address the potentially immense impact of super-competitive firms coming into existence even with low probabilities. Adequately addressing new venture failure rates, computed success probabilities and examining the true competitive impact of new competitive firms would improve strategic planning scenarios.

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SUPPLY CHAIN MANAGEMENT AND LOGISTICS - ABSTRACTS

A study on logistics service providers providing supply chain inventory finance

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Abstract

Supply chain finance is a set of financing arrangements, lengthen payment terms, providing trade credits that link various supply chain partners in a transaction to lower financing costs. The result is a win-win situation for the supplier, buyer and logistics service provider. Inventory financing is an asset-backed, revolving short-term loan made to a company so it can purchase products for sale. Those inventory is served as collateral for the loan if the business does not sell its products and cannot repay the loan.

The inventory is typically financed by the banks. However, in the supply chain, the logistics service providers (LSP) provide distribution and fulfillment services to the partners in the supply chain. They typically specialize in warehousing and transportation services, even though their services may go beyond logistics and include value-added services. Since the LSP is actually inventory holder and manager in the supply chain, in this research, we study the financial benefits of financing through the LSP.

We assume the uncertain demand distributed according to a bell-shaped curve. The supply chain consists of a supplier, a retailer and a logistics service provider. In the traditional setting, the supplier provides the trade credit to the retailer, a financial agreement to let the retailer to buy now and extend the payment later, for its procurement. In addition, the retailer may also finance through banks for inventory loan. However, for the supply chain finance setting, the LSP acts as finance institution instead, who provides inventory loan to the retailer, but maintained a similar trade credit with the supplier.

The computational results showed that a win-win situation for the supply chain partners under the supply chain finance setting. The retailer orders increased. This reduced the stock outs with a result of a higher in profit. An increased in order

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provides the supplier to lower its credit extended to the retailer with an increase in profit. With a higher in quantity shipped and stored, the profit of LSP is also increased. In addition, the LSP earns addition interests on load, providing it has a sufficient capital for transaction.

Keywords: inventory finance, trade credit, supply chains, logistics service providers

ASSESSMENT OF CREDIT RISK BASED ON SUPPLY CHAIN PERFORMANCE

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Abstract

We explore the effect of supply chain performance on the solvency risk of an enterprise and develop a predictive credit rating model based on supply chain performance metrics. Commonly used company rating models undervalue the importance of supply-chain performance indicators. The result is that small businesses are often penalized by overly financial performance-oriented risk models. An inaccurate evaluation of enterprise credit risk could impact negatively the flow of financial resources along the supply chain and give rise to the financial bullwhip effect. Conversely, financially distressed supply chain environments can impact the performance of good borrowers and bad financial performance could spread along supply chains. Through numerical simulation of a 5-tier supply chain environment along a multi-period scenario that is built with VBA on MS Excel, we explore the promptness and the statistically-significant forecast capability of two primary supply chain-related performance dimensions: delivery timeliness and frequency of supplier payments. The significance and the discriminatory power of the two selected performance variables is tested through logistic regression. Our results yield an 87% accuracy of our supply chain based credit risk model, with the frequency of supplier payments being statistically more relevant in the short term, which delivery timeliness more relevant in the medium to long term horizon. Our study shows how alternative credit rating models can help eliciting hidden supply-chain information, and bridge information asymmetries that raise the cost of financing. From the methodological perspective, our study highlights the potential numerical simulation as a powerful tool for credit risk assessment, which allows to extract additional information from data easily available to SMEs.

Keywords: Supply Chain, Credit Scoring, Numerical Simulation, Logistic regression

FORMULATING MORE VALUE: UNITED CHEMICALS CONSIDERS A NEW NODE IN ITS DISTRIBUTION NETWORK

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ABSTRACT

United Chemicals is a leading distributor of industrial chemicals with a broad product basket, global supply base, and extensive logistical reach. With 100 branches across the United States, United delivers to its customers the day after an order is received about 98% of the time. Its business is largely predicated on generating transportation economies, an objective it achieves by ensuring adequate volumes and stable demand patterns of customer clusters, and by locating distribution branches close to customer groupings to minimize travel distances of unconsolidated shipments. In an effort to generate more sales in the Maine and Massachusetts market, the General Manager proposed a new distribution branch in Southern Maine. Students are placed in the role of a Regional Supply Chain Director to lead an analysis of the potential site and to issue a recommendation to upper management.

Keywords: Supply Chain Optimization, Logistics Networks, Chemical Distribution

INTRODUCTION

This case evolved from a multi-year relationship between a Bloomsburg University professor and a global chemical distribution company that possesses a top 5 market position. Multiple engagements with several employees at the company, including classroom visits and in depth interviews led to the identification of the decision to open another distribution branch as the basis for an interesting teaching case given not only the obvious logistics changes but the likely changes in market potential, uncertainty, and risk. Thus, in responding to this case, students must think about and apply multiple issues of supply chain management to come to a well-reasoned decision.

OVERVIEW OF THE CASE

United Chemicals is a leading distributor of industrial chemicals with a broad product basket, global supply base, and extensive logistical reach. With 100 branches across the United States, United delivers to its customers the day after an order is received about 98% of the time. Its business is based on generating transportation economies, an objective it achieves by ensuring adequate volumes and stable demand patterns of customer clusters, and by locating distribution branches close to customer groupings to minimize travel distances of unconsolidated shipments. In an effort to generate more sales in the Southern Maine and Northern Massachusetts market, the General Manager proposed a new distribution branch at Kittery, Maine.

Coleman Topp, the Supply Chain Director for the East Region, must lead an analysis of the impact the additional site will have on cost, service, revenue, and environmental metrics. The analysis includes an evaluation of different facility types (e.g. cross-dock, warehouse, repackaging) and freight flow configurations. A key part of the analysis is the development of a network optimization that considers the above-mentioned issues amidst considerable uncertainty related to demand patterns, market share increases, product costs, product prices, transportation prices, competitor responses, and the like.

The scenario presented is the basis for a Harvard-style teaching case for use in the classroom. The case demonstrates the complex nature of logistics network decisions and applies Supply Chain Guru X optimization software. Students are placed in the role of Coleman Topp and have to decide if he should override his team's decision, cross-dock at Kittery with freight flowing through Bar Harbor, because several factors indicate other options might be more sustainable in the long run and the team's decision relied on multiple assumptions—he doubts each assumption will hold true.

After studying the case, students should be able to describe the role of a distributor in chemical supply chains, assess United's value proposition, and evaluate the potential Kittery facility from financial, operational, customer, competitive, and environmental standpoints.

GAMESMANSHIP BEHAVIOR IN OUTSOURCING VIA COMPETITION

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The importance of outsourcing is widely acknowledged in both academia and in practice. A big challenge in outsourcing is the question of how suppliers can be induced to provide the highest performance to the buyer. One approach is to establish a competition between suppliers seeking to win the buyer's business. In a competition, a decision maker's payoff depends not only on his efforts and the resulting costs, but also on his opponents' decisions. In this situation, the decision-maker might seek a decision anchor or a benchmark as a comparison point against which he evaluates his decisions.

In this research, we intend to introduce the definition of an equilibrium point for a competition in which each player aims to maximize the difference between his profit and his competitor's profit. We call this equilibrium point the "gamesmanship equilibrium". We then show the existence and uniqueness of such equilibrium for different types of competition, in which suppliers compete for the demand share of a buyer.

The idea of making decisions to perform superior to competitors might be appealing to managers since in the complicated business world it is virtually impossible to identify the maximum feasible expected profit of a large company. On the other hand, it is fairly easy to compare the performance of a company with the performance of similar companies working in the same industry and market. Therefore, the relative performance of a company with respect to its competitors might be a better determinant of its stock price or its managers' bonuses. As a result, decision-makers have strong and direct incentives to show gamesmanship behavior as we mentioned above.

Our research considers the scenario of suppliers competing to win the business from a single buyer who is outsourcing the manufacture of a commodity product and who defines three different competition criteria, or performance benchmarks, by which demand is allocated. These competition criteria result in different levels of competition intensity, and we investigate how these

different intensity levels affect the suppliers' behavior. We also examine how heterogeneity in suppliers' costs will impact their gamesmanship behavior.

Using controlled laboratory experiments, we then examine the behavior of subjects who play the role of competing suppliers in an outsourcing problem. Our results show that in most cases, the subjects' average decisions fall somewhere between the Nash equilibrium and gamesmanship equilibrium. This observation suggests while suppliers aim to maximize their own expected profit, they also tend to beat the competition. We also find that the proposed gamesmanship model significantly outperforms the Nash model and explains the subjects' behaviors.

Keywords: Behavioral Operations Management; Gamesmanship Equilibrium; Bounded Rationality; Outsourcing; Simultaneous Competition

Innovative Spatial Modeling for Statewide EMS Coverage Plan

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Abstract:

In designing and planning process of public health systems, people experience inequalities of the emergency medical services in cities, suburbs, rural areas, and frontier areas. Therefore, reasonable response time to save lives is critical to the public. This study examines statewide response time using GIS and integer linear programming (ILP) that encompasses all areas based on the characteristics of the area. Chute time which is available from the NEMIS database is considered to estimate the response time. The study visualized the areas found by reasonable response times of emergency medical service (EMS). To improve EMS services, we recommend relocating existing ambulance locations and/or adding ambulance facilities and adopting innovative operations management in order to reduce chute time.

Keywords: EMS, spatial modeling, ambulance, coverage, GIS

INTERNET OF THINGS AND BLOCKCHAIN TECHNOLOGY: A COMPARISON OF SUPPLY CHAINS

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ABSTRACT

The Internet of Things (IoT) and blockchain technology have been around for years now and are growing in use and application. However, while some companies have incorporated the use of IoT and blockchains into their operations, others have not. This presentation seeks to explore the potential benefits, drawbacks, costs, and futures of companies that are using versus not using these business practices in their supply chains.

SUPPLIERS' DEDICATED RESOURCES: AN ANTECEDENT TO A SUPERIOR FIRM PERFORMANCE

Submission type: Abstract

In this research, we discuss suppliers' dedicated resources as the antecedent of the manufacturing firm's superior performance through a chain reaction in suppliers' flexibility and manufacturer's flexibility (Narayanan et al., 2015; Wagner & Bode, 2014). As a firm specializes in its core competence, it depends more on its suppliers to respond to customer requests in an increasingly turbulent environment (Cao & Zhang, 2011). Our manuscript focuses on flexibility within the firm and its supply chain, which is a strategic choice that enables the firm to sustain competitive advantages (Stevenson & Spring, 2007; Swafford et al., 2006). Despite the increasing recognition of suppliers, there is a lack of attention in research to exploring the suppliers' resources and suppliers' flexibility in regards to a manufacturing firm's performance. Our research make a contribution to the supply chain management field by filling this gap.

A large-scale survey was used to collect 201 responses from senior manufacturing executives. Structural Equation Modeling was used to test the measurement and the structural models (Ellis et al., 2010; Fornell & Larker, 1981; Marsh and Hocevar, 1985; Shah & Goldstein, 2006). The results indicate that suppliers' dedicated resources positively relate to suppliers' flexibility, which enables the manufacturing firm's flexibility. The manufacturer's flexibility eventually helps the firm to achieve the competitive advantages.

In conclusion, the intensified global competition and advanced technology accelerate the pace of change in current business world. In order to be competitive in such an environment, a manufacturing firm needs to be flexible (Narasimhan et al., 2004). Grounded on the resource-based theory and relational view theory (Lavie 2006; Lewis et al. 2010), this research has clarified the determinants that are critical to achieve a manufacturing firm's flexibility, including suppliers' dedicated resources and suppliers' flexibility.

Key words: supply chain, supplier's dedicated resources, manufacturing firm's flexibility, supplier's flexibility

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THE IMPACT OF BUYER SUPPLIER INFORMATION SHARING ON MODULARITY AND

MASS CUSTOMIZATION

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1.Introduction

This study examines the effects of information sharing between module buyer and module supplier on modular product/process which is positively related to the formation of modular organization and mass customization capability. As competition among firms has intensified, a powerful strategic weapon to hold a dominant position has continuously changed. Aligned with resource based view, securing sustainable competitive advantage seems feasible in conjunction with good quality products and services in the past decade. However, Teece (1997) posited that ensuring sustainable competitive advantage with quality goods alone is no longer effective. In addition, most purchasing decisions are made by buying firm, adding more complexity. Adopting resource based view, securing a sustainable competitive advantage under uncertainties requires quick response to changing market conditions. Therefore, collaboration among supply chain partners using information sharing strategy can lower transaction cost between buyer and supplier. The lack of information sharing in supply chain may cause the predicament known as “bullwhip effect” in which irregular orders in downstream supply chain cause inefficiency in entire supply chain partners. This may be alleviated through close information sharing between supply chain partners.

Our study therefore has collected data to investigate the impact of information sharing between module buyer and supplier on mass customization capability and the formation of modular organization to cope with module products complexity. Our study has the following objectives. First, we collected the opinions of experts on heterogeneous industries that widely adopted modularity concept into practice and tested the validity of research model. Second, we have empirically demonstrated the relationships among information sharing, product/process, modular organization and mass customization capability.

Thus, the following research questions are carefully scrutinized to understand the factors affecting the relationship between module buyer and module supplier.

1. What are the most important factors for module buyers and suppliers when outsourcing module component?
2. What are the antecedents of efficient mass customization capability and the formation of modular organization?

To prove the validity of the thesis, a comprehensive survey of various manufacturing industries was conducted and constructs were created. An empirical test was then performed using structural equation modeling on samples of XXX manufacturing firms. The results suggest that multiple dimensions of information sharing between module decision-maker and module supplier facilitates better module products/process as well as the formation of modular organization and mass customization capability. Our study is the first empirical test to attempt to find the effects of information sharing between module buyer and module supplier on modularity and mass customization capability. Further, it provides implication into the exact nature of the influence of information sharing on modularity in the perspective of mass customization as well as modular organization.

Key Words: Information Sharing, Modularity, Mass Customization

THE IMPACT OF PRODUCT HARM CRISIS IN THE GLOBAL SUPPLY CHAIN: A SYSTEMATIC LITERATURE REVIEW

Abstract: Product harm crisis can be a disturbing event for companies and is well-known topic within the marketing literature. However, research on the impact of product harm crisis within the global supply chain research is sparse. The spillover effects on global supply chains tend to be disruptions and a rush for product identification as well as recalls. We provide a systematic literature review on the impact of product harm crisis within the view of global supply chain operations.

Keywords: product harm crisis, global supply chain, systematic literature review

THE INTERNET OF THINGS IN THE GLOBAL SUPPLY CHAIN: BEST PRACTICE AND APPLICATION MODELS

Abstract: The internet of things (IoT) has regained significance as one of the global supply chain (GSC) paradigms for improving competitiveness. With RFID and other IT/IS technologies advancements, the integration of IoT/GSC is advancing. We conduct a review of the current literature and present best practice and application models on the use of internet of things in the global supply chain.

Keywords: internet of things, global supply chain, application models

Manufacturing reshoring in healthcare industry

Abstract

Despite continuing offshoring practices in manufacturing to low cost regions, there has been increasing manufacturing relocation activities to home countries in the recent years. The extant literature identify factors such as cost, quality, flexibility and so forth which motivate reshoring decisions. Using a systematic literature review, this study develops a conceptual reshoring model by examining factors for manufacturing reshoring decisions in the healthcare products industry such as medical devices and pharmaceuticals, dominated by strict quality requirements, regulations, high research and development (R&D) and technology involvement, and complex validation process. Semi-structured interviews with practicing managers find that while quality and regulations are important factors, they are only the minimum determinants for any location decision in medical device and pharmaceuticals manufacturing. The managers also suggested that while domestic production through reshoring can provide benefits, firms in healthcare manufacturing may locate based more on product complexity and specialization in customer-driven products.

Introduction

This study is divided into two sections. Part 1 covers the motivation for this research and ends in a conceptual model developed from a systematic literature review, examined by a series of nine semi-structured interviews of practitioners. This study begins to answer the question of "who" is involved in reshoring, "why" they are considering reshoring manufacturing and "what" they use to make reshoring decisions. Part 2 involves development and testing of a survey instrument to examine the model on a representative sample of a minimum of 200 respondents from the healthcare industry, continuing the "who", "why" and "what" questions.

PART 1

Research Motivation

A company's production location decisions outside of their home country, known as Offshoring, received a lot of attention in the early 21st century literature due to a number of expected benefits including low labor costs, greater proximity to international suppliers and customers, foreign incentives, and less governmental regulation, among other factors. However, as the original offshoring conditions changed, expected benefits began to decrease, or never materialized in the first place, so some of these companies returned production back to their home country. Commonly known as "Reshoring" these activities have played a critical role in job creation and politics in manufacturing location decisions in recent years. As a stated outcome of President Obama and Trump's administration, Reshoring is supported by both political environment and public sentiment which demand economic growth through job creation by brining manufacturers back (Delis et al., 2017). For example, in 2012, large companies such as GE Healthcare announced they will bring production back to the U.S. from China. GE also began reshoring its appliance product lines back to Kentucky, while Walmart encouraged its suppliers to reshore their manufacturing through its "Made-In-USA" program (Whitfield, 2017). Also, while low-cost countries such as China and India have been popular destinations for offshored firms, due to their historical advantage in low labor cost, their rising labor and logistics costs have decreased their attractiveness (Kusaba and Moser, 2011). While offshoring continued, irms began to reverse their offshoring decisions as a correction (Kinkel and Maloca, 2009) because short-term benefits began to disappear, which outweighed their expected profits (Fitzerald, 2013). Even firms that experience expected cost benefits found that offshoring did not increase firm competitiveness related to productivity growth (Capolupo et al., 2017). Failure to achieve expected benefits of offshoring locations, due to strategic and financial reasons, can result in "de-internalization", withdrawal or discontinuity of offshoring operations (Mlody, 2016). The factors which have resulted in an increase in Reshoring activities suggest that the expected benefits were no longer realized, and that the cost-oriented original offshoring decision needs further consideration. A lot of firms realize that offshoring is as costly as or more costly than they expect, and this cost estimation error causes negative impact on their performance (Larsen, 2016). In other words, the original decision to offshore may not consider all of the relevant variables as a source of competitive advantage and the initial cost benefit analysis was incorrect in the long term, or an appropriate decision framework wasn't used by decision-makers. The literature suggests that the same phenomenon may be happening in Reshoring decisions because despite the popularity of Reshoring, there is a paucity of research on Reshoring decisions at the firm level (Fratocchi et al., 2014). If Reshoring decisions are made simply as a reevaluation of the

original Offshoring decisions, the same flaws that existed in the original Offshoring decision may still exist. It is also possible that Reshoring decisions are driven by different motivations. This issue is important because the extant literature is primarily focused on general conditions and the industry (product-specific) or firm specific reshoring factors are under-researched in spite of the potential benefits to practitioners (Fratocchi et al., 2014). The literature benefits because there is a paucity of theoretical and applied research on Reshoring decision-making.

This leads to two general research questions:

1) What are the current factors considered in manufacturing relocation decisions in the literature?
2) What other factors do practitioners use to make reshoring decisions that are not in the extant literature?

To answer these questions, a combination of a systematic literature review and semi-structured interviews were conducted. To answer question 1), a systematic literature review approach is used to develop a framework for reshoring decisions from the existing literature. To address question 2), a series of semi-structured interviews were developed to discover factors in industry that are not in the literature. Based on the findings from the systematic literature review, the research questions were revised to narrow down the scope of the study.

Systematic Literature Review (SLR)

This study uses a systematic literature review (Tranfield, 2003) to investigate currently identified industry-specific reshoring drivers. Then, the findings from the literature review was used to develop a conceptual model for current reshoring decisions as suggested by Gunasekaran and Ngai (2005). The detailed codification and analysis method was based on Carnevalli et al. (2008). The review process followed the three major stages and phases in each stage by Tranfield (2003). The three stages include Stage I planning the review, Stage II conducting the review, and Stage III reporting and dissemination. In Stage I, a review protocol was developed as the two general research questions which this study attempts to answer. This guided how review should be conducted in Stage II. Search keywords such as “reshoring”, “backshoring”, and “relocation” were used for initial search of the articles using ABI/INFORM and Google Scholar as primary database. While ABI/INFORM sift through articles focusing on business, Google Scholar can provide a wider range of resources that may be potentially missing in search. Due to the small number of studies on reshoring, the initial search included white papers, conference proceedings,

dissertations, books and journal articles and references of these sources so that it could include all the available sources. However, in the course of study quality assessment, only scholarly journal articles were included in data synthesis and analysis for the rigor of the study (Gunasekaran and Ngai, 2005). As a selection criteria, these articles should identify at least one reshoring motivation. Then, they were also classified by industry sectors using SIC industry codes. Some articles which follows different industrial classification codes were identified as additional categories. Data codification was based on coding schemes for both quality of the articles and research objectives, which include: a) Publication year, b) Name of journal, c) Methodology, d) Research type, e) definition of reshoring, f) Context (country/industry), g) How reshoring is initiated such as - reversing a previous failure, strategic choice, or reaction to a changing business environment, h) Research theme such as drivers, impact, and process, etc. , i) Unit of analysis, j) documentation type, k) Motivation and drivers of reshoring.

In this process, articles were chosen based on two criteria:

- Articles that have primary focus on reshoring drivers and/or motivations or discuss more than one reshoring motivation
- Articles that were published in scholarly journals

The scope of journals was not narrowed down based on their primary methodological or specific topical focus (e.g. empirical or analytical, logistics, etc.) because of the small number of existing studies in reshoring literature. This resulted in 52 articles published in 29 different journal outlets between 2009 and 2018. Among 52 studies on reshoring published from 2009 to 2018, nine studies (Kinkel and Maloca, 2009; Kinkel, 2012; Tate et al., 2014; Fratocchi et al., 2016; Zhai et al., 2016; Delis et al., 2017; Kim et al., 2017; Heikkila et al., 2018; Johansson et al., 2018) investigated motivations for reshoring including reshoring cases in medical, pharmaceutical, biotech or biomedical industry sectors. However, none of these studies examined these industry sectors and their distinct reshoring motivations. Studies that attempted to examine reshoring in a standalone industry focused on metal and electrical (Kinkel, 2014; Brennan et al., 2015), shoes and apparel (Mezzadri, 2014; Martinez-Mora and Merino, 2014; Baraldi et al., 2018), and electronics and automotive (Ancarani et al., 2015). Detailed classification is in Appendix C.

Theoretical background

Three main theorical views are currently used to explain reshoring including transaction cost economics (TCE), resource based economics (RBV), and eclectic diagram which further developed to ownership, location and internationalization (OLI). These theories are also used to explain offshoring and outsourcing of companies. TCE (Williamson, 1975; 1981; 1985) explains that firms select the governance structure that minimizes transaction costs. RBV (Barney, 1991) argues that organizations develop and focus on resources which brings a sustainable competitive advantage. Thus, RBV particularly analyzes manufacturing capabilities in terms of performance and the competitive position at a strategic level in manufacturing location decisions (McIvor, 2013). These two theories together explain the reshoring phenomenon from a location decision perspective which provides strategic opportunities, cost efficiency, and competitive advantage to firms (Porter, 1994). Understanding offshoring and reshoring as relocation of production plants or services (Gray et al., 2013), Canham and Hamilton (2013) use both RBV and TCE to examine offshoring extending to backshoring in the context of New Zealand. In addition to lowering cost, the authors find that firms' relocation to foreign countries is for competitive advantage obtained from unique resources such as skilled workforce and process innovation. Canham and Hamilton's theoretical framework examines reasons for backshoring as the reverse of offshoring. That is, reshoring decisions are understood as a firm's inability to develop critical tangible and intangible assets or resources which can bring competitive advantage to the firm (Fratocchi et al., 2016). Barak (2014) also adopts RBV as one of the theories to explore key motivations for the reshoring trend in US manufacturing and the impact of the financial crisis on reshoring decisions. This study finds that cost is the major factor for reshoring. However, besides cost, RBV provides theoretical support for innovation and technology, and consumer preference for domestically manufactured products (e.g. Made in USA) as reshoring motivations, both of which create competitive advantage and improve corporate reputation. The current application of RBV in the reshoring literature theoretically supports both cost and non-cost driven motivations.

The eclectic diagram by Dunning (1983; 1988) describes how firms internalize their production based on the specific ownership, location, and internalization (OLI) parameters. Despite the limitation of its context specificity, it has been widely used to identify factors that influence firms to internationalize their production. In particular, Dunning (1980; 1998; 2001) suggests that firms are internationalized based on various locational advantage orientations such as resource seeking, marketing seeking, efficiency seeking, and strategic asset seeking advantages. Ancarani et al. (2015) find an association between the duration of offshored firms and reshoring

motivations including technology, customization level, decrease in cost differentials, physical distance, organizational archetypes, firm size, and "made-in" effect. Their study identifies contextual factors such as firm size, industry, and country features (home and host country) related to offshoring duration and thus reshoring decisions. High-tech industries with high levels of outsourcing, strong contractual power of final producers and OEMs, and products requiring high customization are more likely to reshore in a timely manner.

The definition and scope of reshoring

Reshoring is the most common term used in the literature to refer to "activities of once offshored manufacturing capacities from foreign locations back to the domestic location (Kinkel and Maloca, 2009)". However, backshoring has been increasingly used to refer to the same phenomenon in Europe. Some definitions expand the scope of reshoring to a general relocation of manufacturing to home or other locations by incorporating further offshoring activities. While the literature interchangeably uses reshoring and backshoring to refer to returning to home country, reshoring is also defined as "relocation activities of once offshored manufacturing facilities" (Tate et al., 2014; Fratocchi et al., 2014). This broader definition includes all of three types of relocation activities – 1) bringing back to country of origin (backshoring) (Kinkel and Maloca,, 2009), 2) relocating closer to home country (also called nearshoring) (Hartman et al., 2017), and 3) relocating to a new attractive location (relocating to the 3rd place far from home location). However, a vast majority of existing studies (i.e.Canham and Hamilton, 2013; Gray et al., 2013; Ancarani et al., 2015; Brennan et al., 2015, etc.) define reshoring by confining the regional focus of relocation activities to home location. In addition, the last two types of reshoring are included in a broader reshoring category but are fundamentally another offshoring. Thus, this study defines reshoring as relocating only to home location consistent with Kinkel and Maloca (2009) and Ellarm (2013).

Factors in the relationship between Offshoring and Reshoring Decisions

Current studies on Reshoring focus on how it occurs as an independent event in the context of macro-economic changes. However, given Offshoring is an antecedent for Reshoring, it is crucial to initially understand it as an extension of strategic Offshoring decisions (Delis et al., 2017). This means that the relationship between the drivers for Offshoring and Reshoring can be reciprocal and need to be clarified in terms of motivations for each decision (Wiesmann et al., 2017). In that sense, Reshoring may be dependent to some extent on the original motivation for Offshoring in relation to the expected benefits brought to the firm which can be affected by any

changes that took place since the original decision. Firms that locate manufacturing internationally consider various factors such as location advantages, risks, and economies (Lampel and Giachetti, 2013). Schoenherr et al. (2008) analyzed offshoring decision factors related to product, partner and environmental characteristics from the perspective of supply chain risk. Their study identified cost as the most important risk factor to consider in offshoring decisions as many other studies do. It is obvious that offshoring manufacturing has been prompted by low cost countries (Aspelund and Butsco, 2010). However, other than financial concerns for offshoring in developing countries, studies also find competitive advantages such as innovation (Lewin et al., 2009) to be important motivations for offshoring decisions. Other factors may include access to local markets, government and regulation incentives, quality of human capital, access to talents, etc. (Caniato et al., 2015). Roza et al. (2011) explains that different strategic attributes may drive offshoring decisions depending on their firm size. Offshoring of small and large firms are driven by cost while medium-sized firms tend to use offshoring as resource and entrepreneurial strategy.

The current factors and contexts in Reshoring

Studies find that there are various factors for Reshoring while offshoring has been predominantly driven by cost, particularly labor cost (Srai and Ane, 2016; Johansson and Olhager, 2018). Di Mauro et al. (2018) argue that offshoring is motivated by cost reduction, but the motivations for reshoring are differentiated by shifting the focus from cost efficiency to other factors such as increase in customer value and a change in the supply chain as a competitive strategy. The shift in motivations implies increased complexity in the decision making process. Studies also suggest that factors may differ by context, e.g. in relation to firm-specific or product-specific factors. The context derives from current research focus on certain labor-intensive industries or a “one-size-fit-all” approach versus a high-tech, high-skilled, or highly regulated industry. The general models were developed in order to increase the generalizability in a single decision framework. There are few studies (Canham and Hamilton, 2013; Johansson and Olhager, 2018) that examine how firm-specific characteristics such as manufacturing process, export intensity, R&D intensity, production complexity, product standardization, production volume, and labor intensity affect offshoring decisions. Canham and Hamilton (2013) find that

industry has a significant impact on reshoring decisions. However, there has been no study which evaluates reshoring decision factors at the industry level.

In addition to manufacturing, R&D has been offshored in high-tech sectors, particularly healthcare products, because they suffer from low productivity, and high costs. Hamdouch and He (2009) find that offshoring strategy of medical products (medical devices, pharmaceuticals, etc.) benefited firms by lowering R&D cost significantly in developing regions such as India and China. However, Reshoring in R&D is increasing among medical device manufacturers and pharmaceutical companies due to concerns about quality and intellectual property (IP) protection, among other factors. Despite the high stakes in medical device manufacturing and pharmaceuticals the research is sparse in how these Reshoring decisions are made.

While the medical device and pharmaceutical industries have gained increasing importance due to distinct characteristics of the high cost and heavily-regulated product/production requirements, but have been under-researched in terms of its impact on Reshoring. This issue is important because the rising cost of healthcare is of primary concern in many countries and the cost of medical devices and pharmaceuticals are contributing factors. While medical devices and pharmaceutical companies may operate in different sectors, these two industry sectors as important healthcare products providers are required to meet regulations in product development and manufacturing process under FDA control due to indirect and direct impact of the products on humans. The purpose of this study is to develop an industry-specific Reshoring model for healthcare manufacturing to inform the literature and guide practitioners in making these decisions.

A number of studies identify motivations for reshoring. The literature review finds 75 different reshoring drivers from existing studies (See Appendix A). These include both internal and external factors such as labor costs, quality, government policy, and host country risks. Each study uses different theoretical frameworks to classify these factors. With offshoring as a strategic decision heavily driven by the cost benefits in developing countries (MacCarthy and Atthirawong, 2003), a lot of studies have discussed cost as the strongest motive for firms to relocate their production (Abbasi, 2016; Canham and Hamilton, 2013). This shows that while offshoring was highly driven by low labor cost in developing economies, reshoring is motivated by other factors that are important for operational capabilities (Kinkel and Maloca, 2009; Vanchan et al., 2018; Heikkila et al., 2018). Recent studies recognize that reshoring is driven by other factors which can have long-term impacts on firm

performance and consumers. For example, quality issues and the so-called "made-in" effect (Ancarani et al., 2015). Joubioux and Vanpoucke (2016) also find that reshoring decisions are based on long-term perspectives such as; 1) high value activities, 2) in consideration of total cost for offshored regions, and 3) due to failure in offshoring and changing market situations. Reshoring is also discussed from the perspective of supply chain flexibility and resilience, which benefit supplier relationships through better integration (Bailey and De Propris, 2014). Likewise, Ashby (2016) finds that offshoring provided benefits to firms in terms of low labor costs and proximity to resources but find that it can also result in poor social and environmental performance. According to Ashby, reshoring can increase costs and may cause a scarcity of skilled labor, but it can provide close supplier relationship and improve sustainability practices in the supply chain.

The literature shows various results in investigating determinant motivations for reshoring. While Zhai et al. (2016) and Ancarni et al. (2015) find that reshoring is motivated more by quality issues rather than labor cost , some studies (Grappi et al., 2015; Abbasi, 2016) still find that total cost including transportation cost, labor costs, etc. is the greatest driver, and that motivations may vary in different industries. The majority of reshoring studies do not identify one factor as the strongest motivation. This may be due to the limitation of qualitative investigation of reshoring motivation. However, it also suggests that reshoring is driven by more than quantitative factors. MacCormack et al. (1994) point out that cost-based methods for international manufacturing location decisions is not sustainable as a firms experience changes in its external environment. Due to increasing automation and technology improvements, direct labor cost is less emphasized in production. Thus, with decreasing cost pressure, manufacturing location is likely to move toward the markets with better infrastructure, etc.

Context for Reshoring

Existing studies attempt to empirically examine the motivations for reshoring decision in only a few contexts, mainly Europe (i.e. Germany, Finland, Sweden, and Denmark) and the US. Studies suggest that reshoring decisions can differ by context due to various characteristics such as firm size, industry, customization of products, ownership mode, etc. (Benstead et al., 2017; Ancarani et al., 2015). Some studies include various industry sectors in manufacturing, and others focuses only on industry groups such as automotive and apparel. However, industry can be an important factor in relocation decision (Pennings and Sleuwaegen, 2000; Kinkel, 2012; Fratocchi et al., 2014). This is particularly related to the initial motivation of offshored manufacturing

activities. Although both labor-intensive and technology-intensive industry groups initially offshored their manufacturing based on resource-seeking motivations, labor-intensive manufacturing is focused on low labor cost. Technology-intensive manufacturing tends to locate overseas to acquire unique technology or knowledge in the offshored location. Thus, the difference between these two industry groups can influence reshoring decision factors in turn.

Studies report that reshoring is motivated by a variety of economic reasons, i.e. efficiency, market, resource, and strategic asset seeking drivers without distinguishing impact of industry on reshoring decision factors. However, industry is prone to specific reshoring motivations. Studies (i.e. Canham and Hamilton, 2013) support that industry has a significant impact on reshoring propensity. The impact of industry and products are important in that production requiring high levels of direct labor is likely to migrate to low cost regions not the final market which the products will serve (MacComack et al., 1994). Furthermore, offshoring strategy is common in electronics and automotive industries (Ciravegna et al., 2013; Mudambi and Venzin, 2010). Due to a higher degree of customization, they require close coordination and interaction among suppliers which often result in longer lead times (Ancarani et al., 2015). Products with higher levels of customization cause higher manufacturing complexity due to limited ability to control outsourced manufacturers (Hartman et al., 2017).

Location decisions in healthcare manufacturing

In the early 21st century, pharmaceuticals and medical devices increasingly globalized their production and supply chains due to the low cost and favorable regulations in overseas locations (McIntosh, 2013). Rising R&D cost, and demand for low cost healthcare drives firm to move to emerging economies to create source of revenue by offering high-quality products (e.g. drugs) at low cost (Mohiuddin et al., 2017). However, firms in healthcare experience challenges created by their offshoring strategy. The challenges include poor product quality, which does not meet required product specifications (Gray et al., 2011). Moser and Montalbano (2018) reported that the number of recall notices of Chinese made consumer goods has been substantially growing in the past years presenting about six time higher than U.S. made products. The outsourcing of research and technology intensive processes such as pharmaceuticals can result in harm to the products. Thus, these industries require higher levels of regulatory restrictions and oversight by the FDA due to its medical use (Marucheck et al., 2011). This can cause longer and more complex supply chains when compared to other industry sectors. Chowdary and George (2012)

report that current manufacturing processes for pharmaceuticals are regulated by manufacturing guidelines to assure safety and quality by defining and validating appropriate manufacturing processes. In addition, quality system standards such as ISO 9001 and ISO 13845 are required, for example, for medical devices as industry practice to meet the regulatory as well as customer requirements. These industry sectors also feature high R&D intensity and high safety and security risk (Marucheck et al., 2011). Risk can be higher in healthcare in terms of product quality and safety because quality issues are often not realized until consumers actually use the devices or drugs. As Grackin (2008) argues, cost-based sourcing decision is not appropriate for these industries. These industries create competitive advantage through R&D rather than low skilled and low cost labor which traditional manufacturing sectors require (Silva, 2008). The success of the Thus, this study investigates how quality, regulations and R&D/technology are particularly considered in location decisions.

Thus, the revised research questions are:

1) What are the current factors considered in manufacturing relocation decisions in healthcare?
2) What other factors do healthcare manufacturing practitioners use to make reshoring decisions that is not in the extant literature?

The Conceptual Model

There has been a debate on whether reshoring is merely a short-term reactive decision to failure of offshoring strategy or a true strategic decision (Kinkel and Maloca, 2009; Bals et al., 2016; Albertoni et al., 2017). Motivations for offshoring and reshoring having an interactive relationship, what triggers firms to consider reshroing impact on which factor(s) should be prioritized in decision making process. As mentioned, poor firm performance as a result of offshoring decision often leads to reconsideration of their strategy, which is caused by overestimated total cost benefit of offshoring (Kinkel and Maloca, 2009), locational disadvantages (e.g. cultural distance, longer lead times, etc.), lack of coordination and control, and relationship with local suppliers, etc. On the other hand, firms seek a new or home location and sourcing strategy related to these factors as their specific core competency or strategic objectives. This suggests that identification of whether reshoring is provoked as a failure of previous offshoring strategy or strategic changes at production or firm level as well as reactive decision

to changes in business environment helps firm to refine factors to be considered in their location and supply chain decision.

The literature review suggests that the role of reshoring factors varies from company to company, which make decision highly complicated. As suggested in the framework by Fratocchi et al. (2016), reshoring motivations can be viewAt firm level there are primarily two scenarios in internal environment to be considered as to how reshoring occurs as a strategic choice. First, expected benefits as initial offshoring motivations are decreasing or no longer realized For example, a number of offshoring decisions were made in the past decades anticipating low labor cost in overseas locations. Second, there are expected benefits from offshoring that are not necessarily related to the original offshoring motivations These make home location look more attractive than their offshore locations (Tate, 2014). For example, prevalent product innovation (Gray et al., 2013) in the US and issues of IP protection in the offshored locations such as China can make the US as home country more appealing for manufacturing relocation destination. These two scenarios can be considered based on changes in the external environment as well. Environmental changes in host country create risks and challenges in operations or changes in business conditions in home country enable to create opportunities for reshoring firms.

The literature also finds that there are factors that are not motivations for reshoring decisions but influence these decisions to some extent either positively and negatively. As Schmeisser (2013) argues that firm-specific characteristics influence decision to offshore, these firm level determinants should be considered. These determinants includes manufacturing system, capital intensity, industry, firm size, export intensity, R&D intensity, production complexity, product standardization, and production volume as should in the conceptual model (Canham and Hamilton, 2013; Kinkel and Maloca, 2009; Kinkel, 2012; Fratocchi et al., 2014; Johansson and Olhager, 2018).

The general conceptual model on reshoring factors is developed based on the four categories in Figure 1. Each factor is classified based on these four categories as showed in the model.

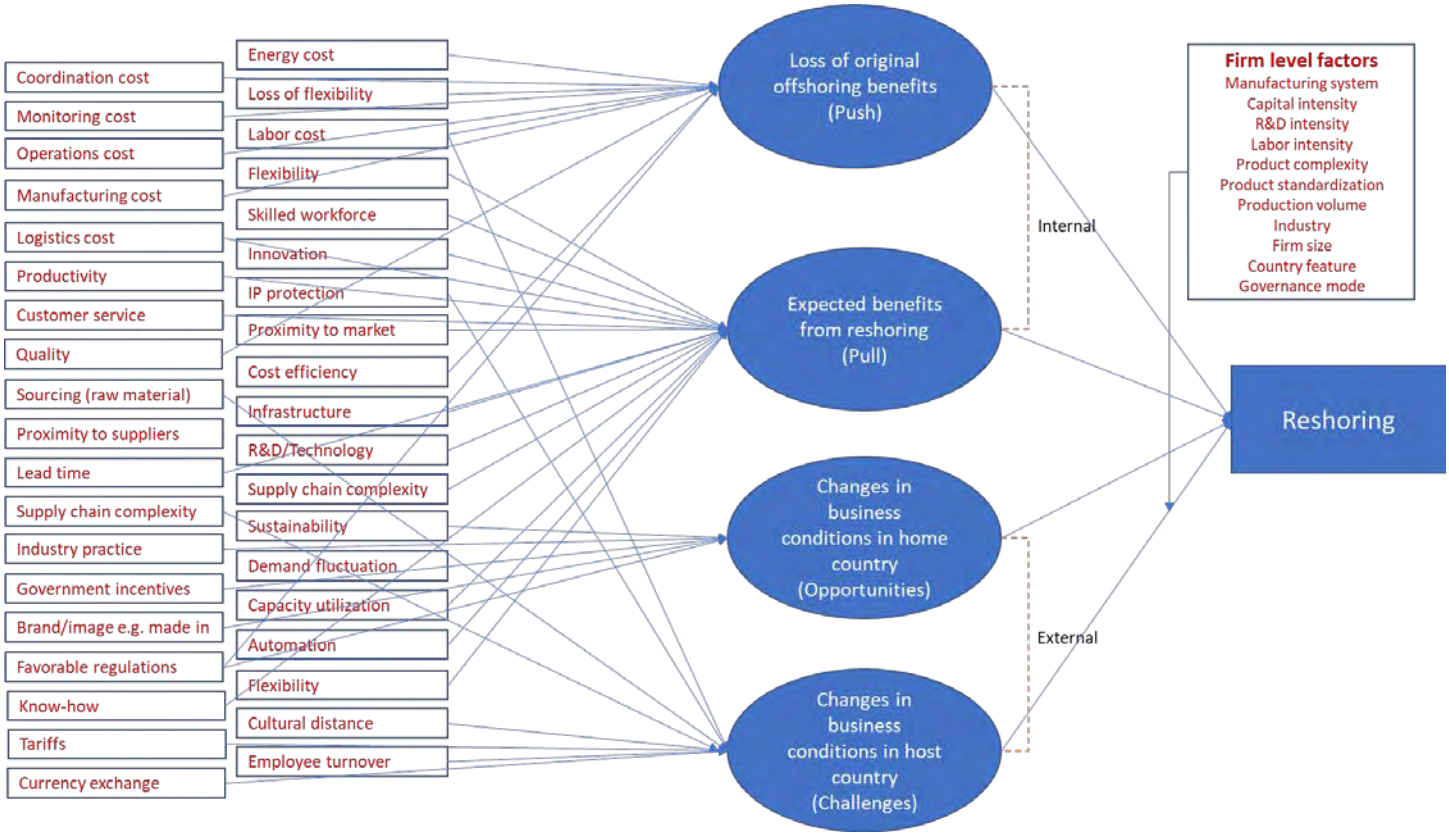

Figure 1. Conceptual reshoring model

Interviews

This study used a literature review to develop and conceptual model and semi-structured interviews (Walker et al., 2008) to develop a relocation decision framework. An interview protocol was developed with questions based on the literature review and research objectives in line with those recommended by Walker et al. (2008) andKvale and Brinkmann(2009). The procedure for the interview protocol development followed Jacob and Furgerson (2012). The interview questions were piloted on an expert in manufacturing operations and a researcher in reshoring for clarity. The semi-structured interview questions obtained information on:

a) Demographics of the interviewees and their organization

b) Role of quality, regulation, and technology in medical device and pharmaceuticals manufacturing

c) Factors considered in location decisions for healthcare manufacturing

d) How these factors can influence reshoring decisions

Nine interviews were conducted in Fall 2018 at a medical industry manufacturing conference in Denver, Colorado. This conference focused on those that provide products and services to the medical device, biotech and pharmaceuticals industries. The interviewees include mid-level managers, owners of medical device manufacturers, others who have expertise in healthcare manufacturing. Six interviewees were senior managers and included managers, directors, and CEOs of American medical device manufacturing firms that have manufacturing facilities located in the U.S. and/or overseas (e.g. India, China, Ireland, Sweden, Malaysia, etc.). Two interviewees are consultants to the medical device and biotech manufacturing. The last interviewee works for an organization that provide healthcare services and also manufacture medical products. These interviewees are a convenience sample selected from a US medical device manufacturing conference. The interviews were conducted face-to-face at the annual meeting of the organization, each interview lasted 20-30 minutes. The unit of analysis is at the firm level. As part of the agreement to be interviewed, the names of some of the firms and interviewees are kept anonymous; however, descriptive information on these interviewees and their organizations are provided below (Table 1).

Table 1. Information about interviewees and their organizations

Interviewee	A	B	C	D	E	F	G	H	I
Position	Director of Sales	Principal	Director of sales	Territory manager	Senior business development manager	Business development manager	CEO	CEO	Executive vice president
Primary products/ services	Medical components (tubes, etc.)	Consulting	Silicone based surgical products	Medical components, drugs, accessories/ supplies	Designing, developing and manufacturing MedTech devices (diagnostics, etc.)	Medical tubing	Dental supplies	Medical device sterilizer	Blood management, (medical products and equipment)
Company background	Distributor of medical components	Consulting process and quality improvement of medical device, pharmaceuticals and other regulated manufacturing industries	Supplier without R&D; Labor is the highest expense	Labor expense largest in the total expense, serve global market and many global manufacturing locations, Sweden for prototyping	R&D and manufacturing facilities in India and serving both India and US market	Contract manufacturer, serve 70% US market and different countries (Malaysia, Ireland - specialization), automated	Small business, labor intensive (manual jobs), products only manufactured in the US	Operate only in the US; not manufacturing any products	Global headquarter located and based in US, a subsidiary of a Japanese multinational firm. Manufacture and sales of medical products and equipment, including pharmaceuticals, nutritional food supplement, blood bags, disposable medical devices,

									cardiovascular systems, vascular grafts, peritoneal dialysis, blood glucose monitoring system, medical electronic, and digital thermometers.

The eight organizations in this study have not reshored their production in the last five years, but operate in the U.S. and/or have manufacturing located overseas serving global markets. However, they are constantly evaluating manufacturing locations and thus have developed decision variables that are pertinent to this study. Considering that these firms have no reshoring background, questions particularly relevant to reshoring decision-making were based on the assumption that they can reshore if needed. The interviewees are knowledgeable in global sourcing and issues in manufacturing healthcare products because of their experience working for and with relevant companies as their supply chain partners. The term, reshoring, was occasionally used during the interview process. However, to avoid misinterpretation of the term among interviewees, reshoring was informed as "bringing manufacturing back to home country," consistent with the use of term in this research context.

Reshoring framework in healthcare manufacturing

The nine interviews suggest different considerations for healthcare manufacturing in terms of reshoring decisions. The empirical findings from the interviews suggest our current reshoring model based on the literature to be modified for healthcare manufacturing. Factors such as technology, quality, and regulation are still important concerns firms pay attention to. However, they may not be the determinants for their location decisions.

Quality and regulation

Quality is an important factor in manufacturing process in healthcare industry. Companies in medical devices and pharmaceuticals particularly strive to achieve high quality and deal with continuing safety issues due to its clinical impact on individuals. A majority of the respondents stressed that quality definitely plays an important role impacting a lot on decisions made in manufacturing process. Though achieving high quality in medical products is important, concerns about quality issues do not play a major role in location decisions. Only one interviewee

responded that location matters to quality achievement, for example, because of higher turnover rate of workers, which creates issues of new untrained employees. They experience little quality issues caused by the locational traits. This is the case due to regulatory requirements as well. Quality and regulation issues go hand-in-hand because firms are enforced by government regulations that require compliance with quality system standards. According to World Health Organization (2003), regulations for quality system standards assure the essential quality requirements, and conformity to these standards is verified through direct testing and certification. Especially if you serve international markets, you have to following international standards as well as local requirements. The OEMs, suppliers, and contract manufacturers all follow these standards because their customers While these factors are important in production due to potential safety issues, they do not necessarily affect their location decisions.

Product specialization and customer requirement

Location decision for medical device manufacturing is determined dominantly by product specialization. For example, when production involves high level of customization and specialization or R&D the company maintains their manufacturing in home or high-cost locations (e.g. Sweden, Ireland, etc.). For example, Company E with 26 different manufacturing and service locations, has its prototyping offshored to Sweden. The company also produces a wide range of products to global market, and its manufacturing locations are chosen depending on where they can find suppliers and contract manufacturers that can and are willing to manufacture what the firm needs based on the customer requirements. Especially for the products whose manufacturing ability does not exist in preferred locations, the company has to migrate based on this availability. Company G as a contract manufacturer has manufacturing located in Ireland as one of their manufacturing locations. Despite Ireland is still costly to produce and far from home country, products that are needed by its customers can be developed and made by the company in Ireland. Compared to the regular consumer goods and other high-tech products such as electronics, medical devices and pharmaceuticals manufacturing are highly customer driven. Thus, firms tend to hold less power in terms of location decisions that can be more favorable to them due to limited availability of manufacturers that specialize in products needed. Thus, this implies that reshoring be more attractive if home location has capacity for products in their specialization, which can be driven by customer requirements.

Cost

Cost is still an important factor for location decision, which explains high competition in medical products market. High risk is found in products as well as product development process because of product failures and verification. Thus, a large investment in R&D and increasing cost also impact location decisions. To reduce high cost incurred in product development and validation (and revalidation) process, firms seek for low cost regions. For example, Company E designs and manufactures medical devices. The company operate in India serving the local market as well as in the US. It was able to reduce cost through offshoring R&D to India. However, if reshored to the US, increasing cost from high R&D intensity can be particularly one of the concerns in their relocation decision.

Product complexity and standardization

Healthcare companies in this study manufacture a wide range of products. Their materials, manufacturing process, the number of off-shored production and suppliers varied. Products (especially components, parts, etc.) with low product complexity such as simple tubing or silicone bags are still manufactured in low labor cost regions. These products are also automated for mass production because manufacturing them does not require higher level of manual jobs. However, not all of the interviewed firms with manufacturing can automate their production, and they produce a variety of products, some of which have high complexity in product specifications and technological requirements. When asked about how factors such as quality, regulation, cost, technology, etc. impact location decisions and reshorability, interviewees commonly mentioned that the impact can depend on what type(s) of products. Medical products can be as simple as generic tubes but can be as complicated as diagnostic devices. Thus, complexity and customization occurring in manufacturing processes also impact location decisions.

Opportunities and Challenges of reshoring

The interviewees responded that reshoring could benefit their firms by providing proximity to customers in their home country. Their customer base is located internationally. However, especially because they recognize that United States has the largest healthcare market in the world, US based medical manufacturing companies can benefit from locating closer to market. It allows firms to shorten their lengthy supply chain process and logistics cost. The respondent from Company D particularly addressed that locating the manufacturing facilities in home

location would provide better control for the focal company. If issues occur in manufacturing process, proper and prompt response would be possible when located closer. Furthermore, according to the manager from Company E which manufacture their products in India, customers tend to have better perception about Made-In-USA products. Also, access to skilled workforce is recognized as an opportunity. Reshoring can be beneficial in regard to tariffs. One of the interviewees mentioned that, with their experience manufacturing in China, changes in government policies affected tariffs imposed on their products. If reshored, firms can take advantage of favorable policies and stability in regulations.

However, challenges of reshoring include high market competition and cost that can be higher than offshored regions. Especially for a firm that has offshored not only manufacturing but also R&D process, there is a concern about cost occurring for R&D which can significantly higher when reshored.

Decision factors for reshoring

While interviewed firms recognized that there are benefits and opportunities which can motivate them to move their manufacturing back home. However, they do not necessarily affect them to reshore. For example, if quality issues occur from their suppliers and contract manufacturers, they rather make an effort to improve these issues or look for alternative suppliers that conform quality standards and thus provide better quality products at low prices. Also, the firms are aware of lengthy supply chain from offshoring which results in long lead time to customers. They currently understand that lead time can be shortened through reshoring. However, most of the interviewed firms like many other firms in the same industry serve local customers in the offshored regions and other countries as well as US market. Targeting international customers, benefits of proximity to market in supply chain aspects do not necessarily attract them to reshore. Rather, these firms make sure that customers are informed about the expected lead time. As suggested by the extant literature, offshoring is driven by low labor cost in developing countries. For some of the interviewed firms, labor cost is likely to take up the largest portion of the total expense. While reducing cost in manufacturing process is important to these firms, they did not see it as the main criteria that determines where to locate operations.

With high competition in the market, who can first introduce the new products in the market is important in medical device and pharmaceuticals. In that sense, locating where firms can produce their specialized products can be key to firm performance, which has higher impact on location decision. This result suggests that currently

offshored firms in medical industry sectors are more likely to consider reshoring as a strategic decision when offshored conditions no longer exist than when they see the new conditions that can potentially bring benefits. That is, since their current location decision will change if they cannot satisfy customer-driven requirements in the offshore locations any more.

Based on the discussion, a revised conceptual model for healthcare manufacturing reshoring has been proposed below (see Figure 2). The revised model suggests that product specialization can be a primary factors for location decisions. While other decision factors are considered in the process of offshoring to potential reshoring decisions, they will be also influenced by the level of product complexity and standardization.

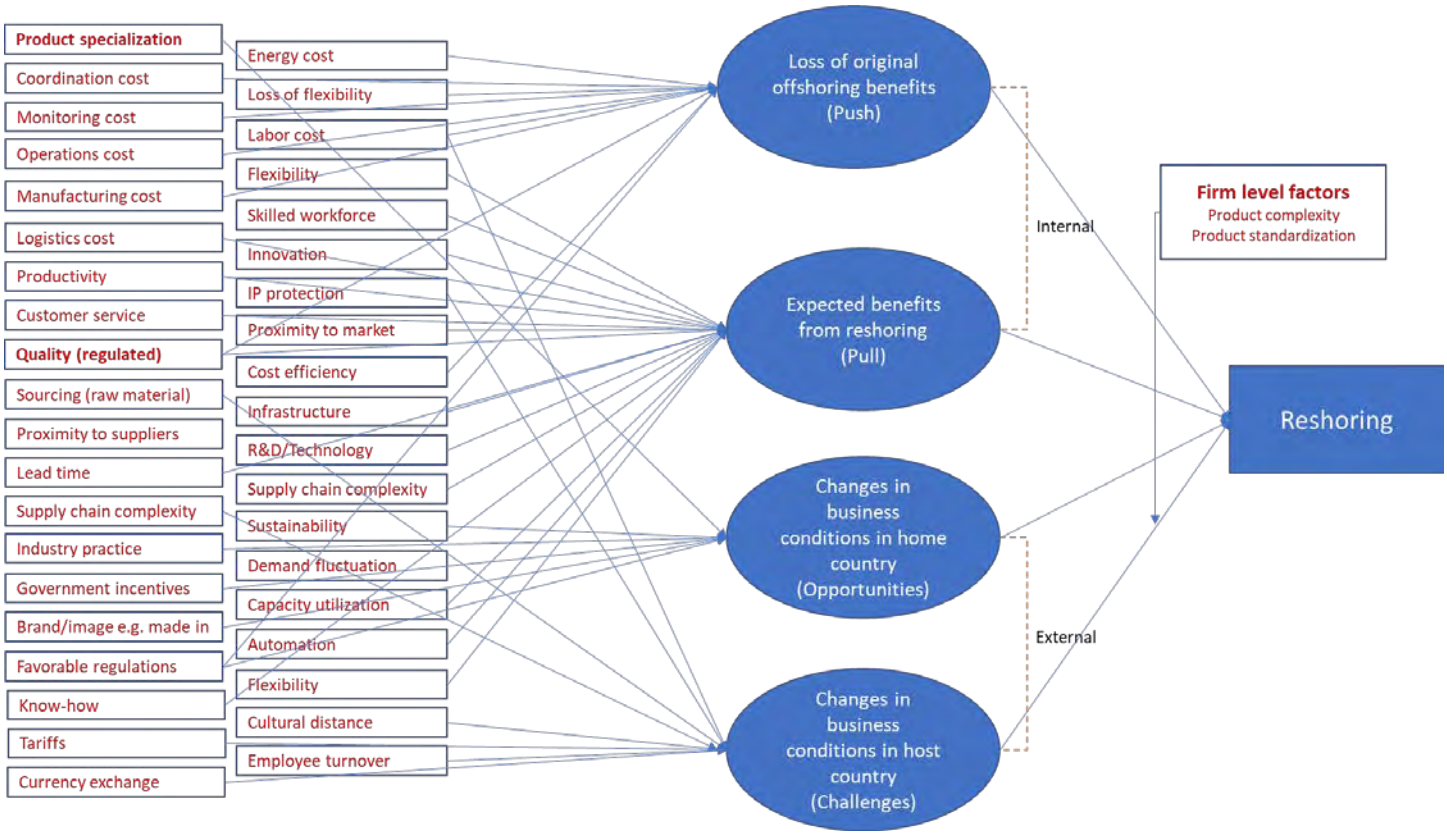

Figure 2. Reshoring model in healthcare manufacturing

Conclusion

The extant reshoring literature have identified a number of motivations in a various industry sectors. Unlike offshoring highly driven by low cost benefit, reshoring motivations are diverse, and thus reshoring involves complexity in decision making. However, while some research on reshoring address the impact of industry on

reshoring motivations and decision, existing reshoring framework has been developed from an "one-size-fits-all" approach in an effort to incorporate all reshoring cases. In this study, the literature review on reshoring and healthcare manufacturing finds that quality, regulation, and technology for high-tech sectors are likely to have more impact on a firm's strategic decision. However, in contrast to what the literature suggests, the empirical findings suggest that these factors are important but are not necessarily important consideration for a firm's location and sourcing decisions. Rather product specialization can be more influential. The contribution of this paper is to better inform the extant reshoring literature how industry and product specific features impact reshoring decisions differently. One limitation of this study is that whether firms are more prone to reshore in the absence of offshoring condition or with more attractive conditions of the home location is not examined. Future study can further examine this relationship through an empirical investigation. Another limitation of this study is seeing reshoring as the only inverse location decision of offshoring. Changes in offshoring conditions and new reshoring conditions influence reshoring decisions. However, they may lead firms to seek for new offshorable locations in practice.

PART2

Survey Methodology

Following the recommendations of Dillman's four-step method (2014) a survey will be developed, piloted, pre-tested and administered to a sample of 200 experts to test the conceptual model. The sampling frame will be the 653 companies in the United States that are associated with an organization in medical device manufacturing. The questionnaire will be developed based on the findings and the conceptual model in Part I. Industrial survey (e.g. Boston Consulting Group) and surveys in the literature in manufacturing and reshoring will be referred in the survey development process. In the beginning of the survey, the definition of reshoring as "moving manufacturing activities back to home country as reverse of offshoring" will be informed to survey respondents to avoid misunderstanding of the term. The first part of the survey will be questions on respondent and firm demographics including work position, work experience, specific industry sectors of the company, firm size, primary customer base, etc. The rest of the survey will focus on verifying the developed conceptual model - how the each factor

considered in their manufacturing process and location decision and ultimately how the factors will affect reshoring decision under two difference circumstances that drive current reshoring decisions.

The questionnaire will be refined through a two-stage pilot-test process. The repetitive pre-testing process will allow to increase the reliability of our survey instrument (Dillman and Bowker 2001). First, it will tested by researchers in academics (professors and doctoral students) in the area of Operations and Supply Chain Management. Based on the pilot test's results, corrections will be made. To further clarify and improve the validity, the revised survey will be tested by a group of business professionals in healthcare manufacturing industry. The final online questionnaire will be distributed using Qualtrics.

The empirical findings from the survey aim to examine the relationship between identified factors in healthcare manufacturing and the firms reshoring decisions or willingness to reshore under two different conditions. The survey will allow for a quantitative evaluation of the factors that are considered in current and future reshoring decisions. The expected survey administration period is January to March, 2019.

Future research directions

In order to understand "how" reshoring decisions are made in the healthcare industry, future study may conduct a series of field studies. For example, field study can be conducted in three companies that manufacture medical devices and pharmaceuticals both in and outside the U.S. These companies were selected because they routinely select manufacturing locations in and outside the U.S., granted access to observe their decision-making process, and allowed interviews with senior/mid-level managers to explain and reflect on what was observed. The studies will be conducted in Medtronics; a medical device manufacturer based out of Massachusetts; Pfizer Pharmaceuticals based in Connecticut; and CVS Health based in Rhode Island. The protocol for the field study will:

1) Allow the researcher to attend strategic or operational planning meetings where manufacturing location decisions are made. These meetings are not currently scheduled and may not be held on a regular basis so the number, duration, and level of access is not currently known. However, issues on their manufacturing location decisions may be addressed in meetings for firms' annual performance reviews

2) Allow the researcher to document the process and conduct follow-up interviews with participants in the meeting to clarify any process and procedures that affect how the decision is made.
3) Allow the researcher to anonymously share the findings with a panel of experts who will assess the data and help classify how the decisions were made.
4) The findings will then be shared with the meeting participants and provide feedback on its accuracy. Revisions will be made and an executive summary will be provided to the senior management of each company.

Appendices

Appendix A. Factors for reshoring decision

Factors	**Authors**
Flexibility	Kinkel & Maloca (2009) Kinkel (2012) Canham & Hamilton (2013)Kinkel (2014) Brennan et al. (2015) Gylling et al. (2015) Fratocchi et al. (2016) Robinson & Hsieh (2016) Stentoft et al. (2016a) Stentoft et al. (2016b)
Quality	Kinkel & Maloca (2009) Kinkel (2012) Canham & Hamilton (2013) Gray et al. (2013) Arlbjorn & Mikkelsen (2014) Bailey & De Propris (2014a) Bailey & De Propris (2014b) Kinkel (2014) Ancarani et al. (2015) Brennan et al. (2015) Gylling et al. (2015) Fratocchi et al. (2016) Joubioux & Vanpouke (2016) Mlody (2016) Moradlou & Backhouse (2016) Presley et al. (2016) Stentoft et al. (2016a) Stentoft et al. (2016b) Zhai et al. (2016)
Coordination cost	Kinkel & Maloca (2009) Kinkel (2012) Canham & Hamilton (2013) Brennan et al. (2015) Mlody (2016) Moradlou & Backhouse (2016) Robinson & Hsieh (2016) Stentoft et al. (2016a)
Infrastructure	Kinkel & Maloca (2009) Brennan et al. (2015) Mlody (2016) Srai & Ane (2016)
Availability of qualified personnel	Kinkel & Maloca (2009) Kinkel (2012) Canham & Hamilton (2013) Kinkel (2014) Tate et al. (2014) Brennan et al. (2015) Fratocchi et al. (2016) Srai & Ane (2016) Stentoft et al. (2016a) White & Borchers (2016) Zhai et al. (2016) Albertoni et al. (2016)
Ability to deliver on time	Kinkel (2012) Canham & Hamilton (2013) Martinez-Mora & Merino (2014) Ancarani et al. (2015) Brennan et al. (2015) Fratocchi et al. (2016)
Labor cost	Kinkel (2012) Canham & Hamilton (2013) Ellarm et al. (2013) Bailey & De Propris (2014a) Kinkel (2014) Tate (2014) Tate et al. (2014) Fratocchi et al. (2016) Mlody (2016) Moradlou & Backhoue (2016) Ocicka (2016) Robinson & Hsieh (2016) Srai & Ane (2016) Stentoft et al. (2016a)White & Borchers (2016) Zhai et al. (2016)
Monitoring cost	Kinkel (2012) Brennan et al. (2015)
Communication cost	Canham & Hamilton (2013) Srai & Ane (2016)
Logistics	Ellarm et al. (2013) Bailey & De Propris (2014b) White & Borchers (2016)
Switching cost	Ellarm et al. (2013) White & Borchers (2016)
Raw material	Ellarm et al. (2013) Srai & Ane (2016) - natural resources White & Borchers (2016)

Country risk (global/political uncertainty, environmental, social/ethical, natural disaster, regulation)	Ellarm et al. (2013) Presley et al. (2016) Srai & Ane (2016) - political stability, natural disaster White & Borchers (2016)
Government trade policies (tax, trade requirements)	Ellarm et al. (2013) Joubioux & Vanpouke (2016) Srai & Ane (2016) - political stability, natural disaster White & Borchers (2016)
Tax rates	Gray et al. (2013) Tate et al. (2014)
Tariffs	Gray et al. (2013) Stentoft at al. (2016a)
Currency exchange	Ellarm et al. (2013) Gray et al. (2013) Bailey & De Propris (2014a) Tate et al. (2014) Joubioux & Vanpouke (2016) Mlody (2016) Moradlou & Backhoue (2016) Ocicka (2016) Srai & Ane (2016) White & Borchers (2016)
Clusters/agglomeration	Gray et al. (2013)
Distance (cultural, psychic, institutional)	Gray et al. (2013) Tate (2014) Mlody (2016) - cultural Robinson & Hsieh (2016) Srai & Ane (2016) - psychic
Lead time	Arlbjorn & Mikkelsen (2014)Tate et al. (2014) Joubioux & Vanpouke (2016) Robinson & Hsieh (2016) Zhai et al. (2016)
Automation	Arlbjorn & Mikkelsen (2014) Tate (2014) Mlody (2016) Srai & Ane (2016) Stentoft et al. (2016a) Stentoft et al. (2016b) Zhai et al. (2016)
Focus on core activities	Arlbjorn & Mikkelsen (2014) Stentoft et al. (2016a)
R&D	Arlbjorn & Mikkelsen (2014) Kinkel (2014) Brennan et al. (2015) Ashby (2016) Joubioux & Vanpouke (2016) Robinson & Hsieh (2016) Srai & Ane (2016) Stentoft et al. (2016a)
Logistics/Transportation cost	Bailey & De Propris (2014a) Kinkel (2014) Tate et al. (2014) Brennan et al. (2015) Fratocchi et al. (2016) Ocicka (2016) Robinson & Hsieh (2016) Srai & Ane (2016) Stentoft et al. (2016a) Zhai et al. (2016)
Supply chain/supply chain resilience	Bailey & De Propris (2014a) Bailey & De Propris (2014b) Joubioux & Vanpouke (2016) Presley et al. (2016) Srai & Ane (2016) Stentoft et al. (2016a) Wiesmann et al. (2017)
Cost (total)	Bailey & De Propris (2014b) Tate (2014) Ancarani et al. (2015) Abbasi (2016) Fratocchi et al. (2016) Ocicka (2016) Robinson & Hsieh (2016) Stentoft et al. (2016b) Zhai et al. (2016) Albertoni et al. (2017) Kim et al. (2017)
Skilled workforce	Bailey & De Propris (2014b) Joubioux & Vanpouke (2016)
Responses to customers	Bailey & De Propris (2014b) Tate (2014)
Technology	Bailey & De Propris (2014b) Gylling et al. (2015) Ocicka (2016) Srai & Ane (2016)
Operations cost	Bailey & De Propris (2014b)
(Customer) services	Bailey & De Propris (2014b) Ancarani et al. (2015) Fratocchi et al. (2016) Srai & Ane (2016)
Innovation	Bailey & De Propris (2014b) Tate (2014) Fratocchi et al. (2016) Joubioux & Vanpouke (2016) Mlody (2016) Robinson & Hsieh (2016) Albertoni et al. (2017)
Turnover	Bailey & De Propris (2014b)
Coordination	Kinkel (2014)
Know-how	Kinkel (2014) Brennan et al. (2015) Srai & Ane (2016) Stentoft et al. (2016a)

Proximity to home	Kinkel (2014)
Increase in domestic production (replenishments)	Martinez-Mora & Merino (2014)
Increase in new products	Martinez-Mora & Merino (2014)
Failure in market	Martinez-Mora & Merino (2014) Foerstl et al. (2016) Albertoni et al. (2017)
CSR	Mezzadri (2014)
Surplus warehouse/manufacturing space	
Productivity	Tate (2014) Mlody (2016) Moradlou & Backhouse (2016) Srai & Ane (2016) Stentoft et al. (2016a)
IP protection (risk)	Tate (2014) Fratocchi et al. (2016) Joubioux & Vanpouke (2016) Mlody (2016) Moradlou & Backhouse (2016) Ocicka (2016) Stentoft et al. (2016a) Zhai et al. (2016)
Shipping requirement	Tate (2014)
Energy cost	Tate (2014)Tate et al. (2014) Moradlou & Backhouse (2016) Ocicka (2016)
Labor cost stability	Tate et al. (2014) White & Borchers (2016)
Transportation availability	Tate et al. (2014) Mlody (2016) Moradlou & Backhouse (2016)
Proximity to customers	Tate et al. (2014) Ancarani et al. (2015) Fratocchi et al. (2016) Mlody (2016) Srai & Ane (2016) Stentoft et al. (2016a)
Made in effect	Ancarani et al. (2015) Fratocchi et al. (2016)Mlody (2016) Stentoft et al. (2016a)
Government incentives	Ancarani et al. (2015) Stentoft et al. (2016a) Zhai et al. (2016)
Capacity utilization	Brennan et al. (2015) Fratocchi et al. (2016)
Import cost	Gylling et al. (2015)
Production cost	Gylling et al. (2015) Mlody (2016)
Cost competitiveness	Gylling et al. (2015)
Demand fluctuation/volatility (seasonality)	Gylling et al. (2015) Stentoft et al. (2016a)
Sourcing risk	Gylling et al. (2015)
Training contract manufacturers	Gylling et al. (2015)
Growth of local economy	Ashby (2016)
Proximity to supplier	Ashby (2016)
Environmental uncertainty	Forestl et al. (2016)
Relational issues	Forestl et al. (2016)
Asset specificity	Forestl et al. (2016)
Reorganization	

Cost efficiency	Fratocchi et al. (2016)
Termination of supply relationships	Fratocchi et al. (2016)
Minimum order size	Fratocchi et al. (2016)
Control complexity	Fratocchi et al. (2016) Zhai et al (2016)
Subsides for relocation	Fratocchi et al. (2016)
Lack of local market attractiveness	Fratocchi et al. (2016)
Counterfeiting	Fratocchi et al. (2016)
Absence of local suppliers	Fratocchi et al. (2016)
Customer duties for re-import	Fratocchi et al. (2016)
Unions' pressure at the home country	Fratocchi et al. (2016)
Adaptation to customer needs & reliability	Joubioux & Vanpouke (2016)
Competitive advantage	Joubioux & Vanpouke (2016)
Unbeneficial legal-administrative conditions	Mlody (2016)
Investment incentives	Mlody (2016)
Proximity to market	Mlody (2016) Srai & Ane (2016)
Control cost	Mlody (2016) Robinson & Hsieh (2016)
Supply chain risk	Mlody (2016) Stentoft et al. (2016a) White & Bochers (2016)
Inventory	Moradlou & Backhouse (2016) Srai & Ane (2016) Zhai et al. (2016)
(extra) Management	Moradlou & Backhouse (2016) Stentoft et al. (2016b)
Travel cost	Moradlou & Backhouse (2016)
Environmental legislations	Moradlou & Backhouse (2016)
Communication	Moradlou & Backhouse (2016)
(Inter) cultural difference	Moradlou & Backhouse (2016)
Language barrier	Moradlou & Backhouse (2016)
Supply chain relationship	Ocicka (2016)
Environmental concern	Ocicka (2016) Presley et al. (2016) Srai & Ane (2016) Zhai et al. (2016)
Lean supply chain	Ocicka (2016)
Supply chain disruption	Ocicka (2016)
NPV	Presley et al. (2016)
Company share value	Presley et al. (2016)

Coordination	Presley et al. (2016)
Reputation/image/brand	Presley et al. (2016) Zhai et al. (2016)
Local incentives	
Relationships/network	Srai & Ane (2016)
Economies of scale	Srai & Ane (2016)
Security	Srai & Ane (2016) Stentoft et al. (2016b)
Contract terms	Srai & Ane (2016)
Raw material cost	Srai & Ane (2016)
Administrative cost	Srai & Ane (2016)
Product development	Srai & Ane (2016)
Downsizing and rationalization	Srai & Ane (2016)
Hidden cost	Srai & Ane (2016)
Vertical integration	Srai & Ane (2016)
Location branding for traceability of the product	Srai & Ane (2016)
Location branding for quality image	Srai & Ane (2016)
Location branding for local social impact	Srai & Ane (2016)
Better traceability of products	Srai & Ane (2016)
Actual cost	Stentoft et al. (2016a)
Production and delivery reliability	Stentoft et al. (2016a)
Shrinking market size	Stentoft et al. (2016a)
Patriotism/loyalty	Stentoft et al. (2016a)
Correction of misjudged decision	Stentoft et al. (2016a)
Bureaucracy	Stentoft et al. (2016b)
Production basis	Stentoft et al. (2016b)
Strategic access	White & Borchers (2016)
Response to demand	Zhai et al. (2016)
Lean manufacturing	Zhai et al. (2016)
Firm specific locational advantage	Delis et al. (2017)
Global competition	Wiesmann et al. (2017)

Appendix B. Interview questions

1) Background (Job title)

2) Company background (industry, primary products/services, etc.)

3) What are the distinct characteristics of products – medical devices (in manufacturing process) compared to other industry sectors (e.g. automotive, etc.)?

4) How do quality, regulation and technology impact decisions made in manufacturing these products?

4-1) what regulation does your firm have to particularly deal with?

5) What are other factors which affect medical device manufacturing How are these factors are prioritized?

6) What are the roles of these factors in manufacturing location decision making?

7) What are the factors that are considered the most and least important in this decision and why?

8) How does manufacturing location impact on product/firm performance?

9) If currently offshored, what can be the primary strength and weaknesses & opportunities and challenges? If not, what are the primary opportunities and challenges in home location?

10) What are/would be the main criteria or factors that affect location decision of your firms?

Appendix C. Literature by industry sectors

Industry	Food products, beverages and tobacco	Textile, textile products, leather and leather products	Wood and wood products	Pulp, paper and paper products	Publishing and printing	Chemicals, chemical products and man-made fibers	Rubber and plastics	Other non-metallic mineral products	Basic metals and fabricated metal products	Machinery and equipment n.e.c.
Kinkel & Maloca (2009)	v	v	v	v	v	v	v	v	v	v
Kinkel (2012)	v	v	v	v	v	v	v	v	v	v
Canham & Hamilton (2013)										
Ellarm 2013	n/a									
Ellram et al. (2013)	n/a									
Gray et al. (2013)	n/a									
Arlbjorn & Mikkelsen (2014)	n/a									
Bailey & De Propris (2014a)										
Bailey & De Propris (2014b)										
Fratocchi et al. (2014)	n/a									
Kinkel (2014)									v	
Martinez-Mora & Merino (2014)		v								
Mezzadri (2014)		v								
Tate (2014)	n/a									
Tate et al. (2014)	v	v				v				v
Ancarani et al. (2015)										
Brennan et al. (2015)										v
Grappi et al. (2015)	n/a									
Gylling et al. (2015)										
Abbasi (2016)		v								
Ashby (2016)		v								
Foerstl et al. (2016)	n/a									
Fratocchi et al. (2016)	v	v								
Joubioux & Vanpouke (2016)										
Lavissiere et al. (2016)	n/a									
Mlody (2016)	n/a									
Moradlou & Backhouse (2016)	n/a									
Ocicka (2016)		v				v				
Presley et al. (2016)	n/a									
Robinson & Hsieh (2016)		v								
Srai & Ane (2016)	n/a									
Stentoft et al. (2016a)										
Stentoft et al. (2016b)	n/a									
White & Borchers (2016)	n/a									
Zhai et al. (2016)	v	v	v			v		v	v	
Albertoni et al. (2017)										
Barbieri and Stentoft (2016)	n/a									
Brandon-Jones et al. (2017)		v			v	v	v			v
Chen & Hu (2017)	n/a									
Delis et al. (2017)	v	v	v	v	v	v	v	v	v	v
Gray et al. (2017)		v							v	
Hartman et al. (2017)	n/a									
Kim et al. (2017)	v	v	v						v	v
Tate and Bals (2017)	n/a									
Wiesmann et al. (2017)	n/a									
Baraldi et al. (2018)		v								
Grappi et al. (2018)	n/a									
Heikkila et al. (2018)	v	v	v	v		v	v	v		v
Johansson & Olhager (2018)	v		v	v		v	v		v	v
Johansson et al. (2018)	v		v	v		v	v	v	v	v
Stentoft et al. (2018)	n/a									
Vanchan et al. (2018)	v	v	v				v	v	v	

Electrical machinery and apparatus n.e.c.	Office machinery, computers and communication	Medical, precision and optical instruments, etc.	Transport equipment	Furniture; manufacturing n.e.c.; recycling	Consumer goods	Industrial goods	Automotive	Aerospace and defense	Pharma and biotech	Services
v	v	v	v	v						
v	v	v	v	v						
					v	v				
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v			v	v					v	
			v							
v	v		v							
		v	v	v			v		v	
v	v						v			
v	v	v	v				v			
	v		v							v

	Construction	Others	Biomedical/medical	Electronics	Mechanical	Home appliances	Toys	Measuring, analyzing, controlling instruments	Repair and installation of machinery and	Hobbies

21	Tobacco Products
22	Textile Mill Products
23	Apparel and other Finished Products Made from Fabrics and Similar Materials
24	Lumber and Wood Products, except Furniture
25	Furniture and Fixtures
26	Paper and Allied Products
27	Printing, Publishing, and Allied Industries
28	Chemicals and Allied Products
29	Petroleum Refining and Related Industries
30	Rubber and Miscellaneous Plastics Products
31	Leather and Leather Products
32	Stone, Clay, Glass, and Concrete Products
33	Primary Metal Industries
34	Fabricated Metal Products, except Machinery and Transportation Equipment
35	Industrial and Commercial Machinery and Computer Equipment
36	Electronic and other Electrical Equipment and Components, except Computer Equipment
37	Transportation Equipment
38	Measuring, Analyzing, and Controlling Instruments; Photographic, Medical and Optical Goods; Watches and Clocks
39	Miscellaneous Manufacturing Industries

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SUPPLY CHAIN MANAGEMENT AND LOGISTICS - PAPERS

Manuscript Submission
2019 Northeast Decision Sciences Institute Conference, April 4-6
Philadelphia, PA

Artificial Intelligence and Supply Chain Management−Applications and Challenges

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ABSTRACT

Organizations that successfully integrate AI into their supply chains can increase their operational efficiency, make decisions that are more informed, and create higher value at the enterprise level as AI can augment existing processes and skills. AI can provide a platform for enhanced demand, logistics, transportation, and supplier management, making key functions more predictive and valuable than before. However, challenges remain to realizing these benefits. AI can face resistance, be costly, need skilled personnel that may be difficult to find and retain for all but the industry giants. More importantly, making a business case for AI, including determining return on investment, may not be easy especially for smaller supply chain actors. To overcome some of these challenges requires organizations to have a clear AI strategy, build top management support and a trusting environment around AI to dampen any resistance to a technology that is at times controversial. Starting AI integration slowly with modest goals and readily measurable outcomes within some function or department, before an enterprise wide adoption may provide a learning opportunity and increase the chances of its success. AI should become a source of competitive advantage to merit the investment in people and resources that it requires.

KEYWORDS: Artificial intelligence, machine learning, supply chain management, technology integration, disruptive technology

1. Artificial intelligence (AI) as a digital disruptor

The late acclaimed theoretical physicist Stephen Hawking said "Every aspect of our lives will be transformed by artificial intelligence," and AI could be "the biggest event in the history of our civilization." While we must await the fullness of time to see if developments will indeed prove Hawking right, it is generally accepted today that AI has become one of the most disruptive digital technologies of our time. AI encompasses the wide-ranging tools that enable people to rethink how we integrate information, analyze data, and use the resulting insights to improve decision-making (West and Allen, 2018). An AI system combines, and utilizes mainly machine learning and other types of data analytics methods to achieve artificial intelligence capabilities (van Duin and Bakhshi, 2017).

A 2017 McKinsey Global Report on AI noted that AI "is poised to unleash the next wave of digital disruption" and companies should prepare for it, since early adopters have achieved higher profit margins and the gap with non-adopters is expected to widen (Bughin et. al 2017). The McKinsey Report estimated that tech giants such as Google and Baidu spent some US$20 to US$30 billion on AI in 2017, of which 90 per cent was on research and development and the rest on acquisitions of intellectual properties or companies. A project undertaken by Price Waterhouse Coopers (2017) estimated that "artificial intelligence technologies could increase global GDP by $15.7 trillion, and a full 14%, by 2030." Global giants such as Amazon, Siemens, Alibaba and Apple are already integrating elements of AI into their products. These early indicators notwithstanding, universal adoption of AI seems to be lagging behind the promise. For example, a study by Deloitte showed that when 1,500 senior business leaders in the United States in 2017 were asked about AI, only 17 percent said they were familiar with it. A number of them were not sure what it was or how it would affect their particular companies. Although the executives

understood there was considerable potential for AI to alter business processes, they still were not clear how AI could be deployed within their own organizations (Davenport, Loucks and Schatsky, 2017). In general, AI use in business appears to be rather low for good reason: by now, executives are used to hearing about the next big hype that fizzles when the reality fails to match the hype. AI may sound esoteric to all but the tech-savvy executive, and some companies may not be aware of its benefits at this time. More importantly, established companies are generally slow or reluctant to adopt new, disruptive technologies (Christensen, 1995).

Despite any misgivings, executives would do well to take a serious look at AI considering its immense potential. One area where AI may be particularly useful is in the area of supply chain management (SCM). We focus on AI use in SCM in this paper because the available preliminary research indicates that SCM, specifically retail and logistics are one of the most important areas where AI can create value (McKinsey, 2017; Chui et al. 2018a). For example, Chui et al. (2018) report that AI can improve performance beyond that provided by other analytical techniques in 89% of cases in transport and logistics and in 87% of cases in retail. The authors report that AI has the potential to create $400-$500 billion in retail, about the same value in transport and logistics, noting that AI has the potential to improve forecasting accuracy by 10 to 20 percent, which translates into a potential 5 percent reduction in inventory costs and revenue increases of 2 to 3 percent. Clearly, AI has the potential for value creation when integrated into SCM. The low rate of AI adoption in SCM may be, in part, because executives do not yet know much about its potential to create value in SCM. More importantly, AI integration into SCM has challenges that organizations need to overcome. Building a knowledge base of these and related issues may be helpful and this paper fills some of the existing gap. The paper is organized as follows: The next section presents the promise of AI. This is followed by the section on the challenges of AI

integration. The section after that presents some guidelines and the final section presents some concluding remarks.

AI has the potential to increase value creation in demand forecasting, management, customer service, and inter-partner coordination to mention a few. However, there are key challenges that organizations need to overcome if the benefits of AI integration into SCM is to be realized. Some key challenges include how to integrate AI into existing systems and processes, understanding the complex technology of AI and the technical and economic resources required to acquire the technology. For example, Ng (2017) reports that despite a promising future, adoption of artificial intelligence (AI) in consumer goods manufacturing and supply chain management has been much slower than in the technology, retailing and financial services sectors due to a lack of data for analytic tools to work on. We explore these and related issues and offer some guidelines for firms desirous of integrating AI into their supply chains in the sections that follow.

2. Artificial Intelligence: A Definition

It is not always easy to define a concept as broadly used as AI. Yet, this is may be one time where a clear definition would help. AI is a poorly understood concept with opinion surveys showing that even top business leaders lack a detailed sense of AI resulting people confusing AI with super-powered robots or hyper-intelligent devices. According to West and Allen (2018), the lack of clarity around the term enables technology pessimists to warn AI will conquer humans, suppress individual freedom, and destroy personal privacy.

There is no universally accepted definition of AI. The Merriam-Webster defines artificial intelligence as (1) A branch of computer science dealing with the simulation of intelligent behavior in computers and (2) The capability of a machine to imitate intelligent human behavior. Marr (2018) observes that definitions of artificial intelligence begins to shift based upon the goals that

people are trying to be achieved with an AI system. For example, Amazon defines AI as "the field of computer science dedicated to solving cognitive problems commonly associated with human intelligence, such as learning, problem solving, and pattern recognition." Machine learning forms the basis of most AI, but it is not the same thing as AI. For example, as Marr (2018) observes, a machine-learning algorithms will never understand what it was trained to do: ML may be able to identify spam, but it will not know what spam is or understand why we want it to be identified. More importantly, unless someone (humans) re-trains the algorithm, it will probably not be able to identify if a new sort of spam emerges.

Marr (2018) observes that people generally invest in AI development for one of these three objectives: (1) Build systems that think exactly like humans do ("strong AI"), (2) Just get systems to work without figuring out how human reasoning works ("weak AI") and (3) Use human reasoning as a model but not necessarily the end goal. According to Marr (2018), the bulk of the AI development happening today by industry leaders falls under the third objective and uses human reasoning as a guide to provide better services or create better products rather trying to achieve a perfect replica of the human mind. AI can be broken into two components: augmentation (AI, which assists humans with their day-to-day tasks, personally or commercially without having complete control of the output) and automation (AI, which works completely autonomously in any field without the need for any human intervention e.g. robots performing key process steps in manufacturing plants). A distinction is sometimes made between narrow, general and super AI. According to Van Duin and Bakhshi (2017) virtually all current AI falls in the narrow category, meaning it can only do what it is designed to do. This means that for every problem, a specific algorithm needs to be designed to solve it. Narrow AIs are mostly much better than humans at the task they were made for: for example look at face recognition, chess computers, calculus, and

translation. Google Assistant, Google Translate, Siri and other natural language processing tools are examples of Narrow AI. While useful, these systems lack the self-awareness, consciousness, and genuine intelligence to match human intelligence. In other words, they cannot think for themselves. The most useful AI is a general AI, a single system that can learn and then solve any problem people present it. Super AI is associated with machines that are an order of magnitude smarter than humans are (Jajal, 2018).

West and Allen (2018) suggest that three qualities of AI, their capacity to operate in an intentional, intelligent, and adaptive manner makes them useful to industry. First, AI algorithms are designed to make decisions, often using real-time data, going up and above what passive machines giving mechanical or predetermined responses can do. AI uses sensors, digital data, or remote inputs and combine information from a variety of different sources, analyze the material instantly, and act on the insights derived from those data. Combining improvements in storage systems, processing speeds, and analytic techniques, AI are capable of tremendous sophistication in analysis and decision-making. Second, AI combines machine learning and data analytics. As long as the data are sufficiently robust that algorithms can discern useful patterns, machine learning can take the data and look for underlying trends, no matter whether the data comes in the form of digital information, satellite imagery, visual information, text, or unstructured data. If AI spots something that is relevant for a practical problem, software designers can take that knowledge and use it to analyze specific issues. Finally, AI systems have the ability to learn and adapt as they make decisions. Semi-autonomous vehicles may be a good example of AI's capacity to adapt. SAVs can take advantage of the experience of other vehicles on the road, without human involvement, and the entire corpus of their achieved "experience" is immediately and fully

transferable to other similarly configured vehicles. In the case of fully autonomous vehicles, advanced systems can completely control the car or truck, and make all the navigational decisions.

3. The promise of AI for supply chain management

Supply chains have become the backbone of the global economy partly accounting for the rapid growth of such giant conglomerates like Walmart and Amazon, to name just a few (Van der Vegt et al. 2015). Despite their importance, supply chains are subject to disruption, face substantial risk, and their management has not always been easy (Christopher and Peck 2004). Developing robust and resilient supply chains is one way of enhancing supply chain performance (Sheffi, 2007) and AI, including machine learning, may play an important role in this respect. This section of the paper explores some specific areas where AI can create value in SCM.

3.1. Streamlining procurement

The process of procurement involves buying raw materials or finished goods and shipping the materials or goods to the desired demand location. The procurement process involves several levels of complexities such as agreeing and delivering on the product or raw material or service, including consideration of the price, quantity, quality, and delivery time. Procurement within supply chain focuses on agreeing on terms and conditions with a third party on the acquisition of goods and services.

Procurement is a strategic function in organizations because organizations spend substantially on purchasing of goods and services (Presutti, 2003). However, traditional procurement systems are known to be complex and inefficient. Lee et al. (2009) argued that the drawbacks of current procurement practices include a lack of coordination and proactivity between buyers and suppliers. In addition, the lack of automation and intelligent advice tools makes the

procurement of suitable suppliers and assessing supplier performance in a timely manner difficult. Some of the most popular tools currently used for procurement are Enterprise Resource Planning (ERP) systems such as System Application Product (SAP) and E-Procure systems. While these systems provide some level of flexibility and solution, their biggest drawback is the lack of transferability and the need for developing a customized edition for each supply chain entity that needs to use it. Organizations may be moving to using technology to overcome some of the existing challenges. For example, some organizations have used Intelligent Agent Technology for managing the procurement process. Agents were able to track demand, reduce the bullwhip effect, discover complex scenarios, and adapt to the fluctuation of the supply chain environment (Kimbrough et al., 2002). Advanced technology, specifically AI, an improvement on intelligent systems, can assist human purchasers in identifying suppliers, search materials, and prepare purchase orders. AI overcomes the transferability problem with current systems because it provides a quicker and more efficient way for searching for data, uses improved algorithms for faster computations, provide unique set of data computations, and a quicker adaptability window with data transfer from one system to the other (Emil and Mărăcine, 2015).

AI can help in the early detection of supply chain disruption and awareness, help compliance issues, and manage quality challenges. In a recent study by Gartner, usage of AI tools in procurement assisted in alerting the enterprise and suppliers to supply chain disruption by approximately 44%, recognizing and flagging supplier compliance issues by 39%, and quickly identifying instances of fraud by 37% (McCrea, 2018). Some of the specific AI tools that can assist in this include cognitive procurement advisors (CPAs), virtual personal assistants (VPAs), the use of natural-language processing (NLP) and natural-language generation (NLG) to increase the speed of procurement and ease of doing business. Agents were able to track demand, reduce the

bullwhip effect, discover complex scenarios, and adapt to the fluctuation of the supply chain environment (Kimbrough et al. 2002).

Smith (2016) suggest that AI powered Chabots (A chatbot also known as a talkbot is a computer program which conducts a conversation via auditory or textual methods) can play an important role in procurement. According to Smith (2016), the impact of Chabots on the world of procurement would be important as their use will take away many of the mundane, routine parts of the job and leave the interesting strategic bits that humans are uniquely equipped to deal with. Bots will handle low value transactions and handle the paperwork, sending orders, chasing orders, dealing with invoices and payments. In other cases, bots enabled information will flow to the buyer so that if raw materials prices fall, the bot will inform the buyer and start the conversation with the supplier for a change in pricing and bots running e-auctions on a regular basis with little or no human interaction can handle all pricing issues. Smith (2016) suggests that an organization and supplier bots can handle most of these transactions without human interaction leading to lower costs both internally and with supplier firms. Some firms are already using AI for procurement. For example, the Hyatt Regency Riverfront in Jacksonville, FL, USA, is a pioneer adopter of AI. The hotel is now able to forecast the demand for food and beverage and to generate spontaneous staffing schedules with superhuman accuracy. The Pan Pacific in San Francisco, CA, was on track to save an estimated 4 per cent of labor cost during the first year of AI implementation. The hotel achieved a daily overall average restaurant accuracy of 90 per cent, with a similar accuracy being achieved for room service and banquet forecasting, allowing the hotel to staff appropriately and reduce costs (Hotel News Wire, 2018). Organizations such as Walmart, Amazon, Google and other strategic buying companies are also currently using AI procurement tools to modernize their procurement process (Turban et al. 2017).

3.2. Supply chain planning

Effective structures and planning tools for demand and supply chain planning (DSCP) are basic requirements for coordinating thousands of individual decisions in supply chain and customer management (Hubner, Kuhn and Sternbeck, 2013). A failure to align demand and supply plans leads to logistical issues. For example, the increasing competitive retail business requires ever-greater customer orientation and operational efficiencies and demand/supply planning is becoming more critical as consumer expectations rise, and competition increases. Accurate forecasting, supply flexibility, and efficient inventory stockpiling are all parts of demand and supply planning. Forecasting and inventory management pose key challenges to supply chains. In supply chains, each member (i) forecasts the demand of its customer, the supply chain member (i+1) that follows it, who, in time, forecasts the demand of member (i+2) and so on until reaching the forecast of the demand of the final link, the final customer. Forecasting is not an exact science, but rather a combination of mathematical calculations based on past observations and judgement from the decision maker. Qualitative forecasting is based on an expert's judgment or group decision-making while in quantitative forecasting, the decision maker uses different methods to assign weights to past observations. Clearly, it is not easy to coordinate forecasting across the supply chain, as errors in forecasting in the supply chain will be magnified, a phenomenon known as the bullwhip effect.

Technology such as decision support systems (DSSs) have been used for individual planning problems. However, the clear focus lies on isolated planning issues rather than on an integrated planning perspective that takes into account interdependencies between individual problems (Fisher and Raman, 2010). Tools that foster better coordination between strategic partners and help forecasting would therefore be useful and this is where AI comes in. AI can help in demand and supply planning in several ways. First, machine learning can help with forecasting

inventory, demand and supply. If integrated with SCM tools, ML could revolutionize the agility and optimization of supply chain decision-making (Kodiak Rating Community, 2017). Second, AI helps in big data analysis as forecasting engines with machine learning can look to see which combination of algorithms and data streams has the most predictive power for different forecasting hierarches (Forbes, 2017). Finally, AI can enable forecasting based on the underlying casual drivers of demand rather than on the more traditional, and less trusted inputs based on previous outcomes, thereby improving forecasting accuracy by 10-20 %, which translates into a 5% reduction in inventory costs and revenue increases of 2-3% (Chui et al. 2018). One example of the utilization of AI for forecasting is what happens in the Ann Arbor-based firm, Llamasoft. The company uses Demand Guru, a form of machine learning to identify hidden patterns such as seasonal demand, and Data Cube, a program that uses a collection of curated weather and economic time-series databases to recognize cause and effect relationships for predicting future demand (www.llamasoft.com). Another example of AI application in SCM is Aera Technology that uses a platform for supply chain demand planning in collaboration with Merck pharmaceuticals (Castellanos, 2018). Other notable applications of AI technology helping in customer demand management already exist. For example, Netflix uses AI to provide highly accurate predictive technology based on customers' reactions to films. Amazon.com uses Amazons' transactional A.I. to predict what customers are interested in.

3.3. AI and warehouse management

The effectiveness of supply chain planning depends a lot on proper warehouse and inventory-based management (Kodiak Rating Community, 2017). Warehousing, the temporary storage of goods, was estimated to cost $126 billons in 2012, accounting for 15% of the overall cost of transportation in the US (Jacob and Chase, 2018). The use of AI can bring efficiency and cost

savings to warehouse management in several respects. First, AI can help the development of lean warehousing (Jacob and Chase, 2018). The use of machine learning and AI can help reduce waste by optimizing material retrieving, minimizing shipping errors, and a reduction in shipping defective material by early detection in the retrieval process. Robots can help with routing, consolidating, cross-docking, redirecting shipments, and optimizing warehouse management decisions. Second, ML and forecasting engines are able to use algorithms and data streams to make predictions, which helps warehouse management (Marr, 2017). Machine learning allows organizations to collect data on inventory – origins, transit routes, times when inventory is scanned or its location and status by applying RF (Radio Frequency) tags (Marr, 2017). Third, AI can greatly enhance customer support within the warehouse environment. The industry research firm, Gartner, predicts that by 2020, the majority of commercial interactions will take place between customers and virtual agents (www.gartner.com). The use of chatbots and other virtual agents can be highly effective for automating low-level customer service inquiries. Autodesk, a global leader in computer aided design and engineering software, has been immensely successful in this endeavor. Using the IBM Watson Conversation service, the company built the Autodesk Virtual Agent (AVA) which is able to answer 40 unique low-level queries at a rate of 30,000 interactions per month and cuts response time to customer inquiries from 1.5 days to 5 minutes, or just about a 99% reduction (Gesing, Peterson and Michelsen, 2018). Finally, AI has enabled automated guided vehicles (AGVs) to use automated material handling across traditional manufacturing boundaries by moving between buildings. Today's AGVs have the potential of being made relatively more autonomous by integrating them with data from existing warehouse management and control systems through a connecting software layer called warehouse execution systems (Bharadwaj, 2018). Several organizations are already using AI to enhance their warehouse

operations. For example, Procter and Gamble, Pfizer, and Wal-Mart are using Warehouse Management Systems (WMS) with state of the art technologies that include voice-activated receiving and packaging instructions. The Gap is using technology provided by Kindred AI to speed up assembly of e-commerce orders with robots using reinforcement learning and deep learning (Vanian, 2017). De Jesus (2018) reports that European retailers are using AI software across three applications: inventory management, visual search and sales. AI can seamlessly connect supply, demand, storage and transportation of materials, with high speed and high efficiency, leading to low cost advantages for the players.

3.4. Logistics and Shipping

Transportation and logistics are essential functional areas for any organization that stores goods and moves these goods from one location (source) to the other (destination). While transportation is concerned with the movement of goods from a source to a destination location, logistics refers to all the entities that are involved in transporting goods and services as well as the physical facilities such as the warehouses, distribution centers, and other outlets that store these goods and services.

Apart from purchasing, transportation is the next most substantial cost component in supply chain management. For example in 2014, the total cost of US logistics was estimated at $1.449 trillion and 62.6% of that spending was transportation-related costs (Gilmore, 2015). This situation is likely to worsen considering the rise in fuel prices and supply chain actors often employ any cost-saving strategies they can use to reduce cost. Organizations typically use distance measurement as a way of determining the most efficient routes. AI improves on distance measurement methods and thereby saves costs. In AI transportation application, very advanced techniques are used for transportation distance calculations. Using specialized algorithms called the Linked Chain Method; AI systems are able to minimize the distance traveled and transportation costs (Tokgoz et al. 2015).

Active RFIDs (Radio-frequency identification) use AI techniques in helping to track transportation routes and distances. For example, Walmart uses Active RFID tags to determine the locations of their trucks, giving the firm the ability to provide real time feedback to its retail outlets, as well as the ability to forecast for, fulfil any Vendor Managed Inventory (VMI) agreement with suppliers, and be on top of their Collaborative Forecasting, Planning and Replenishment (CFPR) strategies. Eventually autonomous driving vehicles may become a usable technology, overcoming human weaknesses and making deliveries.

3.5. Managing supplier selection and coordination

Supplier selection is the process of selecting a supplier to acquire the necessary materials (typically raw materials, maintenance repair and supplies) to support the processing of product outputs for organizations. Selection of the best and/or the most suitable supplier is based on assessing supplier capabilities (Shih et al. 2007). Supplier coordination on the other hand looks at streamlining all the flow of such as raw materials, finished goods, information, communication and financials across the supply chain (Chang et al. 2006). In a typical supplier selection and coordinating environment, firms decide to choose the right supplier by going through a list of guidelines that includes, but not limited to price lists, value for money, quality, reliability, service Ting and Cho (2008). The ability to weigh up the priorities of such importance is one of the topmost priority lists for most strategic buyers. However, there are complexities and challenges associated with the supplier selection process. Some of these challenges include determining the optimal selection criteria, replication of good supplier selection process, building a creative and effective team to manage the process, etc. These challenges are sometimes difficult to manage through regular quantitative and qualitative techniques (Deswal and Garg, 2015). AI can use Fuzzy Logic and other advanced forms of data gathering through conventional and unconventional means

to aid decision-making during supplier selection. AI improves on the selection process because it is capable of using advanced levels of abstractions, larger and more complex data models, more complex algorithms and lots more data to feed the system. Algorithms can learn from the data itself to improve the results and even uncover opportunities for the company. Both Nestle and Unilever have adopted this method in dealing with their supplier selection. According to Smith (2016), chatbot can find suppliers for you by doing market research, asking questions of the suppliers and build a shortlist, and monitoring their performance management. This selection should be easy as bots will run and score tenders and all managers have to do is approve the selections. In addition, AI will help evaluate whether the organization is reaching its targets using Key Performance Indicators (KPIs). KPIs are measurable values that demonstrates how effectively a company is achieving key business objectives. AI will then highlight performance issues to the relevant staff. Logistics companies depend on networks that must function well with high volumes and time-sensitive deadlines and AI offers logistics companies the ability to optimize network orchestration to degrees of efficiency that cannot be achieved with human thinking alone (Gesing, Peterson and Michelsen, 2018).

4. Challenges of AI use in supply chain management

AI is a complex technology and therefore its integration can pose several challenges. Exploring these challenges can give us some clues on how to implement AI to realize its promise and existing research on new technology adoption can help our understanding of some of these challenges.

4.1. Stakeholder resistance to AI integration

The fear that machines will replace human labor has been with us from the time of the Luddites (textiles workers who protested against automation) in the early 19th century. Such fears may be genuine and

organizations cannot underestimate possible resistance to AI introduction from some internal stakeholders as "innovation assassins" may be lurking everywhere. Covert and overt legitimate resistance to the introduction of new technology may be a fact of organizational life. In fact, stakeholder resistance to new technology is a well-known phenomenon (Howell and Higgins, 1990). This is especially likely to be the case with AI as there are legitimate, but perhaps exaggerated, fears that AI may replace people. For example, an Oxford University study predicted 47% of jobs could be automated by 2033 and the 2017 McKinsey's research estimated AI-driven job losses at 5%". According to Leonard-Burton and Kraus (1985), resistance to a new technology often arises because of stakeholder perception that the technology is either not for their benefit or for fear of loss of position with the introduction of a new technology. Resistance can either be benign or grow into sabotage, often taking the technology sponsors by surprise. These challenges may exist for AI integration for a number of reasons.

First, employees may resist AI because of the fear that they will lose their positions. There is little doubt that AI will lead to some job losses. However, history teaches us that fears and concerns regarding AI and automation are understandable, but may be ultimately unwarranted. Technological change may eliminate specific jobs, but it has always created more in the process. (McClelland, 2018). AI and automation can eliminate drudgery and free people to pursue careers that give them a greater sense of meaning, and greater job satisfaction. In the end, AI may create more jobs than it causes us to lose (McClelland, 2018). More importantly, if the past is any predictor of the future, we know that machines will not completely replace humans and the dire predictions today will prove unfounded just like those of the Luddites during the Industrial Revolution. Indeed, AI may actually open up new vistas for industrialization. Second, resistance may come because of the fear that AI will lead to a loss of control that some people have. For

example, chatbots may render customer service personnel, including their supervisors, less useful and that could cause resentment in some cases. Finally, people may look at the technology and decide that it does not give them any direct benefits, even if it allows the organization to create value. The potential benefits and rewards of AI may not be readily apparent to everyone in the organization. The fact is AI may actually eliminate some positions, reduce visibility of others and yet create greater value for the organization overall.

4.2. The challenge of building a trusting environment

Introducing a new technology involves behavior change and change implementation is unlikely to succeed unless internal stakeholders support the initiative, therefore building a trusting environment is important. In a collaborative study by DHL and IBM on the use of AI in logistics, Gesing, Peterson and Michelsen, (2018) note that it is very important for organizations introducing AI to build trust within the organization. According to the authors, a deep understanding of organizational attitudes towards AI is necessary especially because of fear over potential job loss through automation. The potential impact of AI on society has generated significant debate and there may be legitimate fears on the part of some employees that AI will replace them. Indeed, even some notable proponents of AI themselves have expressed reservations about the potential negative consequences of AI. Voices of caution include that of Stephen Hawking who is reported to have said that the “development of full artificial intelligence could spell the end of the human race.” Elon Musk, CEO of Tesla, despite already integrating AI into his firm’s cars is another voice of caution. There are also some positive voices. Amazon CEO Jeff Bezos is positive on AI, observing that "We are now solving problems with machine learning and artificial intelligence that were … in the realm of science fiction for the last several decades." It is important for organizational leaders to explain what the promise of AI

is. Demonstrating that in the final analysis AI will augment, not eliminate jobs, will offer some assurance to employees.

4.3. Managing the cost and securing resources for AI

Talent, data and money may be the holy grails of AI use in SCM. AI requires financial, physical, human resources, which may not be readily available in organizations especially smaller supply chain firms, and there presently exists a big skills gap in AI. As Gartner's Andy Roswell-Jones puts it, AI is hard to implement because of the need for new skills, some of which are hard to find. Individuals with the top skillsets and those that are able to understand AI, its use and how to apply it are inadequate for several reasons. First, AI requires advanced skill sets in data science and information management. One of the biggest challenges facing AI adoption is the lack of technical expertise within organizations. Some (2018) notes that the deployment of AI applications in business enterprises require specialists who have a deep understanding of the current AI technologies, its limitations and the current advancements and the skills gap may be hindering AI adoption. Second, even where they are available, such experts are expensive to hire and retain. Data scientists, data engineers and subject matter experts in today's market are rare and expensive, and smaller organizations may not have the resources to acquire such expensive talent. Third, AI requires hardware including processors that have much advanced processing power that many organizations do not have now. While using cloud computing and massively parallel processing systems can be an interim solutions, the problem is as data volumes continue to grow, and deep learning brings more algorithms that are complex into existence, the challenges grow. Fourth, data acquisition and storage is another challenge in AI implementation. Industrial AI systems depend

on sensor data as its input. The large amount of sensor data collected for AI validation may present noisy datasets that are difficult to store and analyze. Finally, because AI technologies are expensive, all but the large organizations such as Facebook, Apple, Microsoft, Google, and Amazon have separate budget allocations for AI implementation while small, and mid-size enterprises are bound to struggle to implement AI solutions in their business processes (Some, 2018). As Faggella (2018) points out, at this point in the technology's development, artificial intelligence is not easy to "do" in business. The science is hard, the math is hard, and the level of data infrastructure and subject matter expertise needed to derive real value from AI in business are rare. Those seeking expertise outside need to be careful not to be defrauded. According to Faggella, companies seeking to choose AI vendors can look at three things before making the choice: (1) AI expertise in leadership (2) The use of AI in marketing language (3) Assessing a company's investors. Following these guidelines should reduce the possibilities of choosing vendors who may not be equipped for delivering on a successful project.

4.4 AI and the risks of hacking and cyber attacks

Although AI can usher in a period of unprecedented growth in supply chain development and management, the potential for great damage when this system either gets into the wrong hands or is abused needs to be taken seriously. In fact, AI can help reduce cyber fraud (Vasudevan, 2018). At the same time, AI use in SCM can expose organizations to cyber fraud. The malicious use of AI to sabotage the supply chain is a challenge because AI is dual-use by nature, and many of the malicious uses of AI have related legitimate uses as well. In some cases, the difference between legitimate and illegitimate uses of AI could be one of degree and ensuring appropriate safeguards against malicious use is a challenge (Brundage, Avin, Clark et al. 2018). A recent report on the malicious use of AI highlights a range of security threats, from sophisticated automation of

hacking to hyper-personalized political disinformation campaigns (Brundage, Avin, Clark et al. 2018). The authors note that as AI capabilities become more powerful and widespread, the growing use of AI systems leads to increasing threats in at least three ways: (1) Expansion of existing threats. The set of actors who can carry out particular attacks, the rate at which they can carry out these attacks and the set of potential targets may increase. (2) Introduction of new threats. New attacks may arise with AI systems to complete tasks that would be otherwise impractical for humans. In addition, malicious actors may exploit the vulnerabilities of AI systems deployed by defenders. (3) Change to the typical character of threats. The growing use of AI may allow attacks to be especially effective, finely targeted, difficult to attribute, and likely to exploit vulnerabilities in AI systems. Particular areas of vulnerability that were identified in Brundage, Avin and Clark, (2018) include: (1) digital security. There may be an increase labor-intensive cyberattacks (such as spear phishing) attacks that exploit human vulnerabilities (e.g. with speech synthesis for impersonation), existing software vulnerabilities (e.g. through automated hacking), or the vulnerabilities of AI systems (e.g. through adversarial examples and data poisoning. (2) Physical security including novel attacks that subvert cyber physical systems (e.g. causing autonomous vehicles to crash) or involve physical systems that it would be infeasible to direct remotely (e.g. a swarm of thousands of micro-drones). (3). Political security. The use of AI to automate tasks involved in surveillance (e.g. analyzing mass-collected data), persuasion (e.g. creating targeted propaganda), and deception (e.g. manipulating videos) may expand threats associated with privacy invasion and social manipulation. Planning for this level of security is a challenge.

5.0 Recommendations

The promise of AI in SCM is only achievable when organizations plan for, and overcome these and other challenges discussed in this paper. Organizations can do much to ensure that the promise of AI is realized, and we offer some guidelines next.

5.1.Build a business case for AI

It is easier to get stakeholder support when a clear business case can be made for AI integration into SCM. According to a recent Gartner survey, 37% of organizations are still looking to define their AI strategies, while 35% are struggling to identify suitable use cases. Building a business case requires an analysis of the expected benefits and costs associated with a project. The problem of AI is this may not be as easy as AI projects can appear costly without any immediate gains — particularly for loosely bound scenarios and in organizations that are not used to setting aside budget to develop and deploy solutions for new business scenarios (Pettey, 2018). Pettey (2018) observes that making a business case for AI is difficult because there is no such thing as an AI business case. Instead, the business case will be for a particular business scenario, problem or use that employs AI methods and techniques as part of the overall solution. Pettey (2018) suggests that focusing on four questions will help define an AI project. These are (1) why are you doing this project? (2) For whom are you trying to deliver this solution? (3).What solution and technology framework will you employ and (4) how will you deliver this project? Moutusi Sau, principal research analyst at Gartner (https://www.gartner.com) notes that business cases for AI projects are complex to develop as the costs and benefits are harder to predict than for most other IT projects because there are additional layers of complexity, opaqueness and unpredictability that are not found in other standard technology. Be as it may, demonstrating value for the organization from AI integration is a precondition for building legitimacy and support for it.

5.2 Adopt a gradual approach to AI

Despite high levels of interest in AI technologies, current implementation remain at quite low levels. However, there is potential for strong growth as organizations begin piloting AI programs through a combination of buy, build and outsource efforts. The Gartner Group (Pettey, 2018b) makes four suggestions regarding the implementation of AI in organizations. First, it is important to aim low with AI adoption. Starting with a narrow project scope and purposes that are limited to improvements in areas of low-hanging fruit such as improving customer experience or enhancing a process may be preferable to a headlong plunge into AI integration. Setting low targets and aiming for soft outcomes will allow the organization to learn without betting everything. Second, AI should initially focus on augmenting not replace people, and used to help employees create higher value. Third, firms should plan for knowledge transfer. It will be prudent to grow in-house capabilities by planning to transfer knowledge and skills from external vendors. Finally, managers must be able to explain in simple terms how decisions and solutions are reached in AI by choosing transparent AI solutions.

5.3 Develop and implement a plan for AI integration

Organizations need to have a plan in place for integrating AI into their supply chains. AI can be used at several stages of the supply chain to create value. However, AI is costly and as mentioned elsewhere, making a case for it is important. Besides that, firms need a strategy for implementing AI or any new technology as firms often struggle with integrating new technology. Merely pitching the superiority of AI over existing technologies may not be enough to assure that managers and employees will readily accept the technology. Therefore, firms need to develop a strategy for implementing AI into their supply chains and they can do this in several ways.

First, it is important to decide how to acquire AI technology. The range of options includes building an in-house AI capability, outsourcing these capabilities, or leveraging AI-as-a-service offering from vendors (Chui et al. 2018). Stock and Tatikonda (2004) identify technological uncertainty, the lack of knowledge on how to acquire and implement new technology as one of the key factors influencing the technology integration process. According to the authors, the novelty of the technology to the recipient firm, the level of complexity in the technology and the tacitness of the technology and the degree to which it is physically embodied, codified and complete are what determines technological uncertainty. AI ranks high on all the three dimensions and therefore makes its integration more challenging. When an organization acquires the technology from outside, it must deal with managing the client-source relationship. It is important to build a collaborative relationship between the source and the client and frequent communication with the source from which it acquires the technology is important. The coordination of the processes of interaction as well as the willingness of the partners to cooperate are important to having a successful integration of new technology. Experience helps integration and firms who have had some experience in the past introducing new technology will have an easier time integrating AI into their supply chains (Stock and Tatikonda, 2004).

Second, firms need to determine the specific areas within the SCM function where AI application would be most beneficial. Chui et al. (2018) observe that SCM and related areas of retail and logistics stand out as the most important areas that will benefit from the application of AI. In consumer goods, supply-chain management is the key function that could benefit from AI deployment. Organizations need to determine the purposes for which they are acquiring the AI technology and end users of the AI technology should be able to see what problems the new technology can solve. Appointing an implementation team of managers would help the process.

One of the most important jobs for the implementation managers is to ensure that there is close cooperation between those who develop the AI technology and those who will be using it in the organization. According to Leonard-Barton and Kraus (1985) implementation managers should seek user involvement in the: (1) early identification and enhancement of the fit between a product and user needs, (2) preparation of the user organization to receive the innovation, and (3) shifting of "ownership" of the innovation to users. Prospective users should try out the technology early and organizations should not underestimate the scope and importance of preparations that would be necessary for AI integration.

Third, top management commitment and support to the new technology must be consistent. It is the job of top management to ensure that there is championing for the idea. There are those who will sit on the fence, be neutral to the new technology when it comes to supporting its implementation, what Leonard-Burton and Karus (1985) call "hedgers." These people are essentially opportunistic actors, taking credit when the new technology succeeds, and avoiding blame when it fails. According to the authors, sending signs of support from top management, making clear what the criteria is for judging the success or failure of the new technology, and demonstrating top management support for the new technology can reduce instances of hedging.

Finally, it is important to have a governance mechanism for data security to reduce malicious use of AI and cyber-attacks. While governments and policy makers have a big role in planning for cybersecurity, organizations for their part, can do some basic things to decrease the possibilities of malicious attacks on their AI systems. Prabuh (2018) proposed some useful guidelines that firms can use to guard against malicious attacks on their AI systems. First, organizations need make data security a top priority by ensuring that all team members/stakeholders have a basic understanding of security and privacy—things like data classification, data protection techniques,

authentication/authorization, privacy principles, applicable regulatory requirements, etc. must be well understood by all stakeholders. This is important because data and data management are at the heart of AI use in SCM. Ensuring that everyone uses the same terminology and understands the policy and standards would help. Having a good data governance structure in place that covers such issues as ownership and accountability should be helpful as data changes hands at different stages of each workflow. This is particularly important given the wide circulation of data required in machine learning and AI projects (Prahbu, 2018). Second, designing and activating diligent threat modeling of solutions—both at component level and from an end-to-end perspective will be helpful. This will ensure that security is 'built in' into the design and that applicable security requirements are met at every point in the end-to-end system. Organizations must ensure that all threats/risks identified during threat modeling and considered important enough to address are actually fixed by performing a combination of feature security testing and penetration assessments. Exercising good monitoring and security hygiene is important. Making sure all software components are at their latest security patch level, conducting periodic access reviews are all important parts of data security. Lastly, organizations must have a good incident response plan in place so they can deal with a calamity if one does happen.

5.4 Champions and Cheerleaders for AI integration

Organizations integrating AI should anticipate resistance and plan for it by finding a champion for the idea. In a 1963 article, Schon described his experience battling organizational inertia and resistance to new ideas and technology, stating, "the idea either finds a champion or dies" (Schon 1963, p. 84). That challenge may be as relevant now as it was then. A champion is an individual who "recognizes a new technology or market opportunity as having significant potential; adopts a project as his or her own; commits personally to the project; generates support from other people

in the organization; and advocates vigorously for the project." Field and case studies of innovation highlight that individuals who informally emerge to promote innovations through the crucial organizational stages, are pivotal to the successful implementation of an innovation (Howell & Shea, 2001). Burgelman (1983, p. 238) reported that champions articulated a convincing master strategy for the idea and initially mobilized resources covertly by "acting as scavengers, reaching for hidden or forgotten resources to demonstrate feasibility and then, more overtly, by establishing and maintaining contact with top management, to keep them informed and enthusiastic about the project." Galbraith (1982) noted that champions engage in coalition building to secure organizational support for the innovation. In their study of champions' personality characteristics, influence tactics, and leadership behaviors, Howell and Higgins (1990) reported that champions could be distinguished from non-champions by communicating a clear vision of what the innovation could be or do, displaying enthusiasm about the innovation, demonstrating commitment to it, and involving others in supporting it. Leonard-Barton and Kraus (1985) recommend that for a new technology implementation to succeed, the implementation team must include the following: (1) A sponsor, usually a fairly high-level person who makes sure that the project receives financial and manpower resources and who is wise about the politics of the organization; (2) a champion, who is salesperson, diplomat, and problem solver for the innovation; (3) a project manager, who oversees administrative details; and (4) an integrator, who manages conflicting priorities and molds the group through communication skills. Finding champions for AI integration is an important maw for securing legitimacy and resources for the initiative.

5.5. Integrate people and technology

Whether AI and humans can co-exist is already a subject of considerable debate. However, we have shown that both AI and people are not mutually exclusive, but rather, AI can augment what

people do and improve SCM and efficiency. For example, Siri and Alexa have become intelligent digital assistants. Still, there are skeptics and so it is important to assure employees that both the technology and people are not mutually exclusive, but rather complement each other. The fact may be that while AI capabilities are growing rapidly, they still cannot accurately imitate humans. As machine learning helps to increase the system's intelligence, humans can ensure that the technology is used in the correct way and effort made to integrate AI into human performance. Pettey (2018) suggests that organizations using AI should focus on worker augmentation, not worker replacement even though AI's potential to reduce staff head count attracts the attention of senior business executives as a potential cost-saving initiative. A more informed expectation the author notes, however, would be for applications that help and improve human endeavors, as AI promises benefits far beyond automation and organizations that embrace this perspective are more likely to find workers eager to embrace AI.

Organizations using AI should aim for optimizing people and technology, and this issue has been extensively studied by work pioneered at the Tavistock Institute, and subsequent research, under the general rubric of socio-technical systems (Emery et al. 1960). Sociotechnical systems (STS) in organizational development is an approach to complex organizational work design that recognizes the interaction between people and technology in workplaces. Socio-technical theory therefore is about joint optimization, with a shared emphasis on achievement of both excellence in technical performance and quality in people's work lives (Wikipedia.com). Socio-technical systems design (STSD) methods are an approach to design that consider human, social and organizational factors, as well as technical factors in the design of organizational systems. A socio-technical systems approach to managing AI integration should force organizations to focus on both the technology and the user side of the equation. The outcome of

applying these methods is a better understanding of how human, social and organizational factors affect the ways that work is done and technical systems, including AI are used (Baxter and Sommerville, 2011).

6.0 Conclusions

Supply chains face a lot of turbulence (Sheffi, 2007) and organizations can use AI to develop the robustness and resiliency needed to overcome the vulnerabilities and risks associated with supply chains. We have shown in this paper that AI has potential in several areas of SCM. In fact, AI can help organizations create smart supply chains (Wu et al. 2015). AI applications across the supply chain can create new business value in the form of operational efficiencies, cost savings, and increased customer loyalty. Besides its planning and prediction capabilities, AI may allow supply chain actors to react much more quickly to disruptions than ever before. For example, AI empowered Airbus to solve a business problem more quickly and efficiently than prior approaches (such as root-cause analysis based on manual analysis of hundreds or thousands of cases). It is reported that when Airbus started to ramp up production of its new A350 aircraft, the company faced a multibillion-euro challenge. In the words of Matthew Evans, Vice President of digital transformation at the Toulouse, France-based Company, "Our plan was to increase the production rate of that aircraft faster than ever before. To do that, we needed to address issues like responding quickly to disruptions in the factory. Because they will happen." Airbus turned to artificial intelligence. It combined data from past production programs, continuing input from the A350 program, fuzzy matching, and a self-learning algorithm to identify patterns in production problems. In some areas, the system matches about 70% of the production disruptions to solutions used previously— in real time. Evans describes how AI enables the entire Airbus production line

to learn quickly and meet its business challenge (Ransbotham, Kiron, Gerbert and Reeves, 2017). US Industry giants such as Amazon, Facebook, and Netflix, Chinese giants Baidu and Tencent, and Airbus in Europe have all created important economic value with AI and the promise of AI for SCM is not in doubt. Navigating the key challenges discussed and the use of the guidelines point to the sort of things organizations can do to ensure that on balance, the benefits of adopting AI outweigh the possible dysfunctions. As Marr (2017) observes, big data-driven analysis such as machine learning will increasingly play a prominent role in supply chain optimization. While the present beneficiaries tend to be big, national and international networks due to the need for large volumes of up-to-the-minute data and the associated cost and complexity of pulling it all together, the possibilities of developing "as-a-service" and out-of-the-box analytical platforms, combined with new markets for purchasing external data, will open AI up to smaller scale operations.

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IDENTIFICATION AND PREVENTION OF COORDINATED FRAUD FOR REMANUFACTURED PRODUCTS IN REVERSE SUPPLY CHAIN

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Abstract: A difficult to root out source of waste arises from the existence of fraud in a supply chain. Much research has been undertaken to understand the issue of fraud from both a psychological perspective as well as an engineering problem. This study models the issue of fraud in a remanufactured product warranty servicing scenario, when the warranty provider is the victim. We consider the scenario when the fraudsters act in isolation and contrast their actions with when they act in collusion with each other, with the aim of maximizing profits. The aim was to determine if it was more profitable for fraudsters to act in isolation or risk bringing in other parties. Game theory was employed to determine the best response of each party. This study represents only one of many fraud scenarios that exist and helps in establishing more complex models for tackling fraud.

Keywords: End-of-life; Reverse supply chain; Fraud; Remanufacturing; Warranty

1. Introduction

The abundance of high quality and inexpensive products has altered consumer behavior. One noticeable change is that now products are quite often disposed of before they actually spoil or fail. This leads to products becoming obsolete in a much shorter time even though they still have remaining life.

Environmental legislation has encouraged firms into moving away from disposal and more toward End of Life (EOL) strategies. By keeping waste to a minimum, the firm can reduce disposal costs and permit requirements, avoid environmental fines, boost profits, discover new

business opportunities, rejuvenate employee morale, and protect and improve the state of the environment [1].

One such waste stream arises from the presence of fraudulent activities in the supply chain which not only generates excessive costs but also requires time and resources to deal with. Frauds in the new product industry have been generally well covered in recent literature [2- 4] however issues of fraud in the remanufacturing industry have yet to be explored in a meaningful way. This paper discusses the issue of fraud in the warranty servicing industry, namely scenarios in which the warranty provider can be defrauded by the other parties in the warranty service chain. Game theory is utilized to simulate these scenarios and helps in generating the best responses for the concerned parties.

2. Literature review

2.1. Reverse logistics

EOL activities are most often carried out by the product manufacturers themselves. To facilitate the return of large numbers of consumer products back to their origin requires a capable reverse logistics (RL) network. The systemic problems and issues that exist in RL were reviewed by Gupta [5]. Many case studies have examined RL problems involved in consumer product maintenance and product EOL. Du and Evans [6], Tan *et al*. [7], Piplani and Saraswat [8] examined case studies that aimed at optimizing RL networks. Issues in RL from the perspective of EOL were tackled by many researchers including Fleischmann *et al*. [9] and Shih [10]. Reverse logistics encapsulates many different activities, which also include remanufacturing and refurbishing related processes. Because of misconceptions held by consumers, remanufacturers often search for market mechanisms to encourage consumers into purchasing their products [11].

2.2. Warranty as a marketing strategy

The majority of the extant literature was focused on warranties with respect to the new product industry. More recently, many of the same types of issues have also been tackled in the remanufacturing sector. Alqahtani and Gupta [11] described a two dimensional warranty policy where the objective was twofold i) to maximize consumer confidence and ii) to minimize cost to

the remanufacturer. Yeh and Fang [12] planned out the optimum marketing strategy for maximizing profits that includes considerations such as pricing, warranty service and production.

2.3. Warranty Fraud

In the past, statistical fraud detection methods have been useful in handling fraud. Widely used statistical classification methods such as linear discriminant analysis and neural network methods have been shown to be effective tools in such supervised situations [13-16]. Warranty fraud in the remanufacturing industry have been recently explored by Pandit and Gupta [17], which explored the issue of service agent warranty fraud by employing discrete event simulation. This paper builds on this existing work by considering the issue of fraud arising from multiple sources acting both alone and with cooperation from other parties.

3. Description of the system

While warranty services are sometimes carried out in house, it is not unusual to see product manufacturers outsource their warranty services to external companies or service providers. When a warranty provider offers a warranty on a remanufactured product to a customer, there are a host of other parties that are also involved in the service and thus may also be involved in any potential fraud. For the purpose of this study, the various parties are separated into one of two categories (Table 1) [18].

Table 1. Parties in a warranty servicing chain

Categories	**Parties**
Primary	Warranty provider, Service agent, Customers
Secondary	Parts manufacturer, sales channel , Warranty administrator

4. Model and settings

In the past the issues of fraud have been modeled using techniques such as game theory [18], and these have been instructive in providing a basic understanding of the problem a more complex and detailed model is required to fully capture this issue. Possible two-party collusions that may arise with the aim of defrauding the WP are those between (1) the SA and the customer, (2) the

SA and the warranty administrator and (3) the SA and the part distributor. An example of a three-party collusion is that between the SA, the customer and the administrator, again trying to defraud the WP. We consider GT models where the fraud occurs with the perpetrator acting alone and then more complex GT models looking at the fraud that result from different collusions. In the latter case, a hierarchical structure is needed for the GT model formulation. Therefore the design of the experiment will separately examine the effects of two player and three player scenario's.

4.1. Two player scenario

A number of different types of fraud can be modeled but to illustrate the fraud modeling process we consider only the scenario that involves the primary parties, specifically when the service agent (SA) commits the fraud and the warranty provider is the victim. A non-cooperative static game formulation is used to model the interaction between the WA and SA and to determine the optimal values for their decision. The outcome of the game is a mixed strategy Nash equilibrium (NE) and is found from the intersection of the players' best response functions. The amount that the SA wishes to defraud the WP is a variable amount that is modeled as a non negative Continuous random variable X with min a and max b such that $0<a<b$.

The inspection cost and penalty for each "ith" warranty claim is C and P respectively such that $P>C$. The probability that the SA commits fraud is "p" and the probability that they do not is (1-p). Similarly the probability that the WP inspects a claim is "q" and the probability that they do not is (1-q). The monetary payoff to a decision-maker (DM) is a random variable V

The utility function is a measure of the DM's preferences for different values of V, and its shape determines the risk attitude of the DM. A rational DM should make their decisions based on maximizing E[U(V)], the expected utility of the random pay-off earned. This is known as the principle of expected utility maximization. Table 2 describes the four possible outcomes (payoff matrix) of the two player game.

Table 2. Outcome of Two player game (service agent and Warranty provider)

W.P / S.A	Inspects	Not inspect
Fraud	O_1	O_2
Not Fraud	O_3	O_4

O_i – Outcome of game (Z_i, Y_i)

Where the SA's total revenue over the warranty period is

$R= Z_1 + Z_2 + Z_3 + Z_4 + Z_5 + \ldots\ldots Z_{N(W)}$

The WP's total revenue over the warranty period is

$S=Y_1 + Y_2 + Y_3 + Y_4 + \ldots\ldots\ldots\ldots Y_{N(W)}$

4.2. Three player scenario

The equations and variables are similar to those for the two player scenario, the key difference being the inclusion of an additional party to the problem. Possible third parties that may be involved in the fraud may include the warranty administrator, parts manufacturer and part distributers. Table 3 describes the outcome of the three player game.

Table 3. Outcome of three player game (service agent and warranty provider, third player)

	Third player			
	Fraud		Not Fraud	
	S.A		S.A	
W.P	Fraud	Not Fraud	Fraud	Not Fraud
Inspects	O_1	O_3	O_5	O_7
Not inspect	O_2	O_4	O_6	O_8

O_i – Outcome of game (Y_i, Z_i, U_i)

Where the Third parties total revenue over the warranty period is

$T= U_1 + U_2 + U_3 + U_4 + U_5 + \ldots\ldots U_{N(W)}$

5. Results and discussions

For the two player scenario, we assume that nature of the SA and WP effect the outcome of the game, as well as the dependant variables that result in optimal value of each player. 4 scenarios are considered each with a different WP - SA risk relationship. i) Both the WP and the SA are risk neutral, ii) WP is risk Neutral and the SA is risk averse, iii) Both the WP and the SA are risk averse and iv)WP is risk averse and the SA are risk neutral. Table 4 describes the results of scenario 1 for a range of penalty values (P). Solving for all scenarios allowed us to conclude that on average the SA breaks even and the WP incurs a loss. Additionally WP loss decreases as the penalty value increases.

Table 4 - Results of the scenario 1 (WP and the SA are risk neutral)

P							
250		500		1000		2500	
p*	q*	p*	q*	p*	q*	p*	q*
0.2	0.8	0.166667	0.66667	0.125	0.5	0.071	0.28556

Preliminary results for the three player game show that for a risk neutral scenario, the WP loss decreases as the penalty value increases, but more so than for the two player game (as the penalty is accrued from more than one source). Based on early results it was judged that it was better for the SA to act in isolation (overall fraud profit was greater in the three player scenario but so were the penalty costs). Additionally for future work a hierarchal structure would be better suited for solving the three player game theory model.

6. Conclusions

This paper presents some of the literature surrounding the issues of fraud and warranties. Next, an approach to mitigate fraud against the warranty provider was proposed. Game theory models for two and three player games were set up to establish relationship between the different players in the game. This has been an overlooked problem in the area of remanufacturing, and further exploration would prove to be beneficial to all the parties involved.

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INTEGRATED DESIGN CONCEPT FOR REDUCTION OF CO_2 EMISSION AND DISPOSAL WEIGHT WITH MODULARIZATION APPROACH

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ABSTRACT

Manufacturing has faced up to switch from mass production and large consumption to environmentally conscious manufacturing to resolve material starvation and global warming. Reduction of CO_2 emissions and disposal weight are key methods in manufacturing of assembly products. Both CO_2 emissions at a material production phase and disposal weight depend on material type. Then, the potential environmental loads of assembly products are already determined at the product design phase. Hence, the product design is required to pay attention to not only functions and costs but also environmental aspects for environmentally friendly manufacturing. However, actual environmental loads such as CO_2 emissions and disposal weight are occurred in assembly and disassembly production phases. Thus, the environmentally friendly manufacturing needs to address the whole design processes of assembly products in terms of assembly and disassembly.

This study proposes integrated design concept for reduction of CO_2 emissions and disposal weight with modularization approach from both assembly and disassembly viewpoints. First, environmentally friendly design issues in product and production designs are identified. Next, design approaches for environmentally conscious manufacturing are introduced based on previous studies. Finally, summary and future research directions are discussed.

Keywords: Product and Production Designs, Reuse and Recycling, Environmentally Conscious Manufacturing, Assembly Product, Multi-Criteria Decision Making

INTRODUCTION

To deal with depletion of natural resources and global warming, manufacturing has been required to shift environmentally conscious manufacturing for reduction of CO_2 emission and disposal weight [1]. Nasr pointed out that USA throws away more than 250 million tons of end-of-life (EOL) products each year without reuse and recycling [2]. On the other hand, the 2016 Recycling Economic Information Report stated that reuse and recycling of materials created jobs, while also generating local and state tax revenues such as $6.7 billion in 2007 [3]. Reuse and recycling are expected to create more jobs and revenues. Reuse extends the components' or modules' lives obtained from EOL products by using them in the same or different products with or without adding additional value to them [4], while recycling is the recovery of materials out of scrap from end-of-life products [5]. Reuse and recycling can reduce not only the disposal weight of the EOL product and but also save additional CO_2 emissions for the virgin material production by using reuse components or recycled materials instead of the virgin materials for the assembly product in the next generation.

In order to promote component reuse and material recycling, assembly products should be designed environmentally friendly throughout product and production designs. A product design phase is the process of translating an idea into the detailed information from which a product can be manufactured [6] by determining shape and material under limitations of cost, durability, reliability, etc. In terms of environmental aspects, type of material is one of the important factors since both CO_2 emission at the

material production phase and disposal weight at the EOL phase depend on types of materials determined at the product design phase. Thus, the potential environmental loads of assembly products are already determined at the product design phase. Moreover, it is essential for attaining effective and efficient product and its component reuse and recycling to consider product lifecycle at the early design process [7].

On the other hand, actual CO_2 emissions and disposal weight are emitted throughout production stages. Disassembly production can reduce disposal weight and by promoting reuse and recycling. Disassembly is an unavoidable and first step for reuse and recycling. However, disassembly production has conflicts of goals and status uncertainties in EOL products. Then, these conflicts and uncertainties make the designing disassembly production environmentally friendly and economically be difficult.

With regards to improvement of the product design, although changes of product design can reduce environmental loads, actual environmental loads are not always reduced in the disassembly production. For example, if the recycling rate of a certain part with many preceding parts are improved by replacing alternative materials, recycling of the parts would be difficult because of higher disassembly cost. The disassembly cost for the part becomes higher since all its preceding parts need to be disassembled to remove it for reuse or recycling. As another example, although parts are modularized with higher durability for reuse, the module would be not removed for reuse and then, thrown away if complex disassembly operations are required to remove them.

Therefore, it needs to integrated approach of product and production designs to reduce CO_2 emission and disposal weight for promotion of reuse and recycling. Modularization is expected to expand possibilities that reused module unit can be used in other types or generation of products. Moreover, it would lead reduction of combinations of parts for disassembly. Furthermore, if the material of all components in a certain module is the same, it does not have to remove each component by manual disassembly operations for material circulation.

This study addresses the integrated design concept between product and production for reduction of CO_2 emission and disposal weight. First, environmentally friendly design issues in product and production designs are identified. Next, design approaches for environmentally conscious manufacturing are introduced based on previous studies. Finally, summary and future research directions are discussed.

IDENTIFICATION OF CHALLENGES FOR CO_2 EMISSION AND DISAPOSAL WEIGHT REDCUTION IN PRODUCT AND PRODUCTION DESIGNS

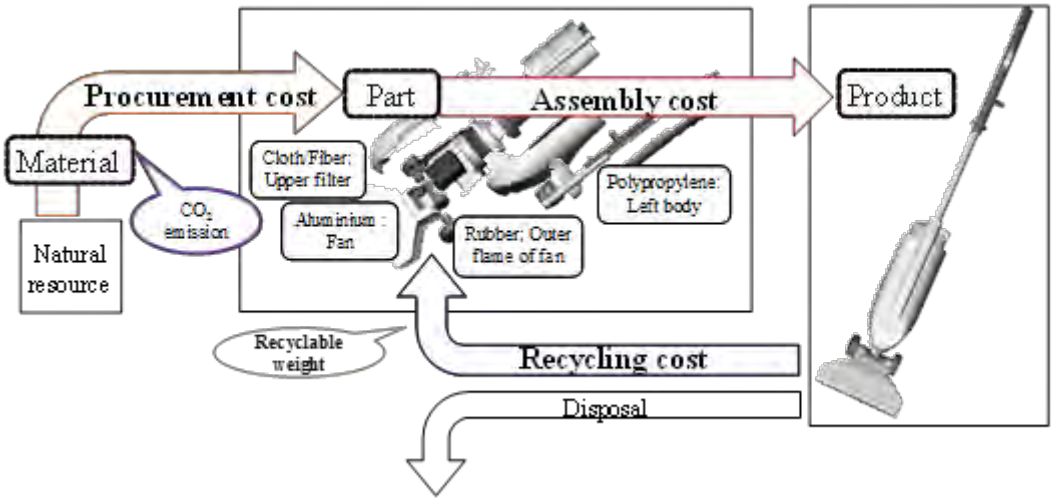

Figure 1 Relationships among costs, CO_2 emission and disposal weight in the assembly product lifecycle
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This section explains the relationships between environmental loads and costs throughout manufacturing of assembly products, and identifies the design challenges in the product and production designs. The CO_2 emission in this paper means the CO_2 emission for a virgin material production from natural resources.

Figure 1 shows relationships among costs, CO_2 emission and disposal weight in the assembly product lifecycle. As illustrated in Fig.1, materials such as aluminum, steel, rubber and plastics are made from natural resources with procurement cost and CO_2 emissions. Then, each part is produced from each material. Parts are assembled into modules or finished products with assembly cost. The products are sent to the market.

After the usage phase, the EOL products are collected to retrieve its components or material values. However, conditions of the received EOL products involve uncertainties caused by unknown statues during a usage phase. The conditions have effect on whether the components can be reused or recycled. For reuse component and recycling materials, disassembly plays an important role to remove the parts from the EOL products. Manual disassembly is known to effective way for dealing with complicated and uncertainties of the EOL product. Hence, although it is desirable to disassembly all parts for reuse and/or recycling, it is difficult from economic terms due to higher labor costs. Therefore, disassembly parts selection is often carried out in recycling factories [8, 9]. Only selected parts are removed from the EOL products with recycling costs. Other non-selected parts are crushed to be disposed. The reused components and recycled materials are used in the assembly products in the next generation. Throughout the whole product lifecycle, CO_2 emissions, disposal weight and cost depend on the material types.

Here, we faces up to challenges to overcome to promote reuse and recycling for reduction of CO_2 emissions and disposal weight.

- Which materials should be selected to reduce not only cost but also CO_2 emissions and disposal weight?
- How should components modularized for promoting reuse and recycling?
- How to design the disassembly production under uncertainties? What kinds of effects are brought to the disassembly production by uncertainties of conditions in collected EOL products?
- Which parts should be disassembled to achieve higher recycling and/or CO_2 saving rates with an affordable recycling costs at recycling factories?

These 4 challenges are come up and identified. Then, next section introduces design approaches to deal with these listed challenges.

DSGIN METHODS FOR ENVIRONMENTALLY FRIENDSLY AND ECONOMICAL PRODUCT AND PRODUCT DESIGNS

This section introduces design approaches to reduce CO_2 emissions and disposal weight in product and/or production designs.

Multi-criteria material selection for cost, CO_2 emissions and disposal weight

Multi-criteria material selection focuses on redesign of the assembly product to reduce total cost and disposal weight and CO_2 emission simultaneously [10]. The total cost is consisted of procurement, assembly and recycling costs. Material selection at the product design phase affects on both costs and environmental loads. Multi-criteria material selection suggests alternative materials to reduce CO_2 emissions, disposal weight and cost simultaneously. This method is expected to give a chance for product designers to investigate other materials, which are not used in the past design, so that both environmental loads and costs are reduced simultaneously.

Environmentally friendly and economical disassembly parts selection

Environmentally friendly and economical disassembly parts selection determines parts for disassembly to achieve lower recycling cost and higher recycling/CO_2 saving rate under disassembly precedence relationships of EOL products [8, 9]. Each part has different CO_2 saving and recycling rates and cost since each part has different material, weight, disassembly operations. The CO_2 saving rate is defined as the saved volumes of CO_2 emissions by using recycled materials instead of the virgin materials [8]. Only selected parts are removed from the EOL products manually for recycling. Then, other non-selected parts are crushed for disposal. Thus, the parts higher with recycling and/or CO_2 saving rates are selected for disassembly under the disassembly precedence relationships with an affordable cost in the environmentally friendly and economical disassembly parts selection.

Disassembly-to-order system for reused components and recycled materials

Disassembly-to-order (DTO) system for reused components and recycled materials determines the optimal number of EOL products and parts for each process such as procurement, disassembly, inspection for reuse and recycling to satisfy demands for reused parts and recycled materials [11]. The DTO involves uncertainties of the EOL products, which affect on whether the disassembled parts are reusable or recyclable, respectively. Moreover, the DTO system contains multiple goals such as maximizing total profit, minimizing purchasing cost for EOL products, procurement cost for additional components from outside suppliers and disposal cost.

Module design and selection for disassembly

Module design is expected to expand possibilities that module can be used in other products or generation design. Furthermore, if the module is designed to contain only parts made of the same materials, the module is not required to disassemble into each part for material recycling because of sorting materials into each type already done. Then, that leads to reduce manual disassembly costs.

SUMMARY AND FUTURE STUDIES

This study addressed the integrated design concept for reduction of CO_2 emissions and disposal weight by using multi-criteria decision makings, identified problems for it, stated possibilities of module design and introduced design approaches. Future studies should take account of module design in the environmentally friendly and economical disassembly parts selection.

ACKNOWLEDGEMENTS

This research was partially supported by the Japan Society for the Promotion of Science (JSPS), KAKENHI, Grant-in-Aid for JSPS Research Fellow, JP18J14789, from 2018 to 2019 and Grant-in-Aid for Scientific Research (A), JP18H03824, from 2018 to 2019.

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RECENT RESEARCH TRENDS IN THE SUSTAINABLE FOOD SUPPLY CHAIN MANAGEMENT

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Abstract

Emerging factors affecting the current food system include increasing awareness of source and content of consumed food, regulations set by governments that address food safety and sustainability issues, and mitigating environmental risks such as the growth of world population and climate change. These recent changes in food supply chain objectives have led to the development of the trending concept: Sustainable Food Supply Chain Management (SFSCM). While existing literature reviews in SFSCM only consider the forward supply chain, we present in this study recent research directions in the closed loop SFSCM with a focus on the design and planning of sustainable models in the food sector. In particular, we conducted a literature review in the areas of reverse logistics, closed loop and sustainability in the food supply chain. The literature analysis followed by selecting specific papers that discussed different approaches to overcome challenges in the development of the SFSCM. We reviewed and categorized the resulted literature review into 10 different directions based on the most critical issues each paper is addressing in the area of the closed loop SFSCM. Finally, we present research gaps in existing literature and propose future research trends.

Keywords: Sustainability, Food Supply Chain, Network Design, Food Waste.

Introduction

Sustainability is improving living standards not only for current society but also for future generations. It aims to balance the economic, environmental and social impact of implementing supply chain goals in the long term. It incorporates objectives wider than just efficient and profitable production and consumption including socially fair and environmentally friendly products (Mehmet Soysal, Bloemhof-Ruwaard, Meuwissen, & van der Vorst, 2012). In

the US, the food sector meets internal food security while providing support to the national economy. One important step in the journey of food products from farm to fork is the transportation and all related logistical processes to deliver food to the consumer. Improving the efficiency of these processes begin with designing Food Supply Chain (FSC) network that considers the design of processing and distribution centers, the management of cold chain and the design of reverse logistics network (Li, Wang, Chan, & Manzini, 2014). These recent changes in FSC management goals have led to the development of the trending concept: Sustainable Food Supply Chain Management (SFSCM). As a result, new key performance indicators are developing that can capture the integrated triple bottom line of sustainability in which profit, people, and planet are working as drivers of the supply chain decision-making process (Mehmet Soysal et al., 2012).

Next, we present recent research directions in the closed loop SFSCM with a focus on the design and planning of sustainable models in the agri-food sector. The sustainability research in the context of the FSC is quite different from the general Supply Chain management due to the perishability nature of food products and other critical issues related to the characteristics of the FSC. The literature analysis followed by selecting specific papers that discussed different approaches to overcome challenges in the development of the SFSCM. We reviewed and categorized the resulted literature review into 10 different directions based on the most critical issues each paper is addressing in the area of closed loop SFSCM (see Figure 1).

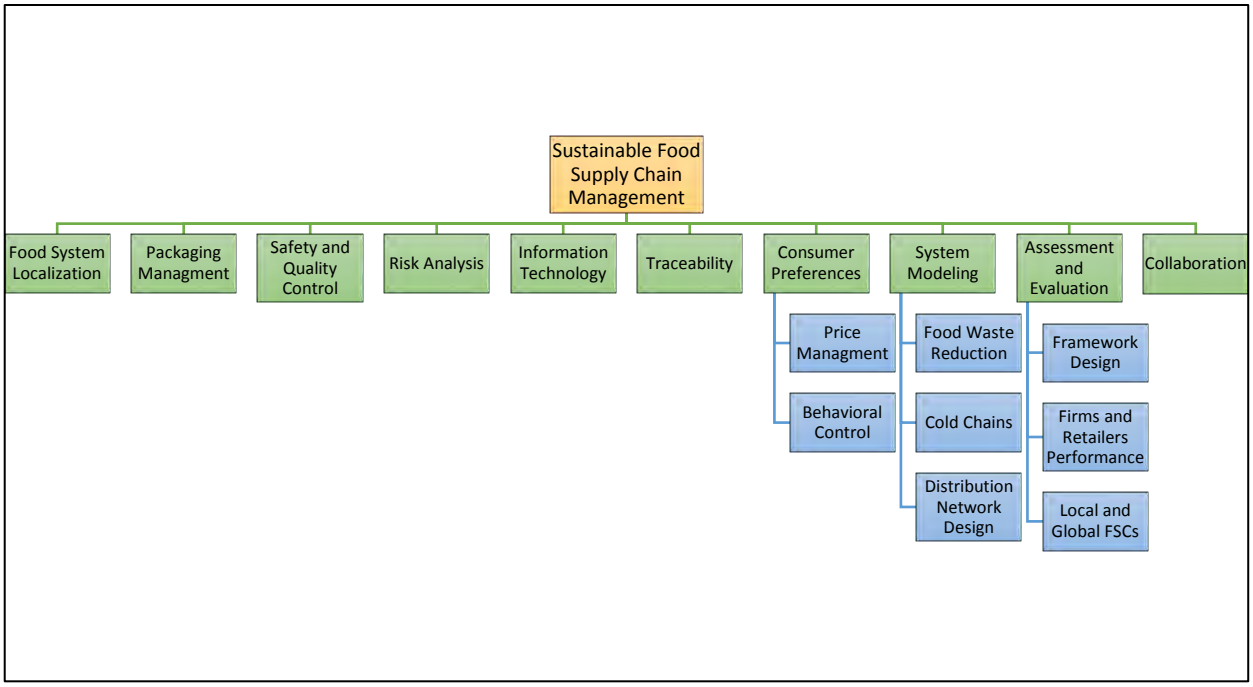

Figure 1: Research Directions in the SFSCM

1. Food System Localization

Local food will result in more public interests toward food safety, nutrition, and energy conservation. However, buying local food has some challenges. The current purchasing systems are more towards ordering from big distributors with advanced ordering platforms. Prices of local food could be higher as local farmers have limited agribusiness techniques that save farming costs. (Biemiller, 2005). Berti and Mulligan (2016) presented a literature review on the innovative organizational strategy "regional and local food hubs" that aims to reconstruct the conventional agri-food system by connecting small producers and consumers, individuals and families, as well as big buyers (Berti & Mulligan, 2016).

2. Packaging Management

Packaging and containers are critical components in food products that need to be managed efficiently and designed intelligently for the development of SFSCM. The Sustainable Packaging Alliance (SPA) defined Sustainable packaging as safe and healthy for users, utilize renewable energy and materials, and recovered in closed loop cycles. Singh et al. (2016) examined the economic and social impact of introducing the use of reusable plastic containers (RPCs) in the distribution network of fresh produce in the AFSC. The authors evaluated process times and product damage to the implementation of RPCs in retailer stores through a Time-Driven Activity-Based Costing (TD-ABC) analysis. The study found that using RPC technology has reduced food waste and damage and increased the sustainability level of the fresh food supply chain (Singh, Shani, Femal, & Deif, 2016). Bortolini et al. (2018) developed a bi-objective mixed integer linear programming model for the purpose of packaging container best selection and storage node location and flow allocation in fresh food supply chains. The study considered disposable and reusable packaging containers and compared between these two types by looking at the total cost and environmental impact minimization over the whole network. The model resulted in the optimum configuration of using 47.1% reusable and 52.9% disposable containers that will guarantee the lowest emissions rate at the minimum cost (Bortolini, Galizia, Mora, Botti, & Rosano, 2018).

3. Safety and Quality Control

Optimization models of the SFSC are needed to figure out the optimal setting of temperature level so that energy consumption is minimized and food quality is increased. Al-Busaidi et al. (2016) analyzed the components of the fish supply chain and discussed related import/export operations and quality control issues. The paper focused on the legislative structure aspects and control standards enhancement for the Omani fish control system. The study applied a SWOT analysis approach to review the current control system and found that there is a potential to improve the distribution process through food safety standard enforcement such as HACCP (Al-Busaidi, Jukes, & Bose, 2016).

4. Risk Analysis

Risk analysis process consists of three parts namely; risk assessment, risk management, and risk communication. Nakandala et al. (2017) developed a hybrid risk assessment model for the fresh food supply chain where risk is identified by hierarchical holographic modeling (HHM). The study conducted the risk assessment process using both fuzzy logic approach and risk filtering, ranking, and management framework. Then, the two assessment techniques were compared and the benefits of both were utilized. The paper conducted a case study in a fresh food supply chain company and the proposed integrated approach was validated (Nakandala, Lau, & Zhao, 2017).

5. Information Technology

Recent advancement of technologies such as the Internet of Things, Virtualization, and sensor technologies are expected to change the whole operations of food supply chains in unprecedented ways. However, the current focus is on information gathering tools such as Radio Frequency Identification (RFID) and sensors, but not on how this obtained information is employed and implemented to improve sustainability at the FSC level. Ahearn et al. (2016) considered responding to challenges in agricultural production and consumer demands by adopting big data technologies. The paper discussed the evaluation of two examples, one is the utilization of sustainability metrics and the other is the potential to increase food safety (Ahearn, Armbruster, & Young, 2016).

6. Traceability

Food traceability has drawn huge attention in the past two decades due to public awareness increase over food product quality, safety, and sustainability. Developing traceable and transparent processes within the FSC would reduce food contamination occurrence and consequences by identifying the original source of contamination and speeding up the product recall process. Shengnan et al. (2017) considered consumer willingness to pay for traceability in the sustainable food supply chain. The study identified four potential transparent strategies and three nontransparent sourcing strategies and found that penalizing the buyer will result in increasing provision of traceable food products (Shengnan, Xinping, & Yan, 2017). Zhu (2017) conducted a return on investment analysis of enabling RFID traceability technology in a two-level perishable food supply chain in which food quality and safety are considered in the evaluation process. Further, the paper proposed a two-part tariff contract to balance cost and benefit among supply chain players in the traceability system. The study found that implementing a dynamic pricing policy could highly reduce food waste and improve retailer performance (Zhu, 2017).

7. Consumer Preferences

7.1 Price Management

Pricing strategies could change consumer-purchasing attitudes to buy more sustainable products, reduce food waste, maximize products sales, and optimize product life cycle for different remaining shelf lives. Moreover, considering consumer preferences and behavior is crucial in developing optimal pricing strategies for sustainable food products. Ingenbleek (2015) proposed price strategies for sustainable food products that minimize environmental and social costs by offering these strategies for managers. The study derived these strategies from an inductive sequential case study of certified food products and the results showed six different strategies based on three mechanisms: price fairness and cost, willingness to pay for quality, and price stability through learning effects (Ingenbleek, 2015). Tekin and Erol (2017) proposed a new dynamic pricing policy for perishable food products that aims to maximize retailer profit, minimize food spoilage rate, and improve product life cycle sustainability. For future studies, the paper suggested developing models that consider different types of products with different deteriorating rates (Pırıl & Rızvan, 2017).

7.2 Behavioral Control

Despite the complexity of food systems that are embedded in the political and institutional structure, yet, sustainability researchers argue that changing consumer behavior can promote sustainability improvement through policy interventions. Grandhi and Singh (2015) analyzed food waste drivers in the retailer and consumer stages of the Singaporean food Supply chain. The study found that food waste key drivers include food spoilage, brand reputation, inefficient food sorting processes, poor reverse logistics operations for waste disposal, lack of recycling facilities, and lack of governmental operations and incentives (Grandhi & Appaiah Singh, 2015). Ladhari and Tchetgna (2015) investigated the impact of personal values of Fair Trade (FT) product consumption by collecting data from 268 Canadian consumers. The study classified values into three categories: self-directed, equality and social justice, and power and social status. The paper concluded that self-directed values have no significant impact; equality and social justice have a positive significant impact, while power and social status have a negative impact on FT consumption (Ladhari & Tchetgna, 2015).

8. System Modeling

Design systems for sustainability development in the food industry has been of great interest by researchers in recent years.

8.1 Food waste reduction and closing the loop in SFSCM

Considering reverse material flow in the design of the SFSC network has been growing recently due to today's governmental regulations, customers' requirements, environmental concerns, and economical advantages. However, the research on closed-loop supply network design models in the food industry is very limited (Sgarbossa & Russo, 2017). Lee and Tongarlak (2016) derived a retailer's optimal order policy under by-product synergy (BPS) that valorizes food waste from the main processes in food supply chain to a useful input onto other secondary processes. Implementation of these BPS policies showed that food waste decreases when demand uncertainty and the tax benefit from donation are low. Further, food donation ca be induced by tax credit and disposal fee (Lee & Tongarlak, 2016). Banasik et al. (2017) proposed a multi-objective model to optimize economic and environmental goals and investigate alternative recycling technologies organic matters for closing the loop in the mushroom supply chain. The study found that implementing recycling technologies could increase the total profit

of the mushroom chain by 11%, while the environmental indicator could improve by 28% (Banasik, Kanellopoulos, Claassen, Bloemhof-Ruwaard, & van Der Vorst, 2017). Sgarbossa and Russo (2017) developed a new sustainable closed loop supply chain (CLSC) models for best resource recovery and waste reduction practices, energy efficiency, and improved social development in the meat processing industry. By implementing the new model, the profitability index showed the viability of recovery plants, reduced global environmental impact, and new skilled positions that improved firm reputation in the social context (Sgarbossa & Russo, 2017).

8.2 Cold Chains and Temperature-controlled processes

A major gap exists in literature related to temperature-controlled and cold chain models that consider energy use and sustainability indicators in the food industry. Chen and Hsu (2015) developed a multi-temperature food model to explore the impact of delivery scheduling on GHG emissions from the Traditional Multi-Vehicle Distribution (TMVD) and Multi-Temperature Joint Distribution (MTJD) systems. Results showed, compared to the TMVD system, that the MTJD reduced routing distances and emissions simultaneously (Chen & Hsu, 2015). Meneghetti and Monti (2015) proposed a sustainable design of refrigerated automated storage in the food supply chain in order to minimize energy use, carbon dioxide emissions and total cost of the automated storage facility simultaneously. The study used the constraint programming method to solve the model (Meneghetti & Monti, 2015). Bozorgi (2016) developed multi-product inventory policies for cold items to determine the order quantity for each product type that minimize cost or CO_2 emissions (Bozorgi, 2016).

8.3 Distribution Network Design

Network design and distribution processes play a significant role in the sustainability performance of FSCs due to increasing consumer demands for sustainable products, the scale of the food industry, the amount of food waste, and the impact of FSC on food security and global warming. Literature review reveals that there is a need for distribution network models that are capable of dealing with key challenges in managing SFSC (M. Soysal, Bloemhof-Ruwaard, & van der Vorst, 2014). Accorsi et al. (2016) used a multi-disciplinary approach to construct a design framework to optimize infrastructure, agriculture, and logistics costs while balancing carbon emissions within the agro-food ecosystem. The model is implemented on a regional potato supply chain that showed a more effective and balanced planning compared to models based on cost efficiency solely (Accorsi, Cholette, Manzini, Pini, & Penazzi, 2016). Bortolini et

al. (2016) developed a perishable produce distribution planner to balance operating cost, carbon footprint and delivery time objectives. The paper applied the proposed tool to a case study of fresh fruit distribution from Italian producers to European retailers. Compared to single-objectives model, the distribution planner resulted in 9.6% CO_2 emission reduction and no food waste due to shorter delivery times, while operating cost increased by 2.7% (Bortolini, Faccio, Ferrari, Gamberi, & Pilati, 2016). Tsao (2016) developed a perishable goods supply chain network design under trade credit arrangements to determine distribution centers locations, improve deteriorating inventory management, and investing in preservation technology. The study used a piecewise nonlinear optimization algorithm as a solution method (Tsao, 2016). Musavi and Bozorgi-Amiri (2017) proposed a multi-objective sustainable hub location-vehicle scheduling model to optimize total transportation cost, quality of food products, and CO_2 emissions in a food supply chain. The study used a non-dominated sorting genetic algorithm-II (NSGA-II) Meta heuristic approach as a solution approach. Results revealed that if the number of vehicles and shelf life increased, responsiveness and transportation costs would increase (Musavi & Bozorgi-Amiri, 2017).

9. Sustainability Assessment and Evaluation

9.1 Framework Design for Sustainability Assessment

Among the challenges identified on sustainability performance metrics are the difficulty to choose between different environmental indicators, compliance enforcement of sustainability measures with governmental regulations, confidentiality issues between different players with conflicting strategies, and the dynamic nature of the FSC that requires time-dependent measures. These challenges and others are key drivers for the need of a state of the art framework for sustainability assessment in FSC based on the integration of sustainability TBL concept with traditional logistics performance (van der Vorst, Peeters, & Bloemhof, 2013). Bloemhof et al. (2015) proposed a structured framework for sustainability assessment of food chain logistics and applied the framework by an empirical study in the Netherland, the UK, and France. Study delivered clear insights into performance indicators, redesign strategies, and barriers to sustainability developments (Bloemhof, Van Der Vorst, Bastl, & Allaoui, 2015). Tajbakhsh and Hassini (2015) introduced a framework design to evaluate the sustainability performance of supply chain operations by developing a multi-stage DEA model. The proposed model is

implemented on a beverage sector case study and results showed that more emphasis should be put on the retailers' stage to improve the sustainability performance (Tajbakhsh & Hassini, 2015).

9.2 Assessment of Sustainability Performance in Agri-food Firms and Retailers

Different firm sizes including small and medium-sized enterprises (SMEs) in the food sector are subject to competitive pressures to integrate sustainability performance with other traditional supply chain measures. Despite the high impact of firm sizes on sustainability performance, a large gap exists in literature for understanding the effect of firm size on sustainability measures in the food supply chain (Bourlakis, Maglaras, Aktas, Gallear, & Fotopoulos, 2014). Ross et al. (2015) analyzed the characteristics of the sustainability initiatives adopted by fourteen top U.S. agri-food firms at different stages of the FSC. Results showed that adopting specific sustainability initiative is dependent on time, sector, and context at which the initiative will be implemented. Further, the hodgepodge approach of equal resource allocation among all initiatives is not an efficient method for improving sustainability performance. Rather, Sustainability initiatives should be purposeful, innovated, and easy to evaluate operations that are aligned with the overall strategy of the firm (Ross, Pandey, & Ross, 2015). Kulak et al. (2016) proposed an integrative multi-stakeholder design process to improve the environmental performance of bread supply chains in France by using LCA and sustainability experts' opinion as an evaluation support tool. Results showed that a 47% potential reduction in the impact of global warming and a 40% reduction in the aquatic eutrophication potential could be achieved by implementing the suggested modeling scenarios (Kulak, Nemecek, Frossard, & Gaillard, 2016).

9.3 Assessment of Sustainability in Local and global FSCs

Climate-dependent food products, different types of production in other countries, year-round availability, and consumer preferences are considered as key reasons for Global trade growth in the food sector, which has led to increasing transportation distances and environmental burdens from associated GHG emissions and energy consumption. Therefore, there is an urgent need to address issues related to the assessment of different potential sources of food in terms of energy and resource use and other sustainability measures (Webb, Williams, Hope, Evans, & Moorhouse, 2013). Gold et al. (2017) investigating barriers of integrating sustainability performance in global agri-food supply chains by businesses such as Nestlé, PepsiCo, Unilever, and Mondelez International. The article presented an empirical analysis that provides a

framework for managers and academics to develop a more sustainable FSCM (Gold, Kunz, & Reiner, 2017).

10. Collaboration in SFSCM

Collaboration in the food supply chain plays a critical role in achieving sustainability, and food safety and quality improvement by different stakeholders (Ilias, 2014). There is a need to develop integrated models for collaboration that consider complexities in SFSCM (Dania, Xing, & Amer, 2016). Dania et al. (2016) provided a thorough literature review of integrated collaboration in SFSCM from vertical and horizontal perspectives. Findings showed that the social aspect of sustainability is not covered at the same level as economic and environmental aspects (Dania et al., 2016). Tidy et al. (2016) examined the use of supplier relationship management and formal supplier engagement programs for GHG emissions reduction in the UK supermarket sector. By analyzing data from sustainability reports, the research found that despite the progress in sustainable supply chain management, the use of supplier relationship management is variable in application (Tidy, Wang, & Hall, 2016). Leon-Bravo et al. (2017) analyzed current vertical and horizontal sustainable collaboration practices in the FSC. Moreover, the study identified sustainability performance areas in different FSC stages, including farming, processing, distribution, and retailing. Results showed that collaboration with upstream stages, namely farming, has the highest priority, as these actors are accountable for ensuring product safety and quality (León-Bravo, Caniato, Caridi, & Johnsen, 2017). Soysal et al. (2018) developed a model to study the influence of horizontal collaboration related to perishable products in order to reduce energy use, CO_2 emissions, food waste, and logistics costs in the Inventory Routing Problem (IRP). Results showed that by implementing the proposed model, aggregated total cost and emissions in the logistics system decreased in the range of 4-24% and 8-33% based on parameters changes, respectively (Mehmet Soysal, Bloemhof-Ruwaard, Haijema, & van der Vorst, 2018).

Conclusion and Future Research in SFSCM

So far, incorporating sustainability into food logistics models in literature is insufficient. Sustainability key performance indicators such as GHG emissions need to be integrated with cost,

quality and responsiveness goals by using multi-objective programming models. These models will improve food systems in terms of quality, safety, availability and sustainability.

Issues related to uncertainty in SFSCM are not generally considered in the literature. Food industry involves many uncertain parameters including information availability, supply, demand and process uncertainties. Including these uncertainties in the design model will capture the complexity of real-life food systems and improve model responsiveness. Another issue is that considering food perishability requires more integrated models than the linear decay models found in the literature. Researchers should develop Quality decay models so that they include all the sustainability-related parameters and allow quality to fall below the minimum level to integrate food waste issues into the model. SFSCM tactical issues that need to be considered include evaluating the environmental impact of SFSCM by analyzing the life cycle assessment of food products, processes, and systems through all the supply chain stages. Considering production sustainability improvement by selecting efficient machines and utilizing land and location to the maximum benefit. Sustainable inventory management by controlling energy use for maintaining food in storage facilities. Sustainable food transportation by considering reducing GHG emissions and fuel consumption.

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RICH CLUBS IN THE CONTEXT OF SUPPLY CHAIN NETWORKS: DETECTING INDIRECT CONNECTIVITY

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Abstract:

Detecting complex structures formed by supply chain partnerships is crucial for understanding issues such as risk propagation, innovation diffusion, and the flow of goods and information. Traditional social network analysis (SNA) offers many concepts that may be useful, including the *rich club* phenomenon – a higher likelihood of the most well-connected entities to connect with similarly dominant network members. This study argues that, when transferred to a supply chain context, such measures nonetheless fail to capture hidden connectivity patterns, and thus we introduce the concept of an *indirect rich club.* This concept captures companies which may not appear particularly well-connected in a direct sense, but do possess a larger-than-usual reach throughout their supply networks, via intermediaries. We propose a way to quantify the rich club phenomenon to include indirect connectivity, and demonstrate its usefulness in analyzing a large network of supply chain partnerships over several years between 1998-2013. Numerical results indicate the indirect rich club phenomenon is substantial and growing with time, whereas the traditional rich club results are indeterminate. Detailed examination of the members of the 2013 rich club raises new research questions on the changing nature of modern supply chain structure, including the growing role of certain service industries such as real estate management in its growing complexity.

Keywords: supply chain networks, social network analysis (SNA), rich club phenomenon

RICH CLUBS IN THE CONTEXT OF SUPPLY CHAIN NETWORKS: DETECTING INDIRECT CONNECTIVITY

1. Introduction

Detecting complex structures in networks formed by supply chain partnerships is crucial for understanding issues such as risk propagation, innovation diffusion, and the flow of goods and information. The contrast between direct versus indirect connectivity is particularly salient to supply chain networks in that these measures translate directly into the "ground truth" of a company's *visible tier* versus those relationships beyond its immediate partners. Furthermore, authentic supply chains appear to be networks in which members with the most direct connections are not necessarily the same set of members with the highest indirect connectivity throughout the network. Figure 1 provides an example, illustrating the top companies in both cases, as reported under FAS 131 in the year 2013, an accounting standard that requires all publicly traded US suppliers to declare their major buyers. Within the resulting network of 4,584 total companies, only Walmart and the pharmaceutical distributor McKesson are present among the top ten companies with the most direct connections, also known as *degree centrality*, and the top ten companies for indirect connections, also known as *undirected 2-step reach*. Furthermore, Figure 1 indicates only eight of the top 25 companies make both lists, demonstrating a persistent distinction between these two network measures.

What the two measures alone do not reveal is whether companies on either side of Figure 1 have any particular propensity to link with each other. In network formation, preferentially connecting to well-connected others, when one is already well-connected, is known as the *rich club* phenomenon (Colizza *et al*., 2006), graphically rendered as dense hub-and-spoke structures whose centers are likewise linked to each other. However, in many real-world contexts, direct links among otherwise well-connected hubs may not be present, but this condition does not preclude indirect connection through the sharing of neighboring nodes. An example would be competitors such as Walmart and Costco, who may not connect through market transactions, but may share many suppliers, or have exclusive suppliers who share common sources. The absence of a direct link between two companies does not negate the risks inherent in sharing indirect connections, an

"indirect" rich club effect that can actually hurt them. One example suggestive of the riskier nature of indirect rich club membership is the 2013 Takata airbag scandal, where a structure of indirect ties between separate but well-connected automotive manufacturers ultimately hosted a synchronized wave of product recalls across Daimler, Honda, Ferrari, and others. In this paper, we examine the traditional understanding of the rich club phenomenon in authentic supply chains, and adapt this concept to illuminate indirect connectivity in those same settings. Results from supply chain networks between 1998 and 2013 indicate that this indirect rich club connectivity is growing, raising new questions about the changing nature of risk in supply chain management.

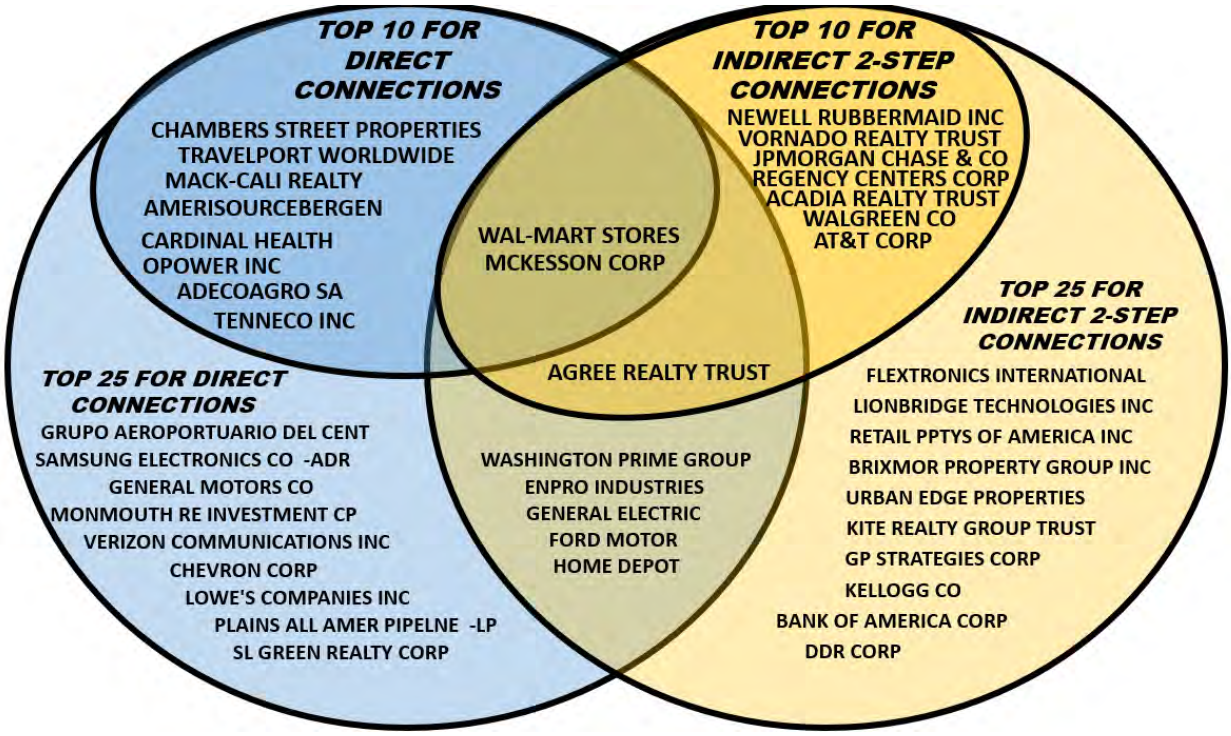

Figure 1. Top 25 firms for directed versus 2-step indirect connectivity across all partnerships reported under FAS 131 in 2013.

2. Related Literature

The theoretical gap motivating this study is formed by two research trends, one in the domain of social network analysis (SNA) and the second in supply chain management. In the first case, extant social network research focuses on node-, dyad-, and network-level measures, with most

research targeting the node- and network-paradigms. Node-level measures quantify the nature of a particular node's embeddedness within its network as a whole; examples include degree centrality and reach, mentioned earlier. In the rarer case of dyads, where the issue of interest is the relationship between two particular nodes in a complex network, studies are largely confined to the condition of being directly connected or, at most, sharing immediate neighbors, expressed as a *topological coefficient* (Goldberg & Roth, 2003; Stelzl *et al*., 2005). Investigations into the defining characteristics of whole networks have been galvanized by the seminal work of Barabási and Albert (1999), who distinguish between complex network classes according to their connectivity (degree) distributions, exponential versus scale-free. Prior to this, the dominant network archetype in social network analysis was exponential, a class which includes random graphs and "small worlds," where all nodes have a comparable number of connections. Degree connectivity within an exponential network follows a Poisson distribution, peaking and then decaying exponentially, minimizing the probability of any unusually "rich" or well-connected nodes. Barabási and Albert (1999) observed however, that many complex, large-scale networks in the real world have connectivity distributions that follow a *power law*, independent of the scale of the network, i.e. they have a scale-free property. The logic used to establish the scale-free concept is that earlier exponentially-generated networks fail to incorporate the principles of growth and *preferential attachment*, both of which are active in the formation of many existing networks. When added to a network-generation algorithm, these two components drive the power-law scaling observed in many real world contexts, characterized by the presence of a few influential nodes whose number of direct connections greatly exceeds the average.

As networks grow, preferential attachment may be expressed as *assortativity*, where nodes with similar degrees tend to connect with each other (Catanzaro *et al*., 2004). Colizza *et al*. (2006) propose a way to quantify the *rich club coefficient*, measuring the strength of assortativity among "rich" or highly connected nodes in particular. The authors evaluate a variety of networks previously examined by Barabási and Albert (1999), including protein interactions, the Internet, air transportation, and scientific citations. For all these networks they discover a monotonically increasing rich club coefficient, but warn that this alone does not necessarily indicate the presence of a rich club phenomenon. An upward trend can also be the natural consequence of high-degree nodes being simply more likely to connect than low-degree nodes, by virtue of the condition that

they have more links to share. Thus, it is important to consider rich club coefficient values relative to what can be expected from the same data in random cases.

Concurrent to the SNA research initiated by Barabási and Albert (1999), network-oriented supply chain research has likewise grown (Bellamy & Basole, 2013). From the outset, network analysis in supply chain management has been heavily focused on the node-level, particularly the use of those node-level centrality measures that have seen the greatest uptake across multiple disciplines outside their native domain of sociology (Borgatti, 2005). In supply chains, these measures have been employed to investigate a variety of outcomes, such as their ability to detect "focal players" in a complex industry network (Yu *et al*., 2008), to describe bottlenecks (Mizgier *et al*., 2013) or to drive firm-level outcomes such as innovation (Bellamy *et al*., 2014) and productive efficiency (Kao *et al*., 2017). Although supply networks have long been recognized as complex systems (Choi *et al*., 2001), relatively little attention has been paid to the topological characteristics of whole networks. Li *et al*. (2010) are, to our knowledge, the first to attempt a rigorous categorization of whole network structure. Both the Complex Supply Networks Evolving Model (CSNEM) used in their simulations and the empirical evidence from the supply networks of three U.S. automotive manufacturers are consistent with supply chains as further example of authentic scale-free networks. Among the few remaining studies focused on network typology, Tang *et al*. (2016) theorize that supply chains consist of both directed physical networks and undirected cyber networks, and observe in a series of simulations the relationship of these structures to network robustness. Giard and Sali (2013) identify supply chain network structure as one of the seven root causes of the bullwhip effect, whereby they distinguish between the following structural configurations: dyadic (single customer with a single supplier), serial (a succession of nodes where each node has at most one predecessor and one successor), convergent (each node has at most one successor but may have multiple predecessors), divergent (one predecessor but any number of successors), and general. The authors observe that most of the existing supply chain literature focuses on dyadic and serial configurations only when discussing the bullwhip effect, and argue that although these two configurations may help explain downstream distribution supply chains, other configurations may be more beneficial in understanding upstream production systems. Adopting Giard and Sali (2013)'s structural typology, Dominguez *et al*. (2015) employ simulation-based scenarios with stochastic demand, and observe the bullwhip effect tends to

increase with number of nodes and structural divergence of the network. Although it is evident from the emerging literature that supply chain network structure represents a significant opportunity for future work, it is also clear that there is a lack of unifying theory that can describe real-life supply networks in a generalizable and yet parsimonious way. This paper is the first of which we are aware to explore the network-level rich club phenomenon in the context of supply chain management, and it assists in theory building by both assessing the traditional SNA understanding of that measure, and by extending that framework to include indirect connections potentially more salient in the case of supply chain management.

3. Methodology

3.1. The Rich Club Coefficient

Colizza *et al*. (2006) provide an analytical expression for the evaluation of the *rich club phenomenon* in a network *G* consisting of *E* edges (links) between a set of *N* nodes. This structural network property is intended to detect when nodes with a large number of links ("rich" nodes) tend to form inter-connected subgraphs ("clubs") more readily than low-degree nodes. To measure the extent of this phenomenon, the authors present the following expression of the *rich club coefficient*:

$$\varphi(k) = \frac{2E_{>k}}{N_{>k}(N_{>k} - 1)}$$

where $N_{>k}$ is the number of nodes with at least *k* connections and $E_{>k}$ denotes the number of edges among that subset of nodes. This proportion is equivalent to the density of the subgraph *G*', a smaller network consisting only of the $N_{>k}$ nodes with at least *k* connections, and only those edges that exist among them. In general, network density is the proportion of edges present relative to all possible edges that could be present among that set of nodes. Indeed, calculation of the rich club coefficient at the lowest membership threshold level, $k = 1$, returns the density of the network under evaluation.

3.2. Adapting the Rich Club Coefficient to Indirect Connections

Figure 2 illustrates a simple network with 20 nodes and 23 edges, yielding a network density of $\varphi(1) = \frac{2*23}{20*19} = 24.2\%$. From the threshold level of $k = 3$ through to $k = 8$, three nodes, labeled

as firms, dominate as obvious rich club members, with one edge meeting that same threshold, labeled "Traditional Rich Club Connection." Thus, the rich club coefficient, which we will refer to as the traditional rich club coefficient from this point forward, would be $\varphi(3) = \frac{2*1}{3*2} = 66.7\%$. As discussed earlier, the rich club phenomenon is not quantified by any particular value at any particular level of *k*, but rather by the stark increase in the coefficient as *k* is increased.

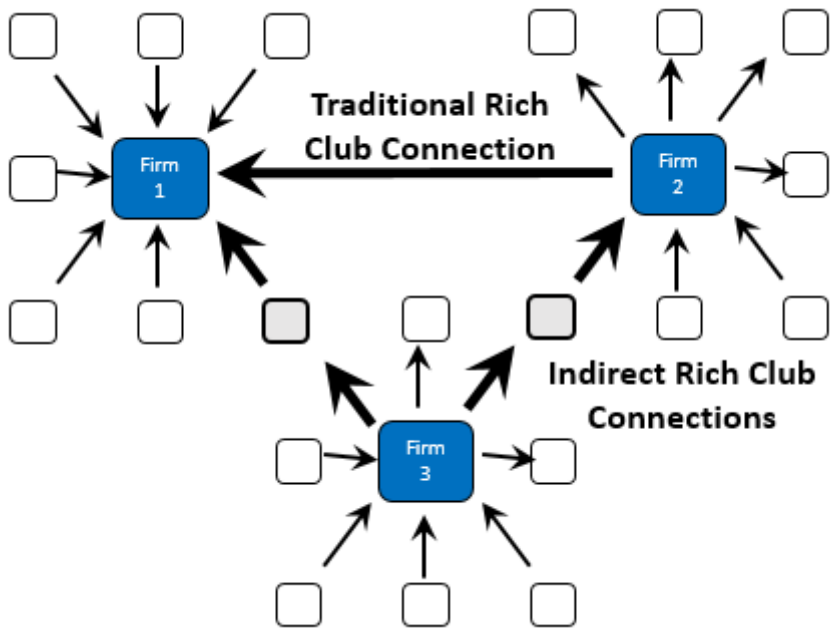

Figure 2. Example network diagram with three "rich club" nodes (firms)

At this point, it is important to note that Firm 3 in Figure 2 is considered a rich club "member", but not viewed as connected to fellow club members in a traditional sense. However, Firm 3 is clearly associated with Firms 1 and 2 in a supply chain sense, in that it serves as a second tier supplier to both in the Figure 2 illustration. In this study, we wish to capture associations that rich club members may have in common through a common partner, and so we propose an *indirect rich club coefficient*, recognizing all 2-step paths as connections, the total number of such paths denoted as $P^{2\text{-step}}$. The indirect rich club coefficient is then:

$$\varphi'(k) = \frac{2(E_{>k} + P_{>k}^{2-\text{step}})}{N_{>k}^{2-\text{step}}(N_{>k}^{2-\text{step}} - 1)}$$

where $N_{>k}^{2-\text{step}}$ is the number of nodes with undirected 2-step reach of k or greater, and $P_{>k}^{2-\text{step}}$ denotes the number of 2-step paths among that subset of nodes. In any instance of k, the paths being tallied under $P_{>k}^{2-\text{step}}$ are undirected paths, meaning that the association between the two nodes at each end of a supply chain path might be the relationship of a second tier supplier to a buyer, as pictured in Figure 2, or the conditions of two firms sharing a client or a supplier. Each of these three scenarios is considered a significant association here. In the case of the Figure 2 illustration, $\varphi'(3) = \frac{2*(1+2)}{3*2} = 100\%$, as the three firms are fully interconnected via direct or 2-step indirect relationships.

3.3 Data and Methods

To explore the rich club phenomenon in the context of supply chains, we use *Compustat* to retrieve all major customers reported by publicly traded US suppliers in compliance with Financial Accounting Standards (FAS) 131 (1997). These disclosures represent major supply chain partnerships that span multiple industries, creating large-scale networks. In this study, we retrieve the data necessary to construct such networks for the years 1998, 2004, 2009 and 2013 (depicted in Figure 3).

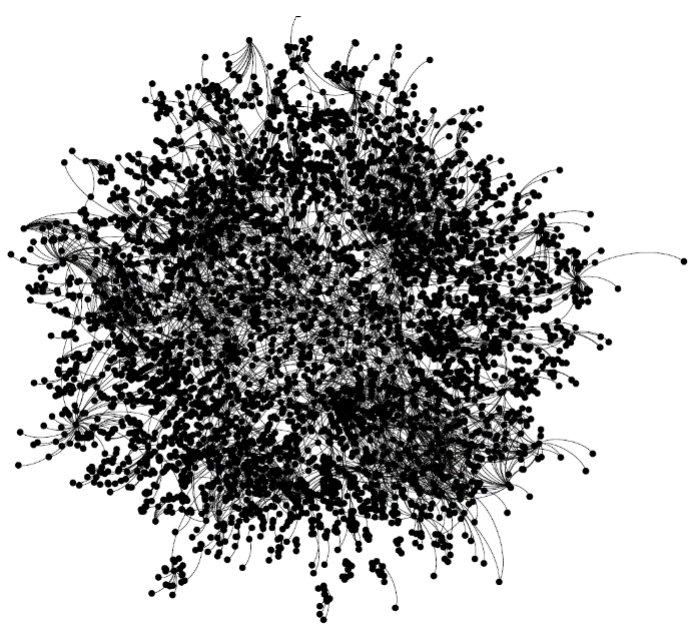

Figure 3. 2013 FAS 131 Supply Chain Network; 4,584 firms (nodes) and 6,111 partnerships (edges).

To discriminate between potential rich club phenomenon and any random tendency for well-connected nodes to connect to one another, we generate random networks of the same size and density as the Figure 3 network, using the network analysis software package *Gephi*.

4. Results and Discussion

4.1 Measuring the Traditional Rich Club Phenomenon in Supply Chain Networks

Table 1 provides rich club coefficient values ($\varphi(k)$) at various levels of threshold k for the FAS 131 supply networks in 1998, 2004, 2009 and 2013, while Figure 4 illustrates these levels across all levels from k =1 to 55. Both suggest the rich club phenomenon is present, as the coefficient increases in value across higher levels of k, although not in the monotonic fashion observed in the coefficient's application to benchmark data sets from other domains (Colizza *et al*., 2006). Rather, all four years adhere to a pattern of initial increase, followed by a distinct plateau and/or shallow retreat, until k hits another threshold and value starts climbing again. This implies there may exist a band of moderately high direct connectivity whose members are perhaps *disinclined* to connect directly to one another, thus dramatic coefficient levels will not be observed until k is raised beyond the upper end of this band, eliminating this group.

Table 1. Traditional Rich Club data for the FAS 131 Supply Chain Networks, at varying levels of membership threshold k

	-1998-		-2004-		-2009-		-2013-	
	Rich Club Size	Rich Club Coeff. (φ(k))	Rich Club Size	Rich Club Coeff. (φ(k))	Rich Club Size	Rich Club Coeff. (φ(k))	Rich Club Size	Rich Club Coeff. (φ(k))
k=1	4708	0.0004	3783	0.0006	4516	0.0005	4584	0.0006
k=5	191	0.0055	296	0.0098	493	0.0079	563	0.0087
k=10	74	0.0070	85	0.0157	176	0.0186	224	0.0227
k=15	37	0.0045	36	0.0349	85	0.0283	119	0.0316
k=20	25	0.0067	21	0.0143	50	0.0286	70	0.0381
k=25	19	0.0058	15	0.0286	24	0.0399	34	0.0374
k=30	15	0.0095	11	0.0545	12	0.0606	19	0.0351
k=35	12	0	10	0	6	0	13	0.0256
k=40	9	0	6	0	4	0	10	0.0222
k=45	8	0	4	0	4	0	5	0.1000
k=50	8	0	0	n/a	3	0	0	n/a

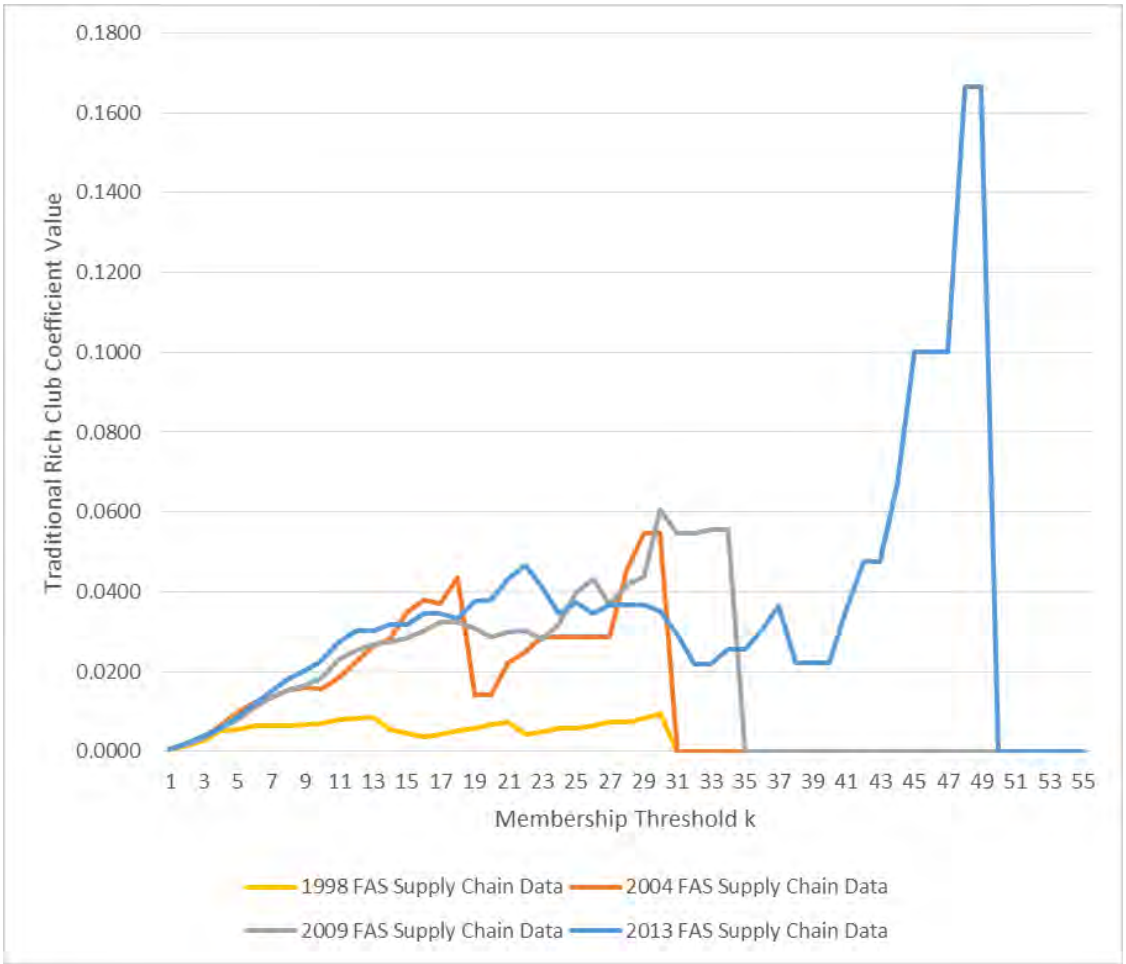

Figure 4. Traditional Rich Club Coefficient over varying values of membership threshold value *k*, for four select years in the FAS 131 Supply Chain Networks

While inspection of Table 1 and Figure 4 does suggest that the rich club phenomenon has grown stronger from 1998 to 2013, it should be noted that even its peak value of 16.67% in 2013, shared by the top four firms for direct connections, is not a particularly high number; indeed, the top four firms for direct connections only share one link between them. Gauging whether that occurrence in fact represents any significant preference of highly connected firms to connect to peers requires comparison of these values to those that would occur if the same number of network nodes were connecting at random through the same number of connections. Figure 5 compares the 2013 rich club coefficient values to the mean rich club values observed in a set of equivalent networks generated at random (4,584 nodes and 6,111 edges in each network). Here it can be seen that, despite the relatively modest coefficient values, the preferential attachment that is captured

in those values is occurring at significantly higher rates than at random. Nonetheless, with a peak density of 16.67%, a tendency for the most highly connected firms to be connecting to one another directly cannot be positioned as a pervasive or even strong description of the underlying data set.

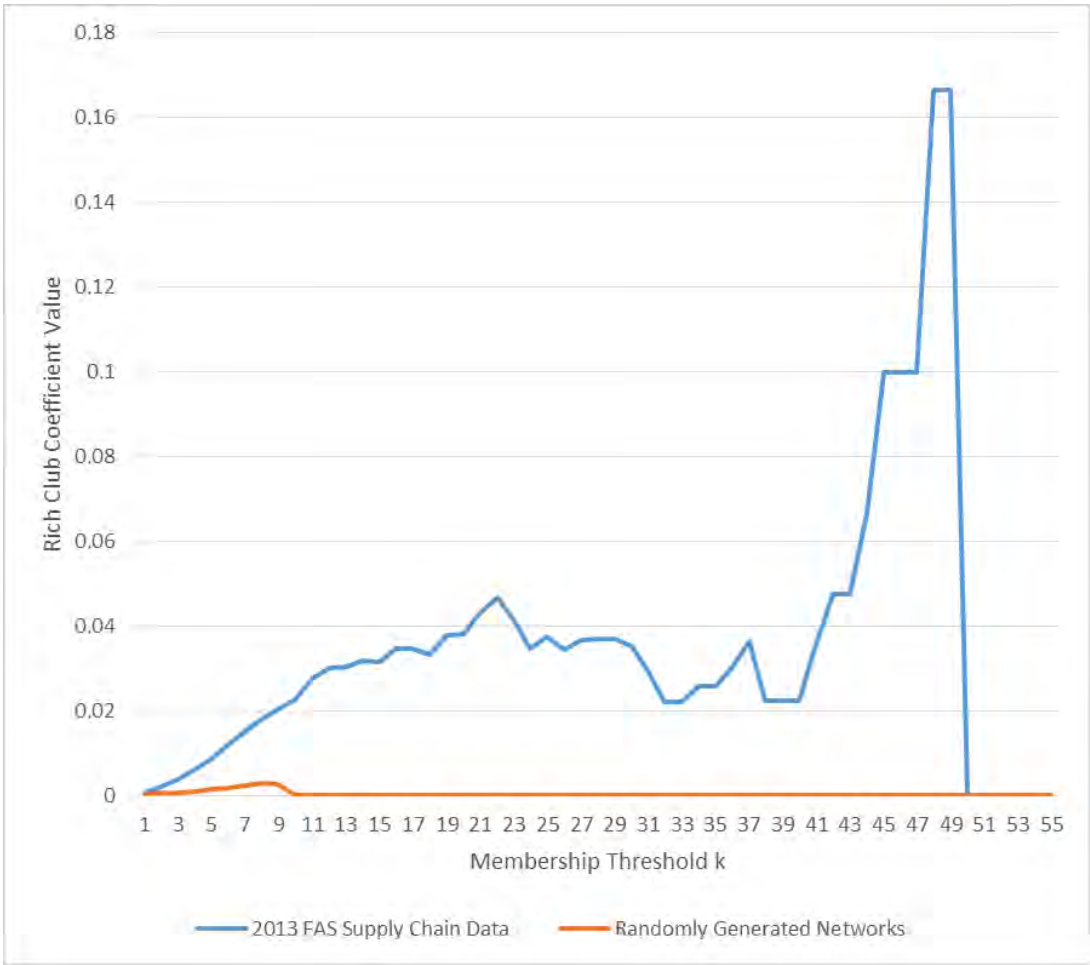

Figure 5. Traditional Rich Club Coefficient over varying values of membership threshold value *k*, 2013 FAS 131 Supply Chain Network contrasted against the mean of six randomly generated networks of the same dimensions

4.2 Measuring the Indirect Rich Club Phenomenon in Supply Chain Networks

The indirect rich club coefficient $\varphi'(k)$ detects the same phenomenon as the original coefficient, with the exception of broadening of the concept of preferential attachment to include the sharing of a partner, such as co-reliance on a certain supplier, or partnership with the same client. This broader measure results in interesting patterns over the four years of data in Figure 6,

differing from the traditional measure in Figure 4. Whereas the highest value of interest for *k* for the traditional rich club is 50 companies, recognizing 2-step indirect relationships increases the measured reach of the richest members five-fold, apparent in comparison of Table 1 with Table 2. Furthermore, where Figure 4 suggests highly irregular growth in the coefficient as *k* increases, Figure 6 reveals a distinctly smoother progression, terminating at a dramatically higher peak of $\varphi'(k)$ = 100% in all four years. Despite the presence of valleys similar to those observed in Figure 4, these periods occur closer to the upper *k*-limit in all four years, and are markedly shallower.

Given that the pattern of traditional rich club connectivity is accepted as distinct from random networks (Figure 5), this same comparison is even more pronounced for the indirect rich club coefficient (Figure 7). However, Figure 5 illustrates how the traditional measure departs from randomly driven levels immediately upon increase of *k*. In contrast, Figure 7 shows that over low levels of *k*, the indirect coefficient maintains only a thin margin over random, until a threshold is crossed at *k* =42, at which no such entities are observed in the random networks, but the supply network continues to provide hundreds of examples, and the strength of their preference for one another continues rising. This may indicate that the indirect coefficient may be of the greatest utility in the study of those firms with particularly high 2-step indirect reach.

Table 2. Indirect Rich Club data for the FAS 131 Supply Chain Networks, at varying levels of membership threshold *k*

	-1998-		-2004-		-2009-		-2013-	
	Rich Club Size	Indirect Rich Club Coeff. (φ'(k))	Rich Club Size	Indirect Rich Club Coeff. (φ'(k))	Rich Club Size	Indirect Rich Club Coeff. (φ'(k))	Rich Club Size	Indirect Rich Club Coeff. (φ'(k))
k=1	4708	0.0037	3783	0.0044	4516	0.0044	4584	0.0050
k=25	924	0.0701	661	0.0913	1004	0.0520	1284	0.0413
k=50	570	0.1455	321	0.2653	439	0.1504	540	0.1162
k=75	347	0.2564	185	0.6069	249	0.3260	302	0.2418
k=100	275	0.3542	154	0.8535	184	0.5364	218	0.3957
k=125	59	0.8369	148	0.9224	158	0.7058	172	0.5745
k=150	3	1.0000	51	0.9302	34	0.6845	58	0.4906
k=175	1	0	7	1.0000	11	0.7818	30	0.5149
k=200	0	n/a	2	1.0000	5	1.0000	18	0.5948
k=225	0	n/a	0	n/a	3	1.0000	7	0.9048
k=250	0	n/a	0	n/a	2	1.0000	3	1.0000

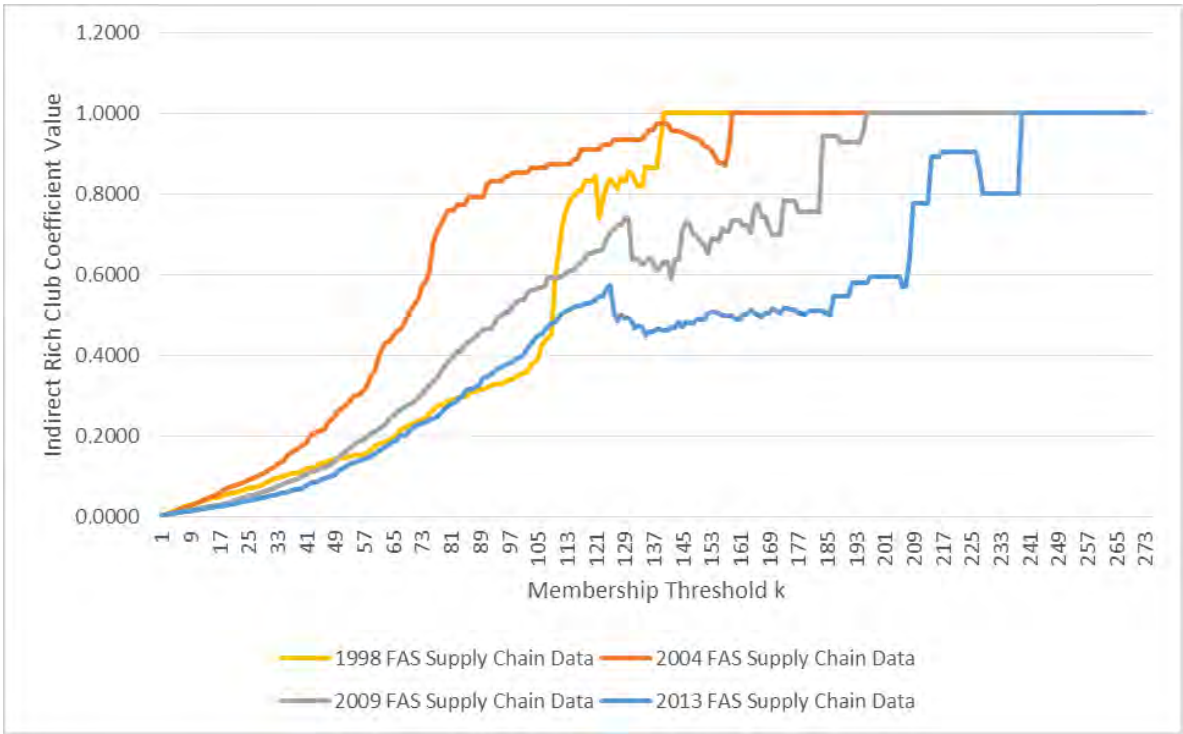

Figure 6. Indirect Rich Club Coefficient over varying values of membership threshold value *k*, for four select years in the FAS 131 Supply Chain Networks

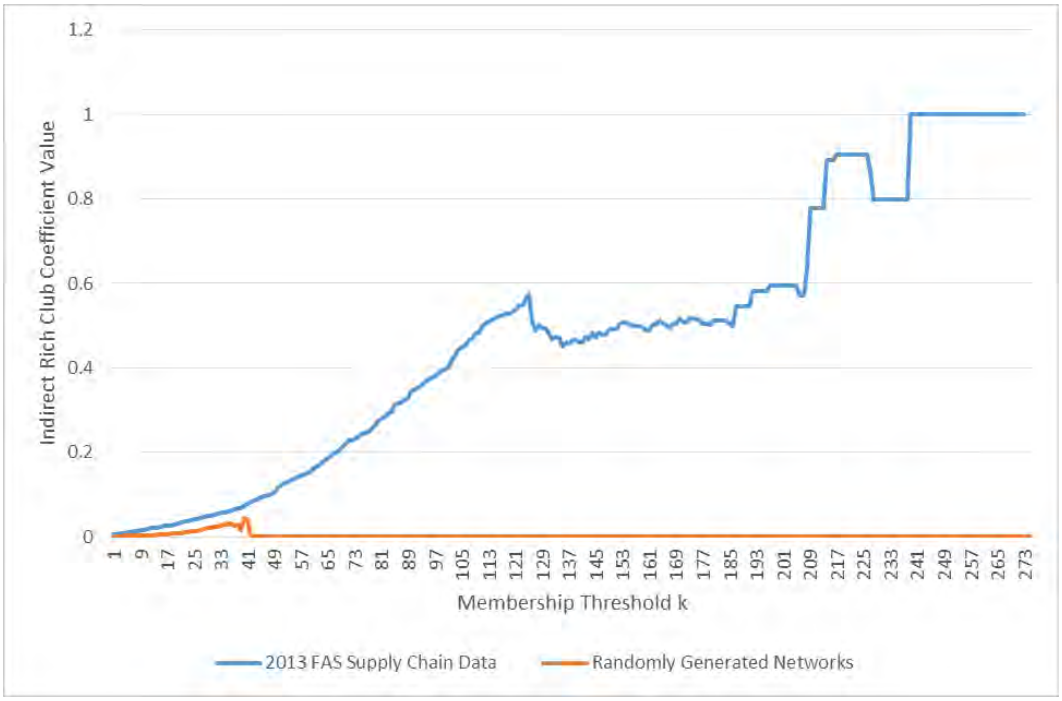

Figure 7. Indirect Rich Club Coefficient over varying values of membership threshold value *k*, 2013 FAS 131 Supply Chain Network contrasted against the mean of six randomly generated networks of the same dimensions

4.3 Examination of the 2013 Indirect Rich Club Members

While results confirm a distinct and growing indirect rich club phenomenon among the FAS 131 supply chain partners, we have yet to examine the rich club membership itself for insight. Table 3 reveals those companies present in the 2013 indirect rich club at the membership threshold $k = 200$, a requirement that each firm possess a direct or indirect 2-step connection to at least 200 other firms to "belong" to the club. As Table 3 demonstrates, reliance on traditional SNA measures alone does risk overlooking important patterns of connectivity that may be crucial to supply chains in particular. Here, traditional focus on direct connections (degree centrality) could lead to tunnel vision centered on certain highest-degree actors such as Walmart, while diverting attention away from other potentially crucial nodes with seemingly limited supply network power, such as the indirect rich club manufacturer Kellogg Co.

Table 3. 2013 FAS data Indirect Rich Club membership at threshold *k*=200

Company Name	Industry	2-Step Indirect Connections (Undirected 2-step reach)	Direct Connections (Degree Centrality)
WAL-MART STORES INC	General Merchandise Retailing	374	125
MCKESSON CORP	Medical & Pharma Distribution	273	49
AGREE REALTY CORP	Real Estate	266	37
VORNADO REALTY TRUST	Real Estate	240	16
JPMORGAN CHASE & CO	Commercial Bank	238	21
REGENCY CENTERS CORP	Real Estate	227	26
ACADIA REALTY TRUST	Real Estate	226	20
NEWELL RUBBERMAID INC	Plastics Manufacturing	216	11
AT&T CORP	Telephone Communications	213	21
WALGREEN CO	Drug Stores; Misc. Retailing	209	25
LIONBRIDGE TECHNOLOGIES INC	Translation Services	208	26
HOME DEPOT INC	Hardware Stores; Retailing	208	35
RETAIL PPTYS OF AMERICA INC	Real Estate	207	20
GP STRATEGIES CORP	Engineering Services	207	23
FLEXTRONICS INTERNATIONAL	Electronics Manufacturing	207	19
KITE REALTY GROUP TRUST	Real Estate	205	24
KELLOGG CO	Food Manufacturing	205	4
WASHINGTON PRIME GROUP	Real Estate	203	29

The network diagram provided in Figure 8 reveals further that the Table 3 rich club has a discernable sub-structure, in that there are two distinct types of club members and three distinct types of inter-club connections. The two categories of members with top indirect reach can be readily differentiated depending on the direction of supply chain interaction – seven "super clients" (left side of Fig. 8) and eleven "super suppliers" (right side of Fig. 8). Each of the two groups associates with the other through one of two different types of shared dependencies, the sharing of non-rich club suppliers (left) and the sharing of non-rich club clients (right). These two clusters are in turn bound together by traditional rich club direct connections (in bold in Figure 8), although almost no such connections are witnessed within the clusters due to the nature of those sub-clubs.

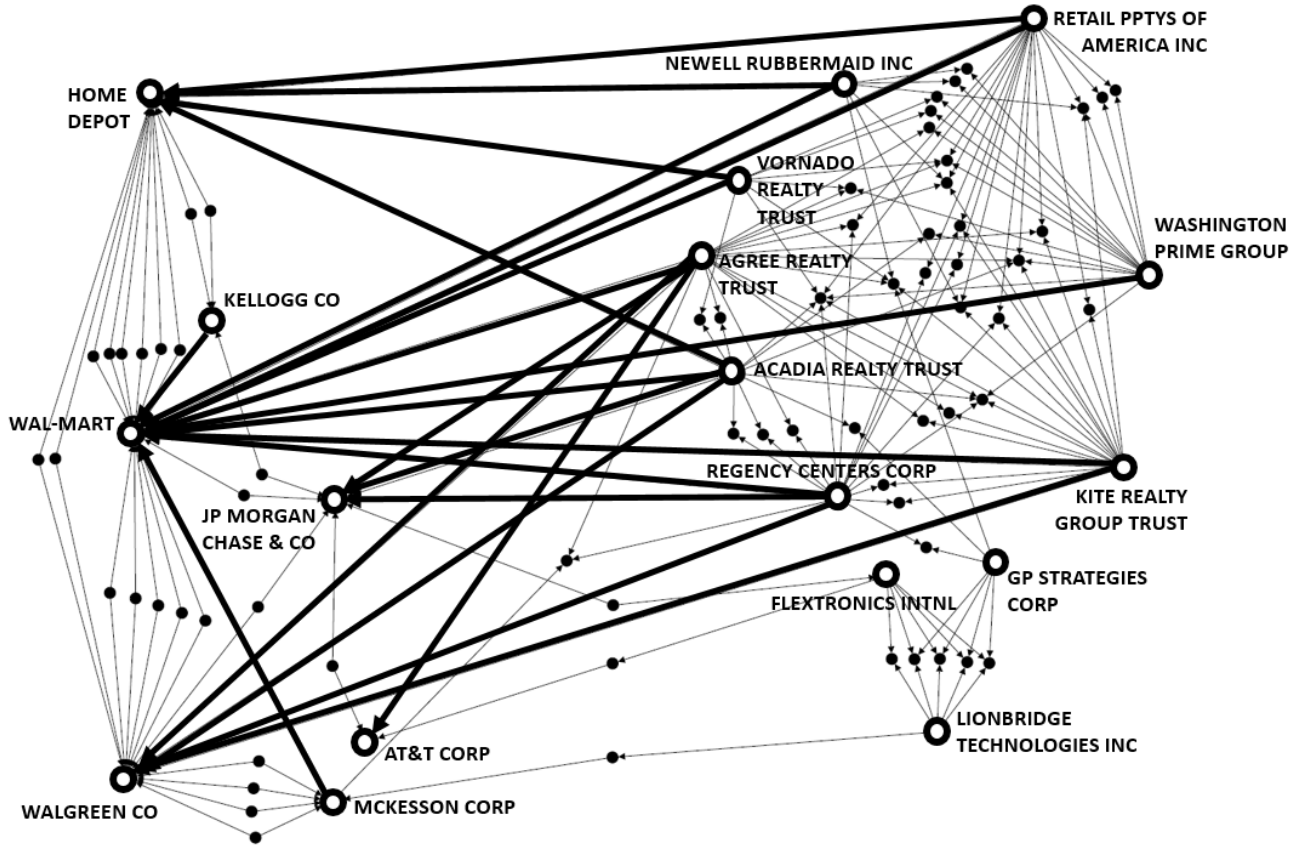

Figure 8. 2013 FAS data Indirect Rich Club network at threshold *k*=200, with traditional direct rich club connections in bold.

Super clients are primarily downstream firms in the retailing, communications, financial, or distribution industry, while the most prevalent super suppliers in the data set are in real estate, particularly real estate trusts and management companies. Unlike some supply partners endogenous to particular industries, such as consumer products manufacturer Newell Rubbermaid in its partnerships with Walmart and Home Depot, real estate management companies are observed supporting many different industries, due to a near universal need for facilities and an increasing trend toward outsourcing the ownership and care of those facilities. Indeed, almost all super suppliers that are directly shared by super clients are the real estate management companies, in some cases with up to four super clients in partnership with the same super supplier.

5. Summary and Conclusions

Traditional social network analysis (SNA) offers many concepts that may be useful to the study of supply chain structure. One example is the rich club coefficient, a measure to detect a higher likelihood of well-connected entities connecting with similarly dominant entities. In this study, we are the first we know of to study authentic supply networks through this lens, although we argue that, like many imports from SNA, the traditional rich club measure fails to capture hidden connectivity patterns, and thus we introduce the new concept of an *indirect rich club*. This concept captures companies which may not appear particularly well-connected in a direct sense, but do possess a larger-than-usual reach throughout their supply networks, via intermediaries. Indeed, our empirical results indicate only a mild tendency for preferential attachment among the most connected companies in our data, when measured in a traditional sense. In contrast, our indirect rich club measure reveals both a stronger phenomenon and clear growth in that phenomenon over four intervals between 1998 and 2013.

In-depth examination of the indirect rich club in our most recent network raises new questions on the changing nature of modern supply chain structure, as this club consists of super clients and super suppliers, but contains little evidence of firms that serve as intermediaries. Increasing levels of indirect rich club coefficient values between 1998 and 2013 indicate that previously independent areas of these large supply networks are becoming more interdependent through the acquisition of shared nodes. Furthermore, detailed study of the 2013 indirect rich club members suggests this

increasing indirect connectivity may be partially driven by the rise of facility ownership and property management as an outsourced service. This alone suggests opportunities for future research, as much of the extant literature on supply network structure focuses on the transmission of tangible product as the flow defining network links. However, application of our new measure to empirical data strongly suggests that the sharing of outsourced services is responsible for much of the growing supply network complexity in our time series. These dependencies, which represent risk exposure just as readily as the traditional understanding of a supply chain partner, would be overlooked if that understanding were framing the problem.

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USE OF GOAL PROGRAMMING IN DESIGNING A CLOSED-LOOP SUPPLY CHAIN NETWORK UNDER UNCERTAINTY

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Abstract

This paper proposes a model to design a Closed Loop Supply Chain network where uncertainty is considered in product demand and number of returned products. The proposed model takes into account the possibility of product substitution. There are three objectives considered; economical, environmental and service level objectives. The economical objective is to minimize the total cost of designing the network while the environmental objective is to minimize carbon emissions resulted from production, transportation and disposal processes by using carbon tax policy. The third objective is to find the optimal inventory level of each retailer. We utilize the advantage of robust optimization and goal programing to solve the uncertainty and multiple objective issue. A numerical example is introduced to demonstrate the validity of the proposed approach.

Keywords: *Closed Loop Supply Chain Network Design, Uncertainties, Goal programming, Service level*.

Introduction and related work

It is recognized that environmental deterioration, consumer awareness and industry revolution has driven supply chain decision makers to change the way they thought about it. In the past, classical supply chain was designed in a way that did not take into account the destiny of end of life (EOL) products. The number of which have risen due to rapid technology evolution. They include returned products for upgrading proposes, dissatisfaction or unprofitable to repair damaged products (Gupta, 2013).

Closed Loop Supply Chain (CLSC) replaced the classical supply chain by integration of forward and reverse logistics processes. This shift has been perceived economically and environmentally beneficial. It has led to a better control, recovery and reuse of products (Pazhani, Ramkumar,

Narendran, & Ganesh, 2013).

Design of CLSC network, which includes strategic decisions of CLSC management that extends to long-term planning, has widely taken researchers' attention. The majority of the research on designing the CLSC network is either intended to achieve a single objective or multiple objectives, by considering the environmental impact (Gupta & Ilgin, 2017; Ilgin & Gupta, 2010; Ilgin, Gupta, & Battaïa, 2015). As market competition increases, it is irrelevant to relay on existing models for designing the CLSC network. Integration of operational features into the problem of designing the CLSC network improves its optimality and sustainability, economically and environmentally (Baghalian, Rezapour, & Zanjirani, 2013; Pazhani et al., 2013).

Service level measures the competitiveness and efficiency of systems. One of the ways to evaluate service level is to associate it with inventory level. The service level of a retailer increases by increasing its inventory level. However, it elevates the chance of unsold products (Baghalian et al., 2013). Although the issue of service level was considered in designing the classical network, only a few studies took it into account when designing the CLSC network (Farahani, Rezapour, Drezner, & Fallah, 2014).

Problem description

A CLSC network consists of multiple alternatives of raw material suppliers, hybrid manufacturering/remanufacturering centers, warehouses and collection centers and retailers. To ship the products between the facilities in the CLSC, multiple transportation alternatives are evaluated. In the forward flow, the role of the hybrid manufacturing/remanufacturing centers is to produce new products and to remanufacture products using the raw material delivered from the suppliers and returned products, respectively. Finished products are shipped to the distribution centers and then shipped to the retailers. In the reverse flow, the EOL products are returned to the retailers. Returned products are then shipped to the collection centers, where they can be inspected and based on their condition, either shipped to be remanufactured or disposed of. The returned products shipped to the hybrid manufacturering/remanufacturering centers, also have different quality levels. In order to improve the service level at each retailer, product substitutability is considered using downward substitution policy. This policy is about new products substituting remanufactured products in case of shortage. In this problem, the uncertainties are allocated in the demand of new products, remanufactured products and number

of returned products.

The goal of the proposed model is to minimize the total cost of designing CLSC network, minimize the carbon emissions resulted from production, transportation and disposal processes. It also aims to determine the level of service at each retailer. The output of the proposed model is the optimal number and location of each facility type, production and transportation quantities, amount of purchased raw material and their supplier. It also determines the optimal quantity of new products to substitute remanufactured products and type of transportation mode to be used between the facilities.

Methodology

We propose an approach that combines robust optimization and non-preemptive goal programing. Mulvey, Vanderbei and Zenios (1995) proposed robust optimization approach that is appropriate for the problems experiencing a high level of uncertainty. The uncertainty parameters in this approach is represented as a set of scenarios and each scenario has a probability of occurrence. The non-preemptive goal programing is a Multiple Criteria Decision Making (MCDM) technique, which have been used widely to solve multiple objective problems in the area of environmentally conscious manufacturing and product design (ECMPR) (Gupta & Ilgin, 2017; Ilgin et al., 2015). The framework of the proposed model is as follow;

$$\text{MIN } Z = \sum_i W_i \ (d_i^+ + d_i^-) \quad (1)$$

$$s.t.\ f_i(X) - d_i^+ + d_i^- = y_i \quad (2)$$

$$Ax = b \quad (3)$$

$$B_{sc}x + C_{sc}y_{sc} + \delta_{sc} = e_{sc} \quad (4)$$

$$x + y_{sc} - \sum_{sc} \rho_{sc} (x + y_{sc}) + \theta_{sc} \geq 0 \quad (5)$$

$$x, y_{sc}, \delta_{sc}, d_i^+ + d_i^- \geq 0 \quad (6)$$

Where, d_i^+represents overachievement of the objective function i, d_i^-represents underachievement of the objective function i and W_i represents the weight of each objective function i. $f_i(X)$is the ith objective function and y_i is the aspiration level of the objective function i. Equation (3) is the design constraint while equation (4) is the variable constraint as defined by Mulvey et al. (1995). In equation (4), $\delta_{sc}$is the violation variable and e_{sc} is the

uncertainty parameter. Lastly, equation (5) is an auxiliary constraint used for linearization and (6) is non-negativity equation.

Numerical example

We consider a hypothetical CLSC network that consists of hybrid manufacturing/remanufacturing centers = 3, warehouse locations = 3, collection centers = 3 and retailers = 10 which include markets who demand only new product, only remanufactured product and demand new and remanufactured product. Table 1, 2, 3 and 4 summarized some of the data considered in the model. 3 road transportation modes are available to ship products between facilities in the CLSC where each mode has a specified size, carbon emission cost and transportation cost (Mohammed et al., 2017). A flat substitution cost = $10 is penalized for each product substituted. The tax of emitted carbon is $40/kg. The numbers of EOL products returned, demand of new and remanufactured products are considered uncertain. They are represented according to low returns/demand scenario, medium returns/demand scenario and high returns/demand scenario with probability of .2, .5 and .3 respectively. The first is to minimize the total cost of designed network and the weight of this objective is .5. The second objective is to minimize carbon emissions and its weight is .3. .2 is the weight of the third objective, which is about the service level. It is assumed that two components are required to produce one unit of product CO = 2. 50% of return products have minor defect, 30% have medium defect, 10% have high defect and 10% have serious defect. It is assumed that 20% of the returned products are disposed of.

Parameters	Values
Cost of opening hybrid manufacturing/remanufacturing centers	Uniform (500000, 1500000)
Cost of opening warehouse centers	Uniform (400000, 500000)
Cost of opening collection centers	Uniform (400000, 450000)
Production capacity at hybrid manufacturing/remanufacturing centers	Uniform (10000, 15000)
Capacity at warehouse centers	Uniform (3000, 3500)
Capacity at collection centers	Uniform (1000, 1500)
Capacity of raw material suppliers	Uniform (6000,7000)
Carbon emission in kg due to production of one unit of product	Uniform (2.1,2.3)

Table1: General data

Scenario	New product demand	Remanufactured product demand	Number of returned product
LOW	Uniform (1200, 1400)	Uniform (400, 750)	Uniform (400, 650)
MED	Uniform (1400, 1600)	Uniform (750, 950)	Uniform (650, 900)
HIGH	Uniform (1600, 2200)	Uniform (950, 1200)	Uniform (900, 1300)

Table2: Uncertainty parameters data

Transportation mode	Minimum capacity	Maximum capacity
Heavy duty truck	100	14000
Mid-size truck	100	10000
Light truck	100	5000

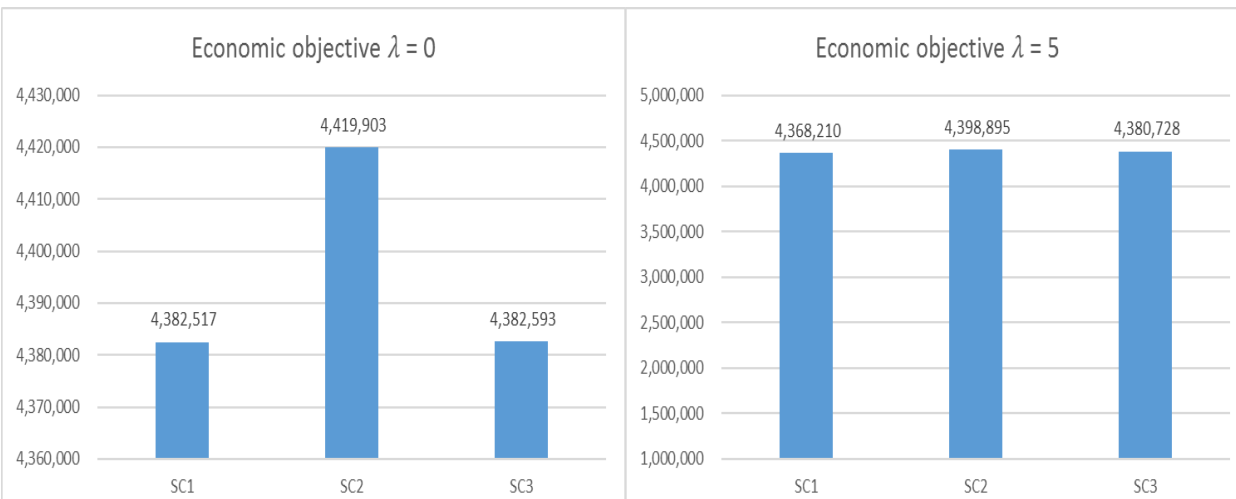
Table3: Transportation mode capacities

Transportation mode	Trans. Cost ($/ton-km)	Carbon emission (kg/ton-km)
Heavy duty truck	0.125	0.297
Mid-size truck	0.118	0.0252
Light truck	0.11	0.048

Table4: Transportation mode cost and carbon emission

Results and conclusion

After running the model using the above data, it can be seen in figures 1-3 that by increasing the value of λ, which controls the solution robustness as defined by Mulvey et al. (1995), the optimal solution of all three scenarios is closer to optimality. This applies to all three objective functions.



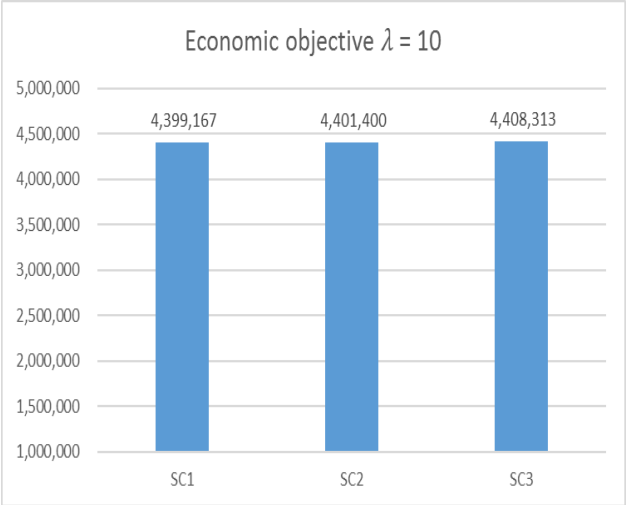
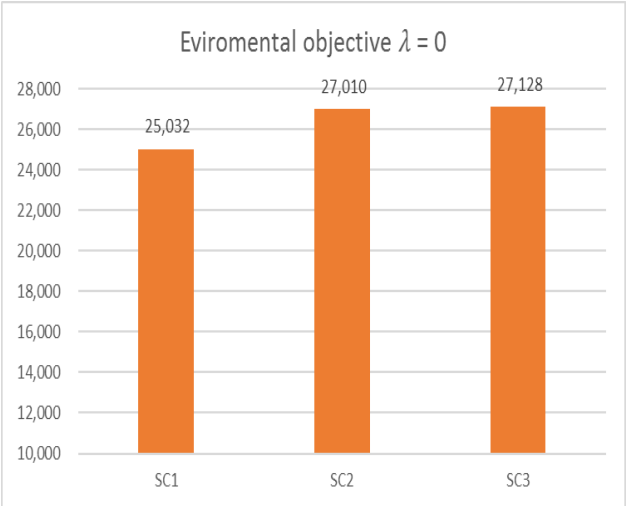
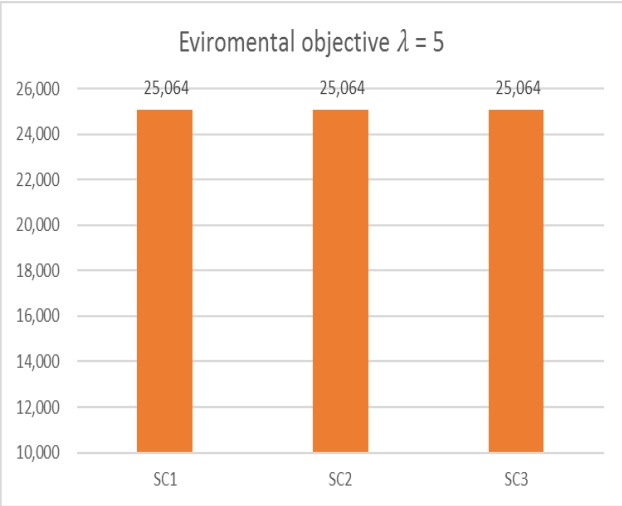


Figure 1: increasing the value of λ in the first objective function





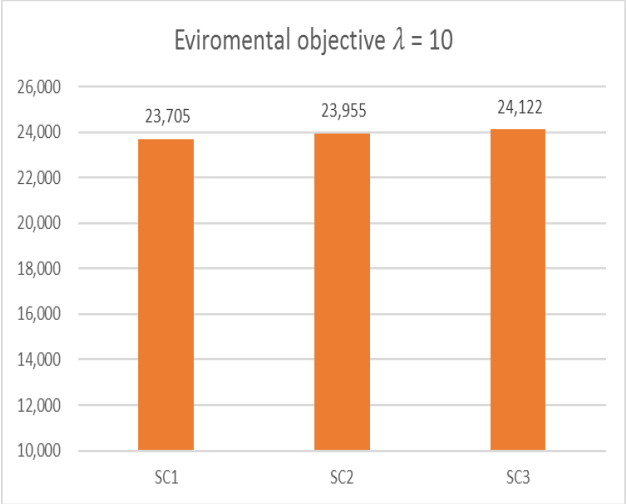
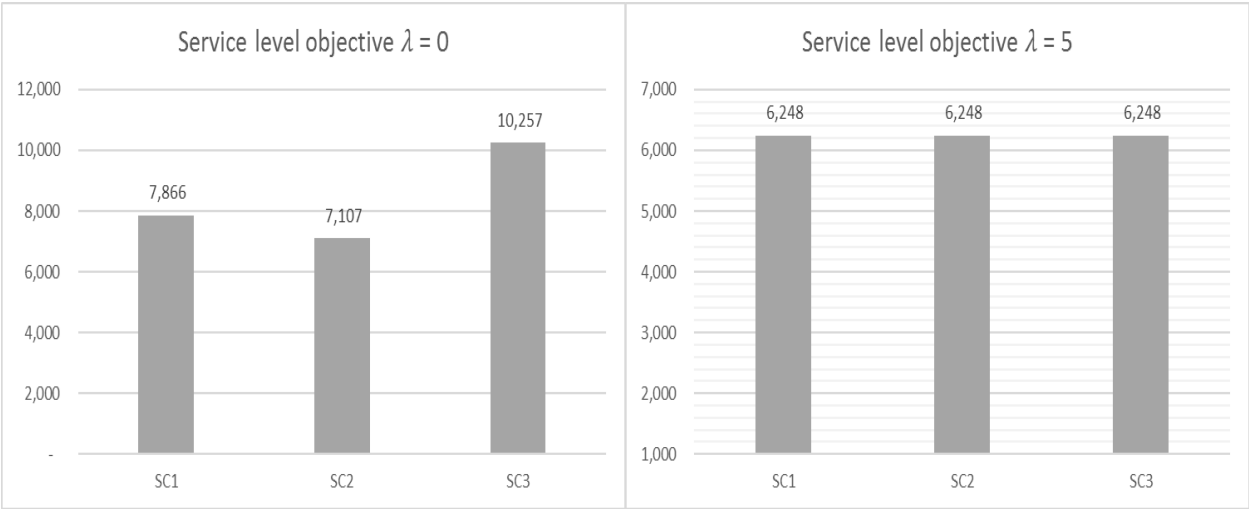


Figure 2: increasing the value of λ in the second objective function



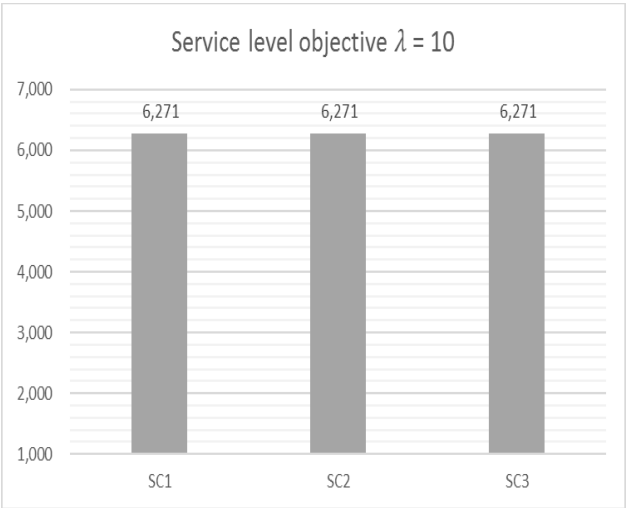


Figure 3: increasing the value of λ in the third objective function

This paper has presented a model to design CLSC network under multiple objectives and uncertainties. In the proposed model, we use carbon tax policy to consider the environmental issue and we allow product substitutability using downward substitution policy. To develop this model, we combine robust optimization and non-preemptive goal programing. The results demonstrated that increasing the value of λ increases the solution robustness for all of the objectives.

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SUSTAINABILITY - ABSTRACTS

A Trade-off between Sustainability Risks and Low-Cost in Outsourcing Contract Manufacturer Selection and Order Allocation

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Abstract

This paper develops an integrated model for supplier selection and order allocation considering supply chain sustainability (environmental, social, and economic) related risks. First, we identify supply chain sustainability-related risks for evaluating suppliers based on practice and extensive literature review. Second, these criteria are used to assess suppliers' sustainability risk performance using principal component analysis. Then, the min-max normalization is applied to principal component analysis scores to generate the suppliers' sustainability risk performance score, which are then utilized to select a set of qualified suppliers. Subsequently, the final supplier selection and order allocation is determined using a bi-objective mixed integer programming problem that maximizes supply chain sustainability performance while minimizing procurement cost. Thus, the proposed framework forms a decision support system for sustainable supplier selection and order quantity allocation. Finally, we present a case study of outsourcing contract manufacturers in the US apparel industry to demonstrate the applicability of the proposed framework in practice.

Keywords: Supply Chain Risks; Sustainability; Offshore Outsourcing; Principal Component Analysis

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AN EMPIRICAL EXAMINATION OF THE EFFECTIVENESS AND SUSTAINABILITY OF OPERATIONAL-LEVEL ENVIRONMENTAL MANAGEMENT PRACTICES IN U.S. MANUFACTURING FACILITIES

Abstract

A firm's operations system plays a critical role in its sustainable development effort because operations are directly related to the design, use, and improvement of the processes that consume physical resources to create and deliver products and services. Yet, the research on the operational-level environmental management (EM) practices is limited in the operations management literature. Using data from the U.S. Environmental Protection Agency (EPA)'s Toxic Release Inventory, this study aims to examine the effectiveness of the operational-level EM practices for improving environmental performance and the long-term effects of those practices at manufacturing facilities. The results of this study help to offer data-based insights about what are the critical practices that firms can utilize to effectively achieve better environmental performance and more importantly, lasting environmental improvements in long term.

Keywords: Environmental Management; Operations Management; Environmental Performance; Sustainability

AN EMPIRICAL EXAMINATION OF THE SUSTAINABILITY ACCOUNTING STANDARDS BOARD'S IMPACT ON REPORTING AND DISCLOSURE

Abstract

Sustainability concerns and the financial risks associated with environmental liabilities prompted the U.S. Securities and Exchange Commission (SEC) to issue interpretive guidance for registrants regarding disclosures related to these matters. The SEC's 2010 document is focused on four main themes: (1) impacts from existing regulation and legislation, (2) effects generated by international accords, (3) expected indirect results of new environmental protection rules, and (4) risk consequences on business activities connected with the physical effects of environmental alteration. Disclosures from these four areas are likely to create many questions and uncertainties about the materiality of sustainability financial risks.

The Sustainability Accounting Standards Board (SASB) has developed a wide array of measurement methods and reporting guidelines with respect to major industrial and service sectors in the U.S. economy. The SASB's efforts complement regulatory reporting as firms comply with mandatory SEC filings.

One of the most significant financial elements related to threats such as global warming is the risk that these phenomena might add costs to operating a company and reduce the firm's economic outcome. The empirical research described here is focused on disclosures about sustainability risks that a selected group of SEC registrants, those in the health services sector, made in connection with SEC disclosure guidance and the SASB's reporting standards.

This study seeks to determine whether firms in a high-profile sector of growing importance disclose their efforts at furthering sustainability. Data are gathered from the years 2008 through 2017 Form 10-K filings of every publicly traded SEC registrant in two cognate SIC Major Groups: #80—Health Services and #83—Social Services. All of the firms selected for study have a fiscal year ending date that would have made them subject to the new SEC guidance starting with financial reporting for year 2010. All of these firms are especially focused on a "business" that is imbued with the public interest in a unique way.

Both quality and quantity of disclosure regarding sustainability are considered with a content analysis approach. Years prior to the SEC action are included as part of the study so that an assessment can be made regarding the impact of the government's disclosure promulgation. Any additional efforts that firms exert to comply with the voluntary SASB promulgation (SASB metric HC0301-14: "Climate Change Impacts on Human Health and Infrastructure") are used to further assess transparency of the studied firms' disclosures and their posture toward sustainability and corporate social responsibility accounting.

The results of this research contribute to the area of financial analysis in a practical way. Financial markets impound decision-relevant disclosures in an efficient manner. Environmental risk assessments and reports of efforts at maintaining sustainability that are provided by management in publicly available disclosures like Form 10-K assist investors in making economically rational decisions. This is particularly true for social service enterprises, hospitals, and health-care delivery companies. These firms often cite the merits of being in harmony with the environment as part of their corporate social responsibility goals. Public policy makers, too, will find disclosures of this sort relevant as they continue to formulate market-based incentives to maintain physical sustainability, control greenhouse gases, and blunt the deleterious environmental effects of industrial pollution.

Keywords: corporate social responsibility, environmental disclosures, SASB, sustainability

AN INTEGRATED MRIO AND DEA APPROACH FOR RENEWABLE AND NONRENEWABLE ENERGY ANALYSIS OF THE U.S. MANUFACTURING

In this research, 16 U.S. manufacturing industries' direct and indirect economic and energy impact assessment is studied. Multi-region Input Output (MRIO) framework is merged with Data Envelopment Analysis (DEA) to assess the total energy use and the share of renewable to nonrenewable energy use of the U.S. manufacturing industries over a 20-year study period. The study period was determined based on data availability. Data were collected from World Input Output Database (WIOD). Results are compared in terms of the change manufacturing industries dependency on renewable and nonrenewable energy. Critical industries and countries in domestic and global supply chains are investigated.

Keywords renewable energy nonrenewable energy multi region input output analysis

FORECASTING ELECTRONIC WASTE FOR REVERSE LOGISTICS OPERATIONS USING IMPROVED GREY MODELS

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Rapid changes in technology and increasing consumer demand resulted in fast accumulation of waste of electrical and electronic equipment, namely WEEE or e-waste. Therefore, e-waste has emerged as one of the fastest growing municipal solid waste streams in the United States. Efficient management of e-waste becomes crucial to create and sustain green cities. Accurate e-waste predictions that municipalities can utilize to build appropriate reverse logistics infrastructures gain significance as waste collection, recycling and disposal operations become more unpredictable. The literature offers various methodologies focusing on prediction of e-waste generation. Among these, Grey Modeling (GM) approach has drawn attention due to its ability to provide meaningful results with utilizing relatively small-sized data. In order to improve the overall success rate of the approach, several GM-based models have been developed over the years. The performance of these models, however, heavily rely on the parameters used with no established consensus regarding the suitable criteria for better accuracy. To address this issue and to provide a guideline for academicians and practitioners, this study presents a comparative analysis of most utilized GM methods in the literature improved by Particle Swarm Optimization (PSO). A case study utilizing Washington State e-waste data is provided to demonstrate the comparative analysis proposed in the study.

Keywords: Electronic Waste, Improved Grey Modeling, Particle Swarm Optimization, Forecasting, Reverse Logistics.

A CURRENT AND FUTURE STATE OF ART DEVELOPMENT OF SUPPLY CHAIN MODELING OF SOLAR POWER INDUSTRY: A REVIEW

Abstract

With the concern of large pollution emissions from coal-fired power plants and new commitment to green energy, solar power industry is a recently emerged field. Large investment from industry, various formats of subsidies from government and future workforce expectations arise lots of practical decision making problems and have received growing academic attention. With the large number of quantitative models but without general framework, it is the time to have a systematic review. This project will study the mathematical models regarding to supply chain management proposed in the solar industry in the past 30 years and divide all the work according to different categorization schemes such as disciplines, the type of research problems and the methodologies. This paper concludes with suggestions for future research.

Key Words: Solar Power, Supply Chain Modeling, Literature Review

Value Depreciation and Price Gap for New and Remanufactured High-Technology Products

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ABSTRACT (Extended)

Governmental regulations for expansion of e-waste and customers' awareness of green goods drive the researches on environmentally conscious manufacturing and product recovery (ECMPRO). Based on the two survey papers about the studies in the area of ECMPRO, scientists' attention was on environmentally conscious manufacturing and material/product recovery. Then they extended the topics to product design for environment, closed-loop supply chain, and remanufacturing [1], [2]. Remanufacturing is a comprehensive and rigorous industrial process by which a previously sold, worn, or non-functional product or component is returned to a "like-new" or "better-than-new" condition and warranted in performance level and quality [3]. Remanufacturing practices have been implemented in many fields including heavy-duty equipment, motor vehicle parts, information technology products, medical devices, and retreated tires [4]. Researchers did thousands of studies on acquisition strategy, product recovery and production planning for durable goods. Only a few of them focused on marketing issues especially for short lifecycle products, such as high-technology products.

Because of fast technology development, high-technology products are replaced by the new generation models quickly. The value of the new products belonging to the early generation is depreciated because they are less demanding. Customers begin to purchase the new models and return the old ones. The end-of-use products are the supply for remanufacturing. However, customer's acceptance for remanufactured products is still lack. How to sell new products belonging to old generation and remanufactured products is critical for market sustainability of high-technology manufacturers. The market strategies including price decisions and feature designs should be attended.

This study is an extension of the previous study about price modeling for new and remanufactured Apple iPhones belonging to different generations [5], but focus on how technological features and customers' attention affect price differences between new and remanufactured products belonging to the same generation and value depreciation for new products when the later models become available. The customer's hit increase curves and fans

increase curves for different models are different. The results show that the shapes of curves do influence the price gap between new and remanufactured products. Besides, time since release and product thickness highly correlated with the value depreciation and the price difference between new and remanufactured items.

Keywords: Value depreciation, Product generation, Technology features, Customer attention

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SUSTAINABILITY - PAPERS

THE IMPACT OF SUSTAINABILITY PERFORMANCE AND TECHNOLOGICAL STRENGTH ON FIRM PERFORMANCE

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Abstract

This study empirically explores the strategic significance of corporate sustainability performance, corporate reputation, and technological strengths for a firm's economic performance in the leading corporations in North America and Europe. Based on 152 firms in North America and Europe, this study finds that technological strength and environmental performance has significant impact on market-based performance while they have insignificant association with accounting-based performance. Previous studies used either green performance or technological strength only when investigating its association with firm performance. Further those studies looked into either accounting- or market-based performance. This study combines them together and looks at the relationship from a wholistic standpoint. The findings contribute to new strategic implications of green strategy for corporate sustainability performance and its integrated synergy effect with technological strength on firm's financial and market performance.

Key words: Corporate Sustainability, Environmental Greening Strategy, Corporate Reputation, Technological Strength and Capabilities, Firm's Economic Performance

Introduction

In the face of various global competition, market uncertainty, and increasing pressure from shareholders and stakeholders over long-term firm sustainability, managers are looking for compelling and sustainable competitive advantages. The impact of corporate environmental sustainability and technology competences on firms' economic performance and their sustainable growth has developed into a critical dimension of competition in today's economic and business landscape.

Some studies have theoretically and empirically investigated the strategic impact of corporate sustainability and technological innovation and strength on a firm's financial performance (S. Jung, Nam, Yang, & Kim, 2018; Wang, Tong, Takeuchi, & George, 2016; Li, Jayaraman, Paulraj, & Shang, 2016; Sen, Roy, & Pal, 2015; Berrone, Fosfuri, Gelabert, & Gomez-Mejia, 2013; Jacobs, Singhal, & Subramanian, 2008). Few studies have investigated the impact of sustainability and technological strength on various economic performance measures at the same time. The significance of a greening strategy, corporate reputation, and technological capabilities may have a different impact on firm performance depending on which performance measures are used (E. H. Hall & Lee, 2008). The extant effects of green strategy and technological capabilities on a firm's economic performance may also vary upon functional controlling factors. While studies have confirmed that sound corporate sustainability and technological capabilities are financially profitable for firms (Artz, Norman, Hatfield, & Cardinal, 2010), the proactive effect of environmental sustainability and technological capabilities on firm's diverse economic performances are still unclear.

To address the above research issue, this study seeks to answer this question, "How does a green strategy and technology strength influence firm performance?" This study is an attempt to empirically investigate the strategic effect of corporate sustainability based on environmental strategy and technological capabilities concerning technology investment and technology strength on a firm's economic performances for various indices of

performance by utilizing accounting- and market-based performance. Further, this study aims (1) to explore the existence of a diverse set of linkages between greening strategy and technology factors and (2) to determine the relative importance of selected key strategic determinants like corporate green strategy, corporate reputation, and technology factors.

Hypothesis Development

A firm's strategic commitment to environmental greening issues for corporate sustainability has been an emerging challenge for global firms. Proponents of corporate sustainability advocate its significance as a way to increase market share and profit margin, gaining a competitive edge in the existing and potential market in the future. However, the strategic significance of corporate sustainability via environmental greening strategy is still inconclusive and ambivalent depending on performance measures under scrutiny.

In a study of the significance of green strategy, a firm with a better progressive environmental strategy relative to the firm's tangible and intangible assets has a significant and positive impact on the firm's market value which may be one of the favorable predictors of the firm's financial profit in the future market. Shareholders value corporate social responsibility for greening, and there is a significantly positive connection between return on assets (ROA) and sustainability index based on CSR disclosures and firm transparency (Dincer, 2011; Dowell & Muthulingam, 2017). Such positive role of sustainability for a better financial performance can also be derived from the fact that productive sustainability performance creates economic benefits throughout a firm's improved differential social standing with its constituencies such as government, banks, and other stakeholders (Li et al., 2016; Nidumolu, Prahalad, & Rangaswami, 2009; Sen et al., 2015). Different findings in the literature necessitate the needs to investigate the link between corporate sustainability performance and the firm's economic performance. Accordingly, we hypothesize,

H1: Corporate sustainability performance is significantly and positively associated with a

firm's accounting- and market-based performances.

Corporate reputation is significantly associated with corporate performance and plays an increasingly important role in building and sustaining a competitive edge in the market. A variety of studies have confirmed that firms with a good or excellent reputation are likely to be financially profitable over their rivals. A corporation's reputation benefits stockholders to gain external legitimacy for the firm's operations and initiatives (Sánchez & Vega, 2018; Lee & Roh, 2012). Increase in sales means higher profit for the company, and consequently, the firm will sustain more valuable corporate image and reputation. A company will also become attractive to potential job seekers, attracting higher quality employees with a high level of loyalty and productivity. The reputation of the company through the professional image has been known as one of the most significant influences for today's top talent. If a corporation can attract and keep the best employees available, then the company will operate at a higher level of performance, which will eventually reflect positively on the firm's sustainability.

Another perceived effect of corporate reputation on the firm's competitive edge in the market is that the company will have a better assessment from suppliers and thus be able to benefit from lower prices and enhanced credit. Having a lower supply costs and a higher credit line to work with will enable the corporation to generate a lower level of operating costs. As such, firms with a favorable social reputation can utilize more intangible and endurable asset that are unique attributes for their business activities. Therefore, we would like to propose the following hypothesis.

H2: Corporate reputation is significantly and positively associated with a firm's accounting- and market-based performances.

With high attention to the sustainability, more proactive investment in R&D can be a positive contributor to a firm's overall performance through the introduction of new products that may reduce costs for overhead and penetrate a new market. As such, many

firms that open their horizons to a new sustainable technological innovation by R&D. Such positive linkages may be due to fostering product and process innovation as well as technology innovation. Besides, although there remains some controversial arguments on the strategic relationships between increased R&D investment and firm performance, technology innovation obtained through previous investments in R&D provide a crucial incentive to improve the quality of products and market expansion in the long-term viewpoint. Interestingly, the potential power of technology strength by R&D for increased production and investment in a long-term sustainability program. Technological innovation and strength by R&D strategy is the most common means for firms to differentiate from and mitigate competition (Sambharya & Lee, 2014).

R&D serves as one of the most common means for a firm to differentiate itself in the market, and it appears as the most distinctive strategic determinants in generating favorable financial profit as well as market growth. Although technological capabilities via R&D activity can contribute a firm's performance, the level of R&D investment (e.g., amount and time lag effect) and its strategic rewards are still questionable mainly because of different managerial goal setting within the organization. R&D strategy for technological capabilities is one of the most open-ended strategic ingredients to choose because there are usually not clear goals for the firm to focus on and accomplish in a short-term period. However, firms with a higher investment in R&D find that investment is more beneficial in generating a better performance over their competitors particularly in a long-term perspective (Yeh, Chu, Sherc, & Chiua, 2010). As a result, technological innovation and strength by R&D strategy would likely contribute to the success of firms maintaining corporate sustainability. Thus, we propose the following hypothesis:

H3: Technological strength by R&D strategy is significantly and positively associated with a firm's accounting- and market-based performances.

Technology innovation provides business organizations with a means of creating a sustainable competitive advantage in today's turbulent environment and is positioned as a

driver of economic growth. Innovation is a mechanism by which organizations can draw upon core competencies and transition them into performance outcomes critical for success (H. J. Jung & Lee, 2016). Although there exists no common or universal assessment of technology innovation for its capabilities and strength, one of the most commonly used criteria is patents, particularly in its number and citations for their impacted influences. Studies have taken patents as one of significant proxy measures for technological innovation and strength. As such, the value of patents can be indicative of the substance of technological capabilities for new products development to improve financial profit and market growth in both existing and potential markets domestically and globally. The number and frequency of patent citations indicate the size of research inputs and the quality or impact of the research output for technological strengths. Concentration and patent citations relate to significant increase in profit and market growth in sales. In fact, higher performance in growth and profit significantly relies on technological strength, particularly for the long-term success and sustainable growth through the continued application for the development of new products (Berrone et al., 2013).

The number of patents and their quality as measured by the number of citations appears to be a direct indicator of a company's technological strength that may exhibit a positive correlation with sales and profit as well as market value (B. H. Hall, Jaffe, & Trajtenberg, 2005). Conventional studies on the value of patents support the strategic effect of the granted patents for financial profitability and market growth (Sambharya & Lee, 2014). Mainly, technological capabilities and strength via patents can give high-tech firms more competitive advantages over their rivals by its significant impact on productivity growth as well as financial performance. In addition to the number of patents, the frequent citations of registered patents also provide a reasonable proxy measure of technological strength for the value of technology. Impacted influence of patents granted may imply the real substance of its creative prowess.

In a study of the significance of patent citation, the frequent citations of patents granted have significantly influenced the financial profit as well as market value even after

controlling for the difference between the various dimension of citation both internally and externally and also patent ownership differences (Artz et al., 2010). Besides the impact of patent citations on market performance, international patents can also be an indication of the impact of research capabilities on a firm's accounting and financial performance concerning return on assets (Ernst & Fischer, 2014; Giarratana, Mariani, & Weller, 2018). Although studies are inconclusive, the strategic significance of patents and its impacted citations provide firms with technological advantages not only for a wealth of detailed information but also for comprehensive coverage of technological capabilities and strength. Therefore, we proposed the following hypothesis concerning technological strengths and capability through the numbers and citations of a patent:

H4: Technological strength is significantly and positively associated with a firm's accounting- and market-based performances

Empirical Design and Methodology

Samples and Data Collection

The sample was initially from The World's Greenest Companies: The 2013 Rankings by Newsweek. For the generalizability of test results concerning technological strength and capabilities, firms in finance and insurance fields (SIC 6000-6999) were excluded. The initial sample was matched with the USPTO, the Patent Scoreboard, corporate reputation (World's Most Admired Companies by Fortune), and CompuStat. Companies with missing values were also dropped. The final sample with commonality in greening score, corporate reputation, R&D intensity, and patent data were linked to the firm's financial/accounting- and market-based performance including sustained growth rate. All other functional controlling variables were obtained from S&P Research Insight - Global Vantage for the period 2011. The final dataset contained 158 firms (97 for U.S. & Canada and 61 for EU) during the year of 2010-2012. Table 1 presents information about the data.

Insert Table 1 Here

Description and Measurement of Variables

In order to investigate impacts of environmental greening, technological strength and capabilities, and corporate reputation on the firm economic performance in leading U.S. and European corporations, the following measurements serve as proxies for endogenous and exogenous, and functional control variables.

Firm Economic Performance: Most previous empirical studies investigating the impact of R&D intensity, sustainability the respect to environmental green score, corporate reputation, and patents on performance focus on the use of a single measure of performance such as accounting-based performance or market growth. Accounting-based performance measures reflect the firm's financial performance over past years whereas market-based performance measures that reflect investor's expectations about a firm's future performance that include a firms' stock equity and market value and replacement cost of a firm's assets. Considering that accounting-based measures of performances reflect a past year's earnings in a current balance sheet, and market-based measures of performance reflect the market's perceptions of future earnings as financial sources for sustainable growth, it is desirable to examine both measures as indicators of performance. To minimize the impact of accounting standard variations across countries, this study uses earnings before interests and taxes (EBIT) as the performance measure.

Strategic Variables: This study represents sustainability by environmental greening strategy, corporate reputation, technological strengths and capabilities represented by R&D investment and value of patents.

(1) Corporate Sustainability: Environmental green strategy can be viewed as one of the new emerging strategic competencies for corporate sustainability performance in today's competitive global market (Lee et al., 2011). Newsweek derives the "Green Score" from

three components: (1) an environmental impact score, a comprehensive, quantitative, and standardized measurement of the overall environmental impact of a company's global operations, (2) an environmental management score, an assessment of how a company manages its environmental footprint, including its environmental policies, programs, targets and impact of its products and services, and (3) an environmental disclosure score, which indicates the quality of company sustainability through key transparency initiatives, such as the Global Reporting Initiatives and Carbon Disclosure Project (Please refer to www.greenbiz.com for details). The "Green Score" is measured by the weighted value of the three key component scores as an environmental impact score (45%), an environmental management score (45%), and an environmental disclosure score (10%) (Newsweek, 2011 & 2012).

(2) Corporate Reputation: Corporate reputation, a proxy variable of corporate social responsibility, was measured using Fortune's (2011) "World's Most Admired Companies." Fortune, using a total of nine criteria, solicited the opinions of experts, executives, members of boards of directors, and corporate analysts in assessing corporate reputation. A Likert scale, from 0 (poor) to 10 (excellent), was used to assess a firm across the eight criteria previously introduced (see Fortune's World's Most Admired Companies for details). These measures were then averaged to arrive at a composite score for each company. The Fortune list has been the popular measure of corporate reputation in past research studies (Fombrun & Shanley, 1990).

(3) Technological Strength and Capability via R&D Intensity: The technological capability embodied in firms is crucial to the firm performance particularly for the foreign market expansion by export activities. The barometer to gauge the firm's technological capability and innovation is the extent to which the firm concentrates on research and development. R&D intensity, which is one of the most validated measures of technological strength and capability, is computed as the ratio of book values of R&D expenditure to the total sales which is a ratio of R&D Expenditure and Sales Revenue.

(4) Technological Strengths and Capability via Value of Patents: Citation of a patent, the number of cites received per patent, measures innovation value and knowledge flows. In the meantime, technology strength measured as the multiplication of the number of a company's U.S. patents and current impact index indicates how strong a firm's technology has become around the world. Current Impact Index (CII) is a normalized measure of citations received from other patents. For example, CII of 1.2 indicates this company's patents received 20% more citations than the average. The impact of technological strength indicates the frequency of patent citations. For instance, a value of 1 represents the average citation frequency and a value of 2 means twice the average citation frequency. These citations indicated the technological, scientific or marketing importance of a given patent. Thus, this measure corrects for some of the weaknesses associated with using total patent counts.

Functional Business Control Variables: since the strategic linkages between environmental strategy, corporate reputation, technology strength, and firm performance can appear differently in specific contexts, it deems necessary to control for certain confounding variables, particularly those that are important for sustainable competitive edge across countries. The functional strategic control variables incorporated in this study employs five strategic factors: firm size, capital intensity, debt leverage, selling & administrative cost efficiency, and newness in plants & equipment. These factors may directly moderate the strategic paradigm of sustainability-performance links. Each of these control variables takes the subsequent operationalization:

Firm Size = Natural log value of Total Sales (US$ based)

Capital Intensity = Total Assets / Total Sales

Debt Leverage = Book value of Total Debt / Shareholder's Equity

Selling & Administrative Efficiency = Selling & Administrative cost / Total Sales

Newness in Plants & Equipments (PL & EQ) = $(PL\&EQ_t - PL\&EQ_{t-1})/PL\&EQ_{t-1}$

Country Dummy: U.S. & Canadian firms (1) vs. European Countries firms (0)

Empirical Model and Statistical Methods

Hierarchical regression analysis allows for empirical examination of the impact of exogenous variables on endogenous variables. This study takes three steps to investigate the hypotheses proposed in this study. In the first step, all the control variables are entered in the model and provide a more rigorous test of their individual effects on various firm performance measures. By eliminating the moderating effects of other control variables including corporate reputation first, it is possible to more accurately assess the actual impact of environmental greening strategy and technological strength and capability on the various firm performances. The following three steps of hierarchical regression models employ two different dimensions of performance measures including sustained growth rate (SGR).

Performance (Accounting-based and Market-based Performance) based on

Step 1: Functional Control variables (country dummy, Firm size, Capital Intensity, Selling & Administrative cost efficiency, Debt leverage, Newness in Plans & Equipment) and Corporate Reputation

Step 2: Functional Control Variables, Corporate reputation, and R&D and Patents based Technological Strength and Capability (R&D Intensity and Patents)

Step 3: Functional Control Variables, Corporate reputation, R&D and Patents based Technological Strength and Capability (R&D intensity and Patents) and Environmental Greening Strategy

Empirical Analysis and Discussion

Descriptive Statistics and Correlation Analysis

The mean and standard deviations of primary strategic variables (e.g., environmental

aspects of green strategy, corporate reputation, R&D intensity and patents based technological strengths and capability) in addition to various dimensions of performance measures in Tables 2 – (A&B). For the firm's performance measures, firms in North America uniformly show higher performance for two indices of performance measures including sustained growth rate (SGR) than do those in EU counties based on selected samples in this study. This finding indicates that overall performances of mainly North American firms are superior to those of European countries regardless of different aspects of firm performance during that period. Notably, a higher SGR in North American firms displays a clear contrast to the traditional assumption of performance goal (Lee & Roh, 2012). The overall green score (60.79) in European firms appear to place more emphasis on environmental issues than it does for firms in North America. Particularly, patent-based technology strength in North American firms remains well ahead of that of EU firms. As such, North American firms are likely to be sustainable through technological capability via R&D investment and patents but to a lesser extent through environmental focus.

Table 3 presents the interrelations between major exogenous strategic factors and the multitude of different performance measures across two country groups. Although their correlational dependences are different in their directional signs, both environmental greening- and technological-strategy factors have clear correlations with a firm's economic performance measures, particularly with market-based performance measures.

Insert Table 3 Here

The Result of Hierarchical Regression Analysis

The hierarchical multiple regression analyses with three steps will explore the unique contribution of corporate sustainability via environmental greening strategy, corporate reputation, and technological strength and capabilities in the explanation of the firm's

economic performance. Tables 4A presents the results for accounting-based performance and 4B for market-based performance. This result supports the hypotheses that even when other business strategy factors are held constant, a firm's drive toward environmental greening and technology strength by a patent is more likely to be conducive to improving the firm's performance regardless of different indices of performance measures.

Corporate sustainability via various dimensions of environmental greening scores appears to be a significant strategic determinant for market-based performance including sustained growth rate in a uniformed manner. Overall greening score and other environmental aspects of sustainability, however, does not show significant impacts in determining the firm's accounting performance except in sales-based return. Most environmental scores including overall green score are uniformly significant for most market-based performance including sustained growth across, which is decisive evidence of the first hypothesis. Strategic efforts for sustainability can go a long way in providing profit margins or loss in a company since a firm using sustainable efforts does not always immediately recognize financial profit margins. A firm may not notice immediate financial gains from sustainability initiatives but can earn strong support from its stakeholders for outreaching to address sustainability (Peloza, Loock, Cerruti, & Muyot, 2012).

Although there are limited studies on the impact of the environmental green score on performance, the finding of this study lends support to the notion that firms can sustain and maintain the market competition. The findings of this study support that committing to sustainability is beneficial to a company in terms of long-term strategic drives such as market growth and firm value than short-term financial profitability. More proactive integration of sustainability into various business operations can contribute to the firm's long-term benefits by reducing wastes and costs. Firms with productive sustainability development for environmental issues can also contribute to driving various social recognition and rewards for partaking in environmental improvement domestically and globally (Wang et al., 2016).

Corporate reputation and R&D intensity emerged as a significant strategic determinant of the firm's performance regardless of different aspects of performance measures. In particular, corporate reputation is highly significant (at least at $p<-0.01$) and it is one of the significant distinctive determinants for most economic performance measures. Thus, firms with a better reputation produce a better performance status over their competitors. Further, corporate reputation as one of the notable characteristics for social responsibility and image is a robust determinant for a firm's economic performance, consistent with other studies in which firms with relatively good reputations are better able to sustain superior profit outcomes when interacting with technology development (Fombrun & Shanley, 1990). The result fully supports our proposed hypotheses (H2 & H3).

Although R&D intensity can be used to sustain competitive technological strength and capabilities for success, there remain some controversial issues on the significant linkages between R&D and firms performance concerning financial accounting profit. However, the finding of this study appears to be enough to contend that investment in R&D may reflect a company's willingness to forgo market performance as well as sustainable growth to improve future returns and performance across countries (E. H. Hall & Lee, 2008). Contrary to corporate reputation and R&D intensity, technology innovation and strength represented by the number and citations of patents are not uniformly conducive to the firm performance, particularly in accounting and financial returns (H3 received partial support). Patent oriented technological strength and capabilities are not likely to be used as a determinant for most measures of accounting performance, but it is a significant strategic factor (at $P<0.05$) for most market-based performance measures including sustained growth rate. The number of patents granted and citations of the patent are likely to contribute to explaining market-based performance (at least at $p<0.05$ except market value and Tobin's q). It supports the traditional notion that the significant impact of firm performance on technology development by the patent can be used to improve performance (Artz et al., 2010) but it does not fully support other findings in which citations of patent significantly affects market value. Our findings support the competitive

advantages of firm performance, notably market return and growth and the increase of technological strengths and capabilities regardless of different country settings. Further, it also supports another previous finding in which the technology strength is significant in a market-based performance, particularly for Tobin's Q (Lee & Pati, 2012).

As proposed for other functional strategic control factors (H4), among other things, firm size shows a significant association with most performance measures (except with Tobin's q). The result of this study continues to support the traditional notion that firm size can be viewed as one of the most validated determinants of firm performance in terms of technology development endeavors as well as corporate sustainability performance (S. Jung et al., 2018; Sen et al., 2015). Next, capital intensity is also a significant predictor of firm performance irrespective of different dimensions of performance measures except for EBIT/ROE. The effect of capital intensity on the firm performance may stem from the argument that companies may require more capital investments to sustain competitive earnings and growth in the global market (Lee & Blevins, 1990). Besides, selling & administrative cost efficiency has an association with all market-based performance, but it is statistically significant in EBIT/ROA and EBIT/ROS. That is, firm size and selling & administrative cost efficiency appear to be two of the major determinants for the multitude of performance measures regardless of different financial and market competencies across countries. Newness in plant & equipment and debt leverage does not appear to be significant as strategic determinants for firm performance. The assessment of the firm's debt leverage in terms of sound capital budgeting is not likely to be a significant determinant for performance concerning the environmental greening related performance.

Also, corporate sustainability, corporate reputation, and technological strengths and capabilities do not likely vary across countries in North America and the European Union. The only exceptions emerged in EBIT/ROA ($P<0.05$) and Tobin's Q ($P<0.01$) only (with a positive sign). The marginal value of strategic variables in determining market value performance in the U.S. (& Canadian) firms is higher than that of European firms. Although

the results may not appear uniform in their signs, firm size, capital intensity, and selling & administrative cost efficiency are most likely to be considered as significant explanatory variables in determining performance regardless of different dimensions of performance measures including sustained growth rate across different country settings.

Key Findings and Conclusions

The purpose of this study is an attempt to empirically examine the nature of the strategic impact of environmental strategy and a focus for corporate sustainability, corporate reputation, and technological strengths and capabilities on the firm's economic performance with different dimensions of performance measures including sustainable growth rate. The main question addressed in this paper relates to how corporate sustainability influence firm performance in leading firms. As for sustainability, this study focuses on green strategy and technological strength and examines its impact on firms' economic and market performance.

The findings of the study support the statistical significance of corporate sustainability through green strategy, corporate reputation, proactive R&D investment and following patents for technological strength and capabilities and firm size can be implemented as the competitive determinants for improving the firm's economic performance, particularly with market-based performance. The positive and significant effects of strategic competencies suggest that higher and stronger technological capabilities and environmental sustainability performance are more conducive to firms' sustainable strength in financial profit and market growth regardless of different business and economic contexts. The study also finds that proactive strategic drives for environmental awareness and technological development are essential to sustaining competitive advantages. His result may also support the synergy effects of distinguishing strategic factors for a firm's competitive advantages in both domestic and global markets.

Although sustainability will lead to higher profitability, questions remain about managerial

incentives in attempting sustainability development. Once the firm decides to implement a sustainable process, it will take time to develop and launch. Implementing a sustainability process within a business organization does not lead to immediate success due to many other challenging factors internally and externally. Sustainability is still one of the very complex and delicate strategic strives for achieving performance, particularly subject to managerial willingness to take no immediate cost return. Besides, other functional strategic factors such as firm size, capital intensity, and selling & administrative cost efficiency in promoting environmental greening and technology development and corporate reputation are strategic for market-based performance, including sustained growth rate (SGR) in a uniformed manner.

Thus, most leading world firms signify environmental greening for sustainability, reputation for social responsibility and images, R&D and patents for technological development giving them more competitive advantages in maintaining a better financial profit and growth in the global market. Larger firms with a more aggressive capital investment in technology development may take more opportunities to gain new operational capabilities that may accelerate their advancement in environmental issues in both products and markets for company reputation in the market. As such, an orchestrated synergy effect through environmental sustainability and technological strengths can be the foundation of competitive advantage in competitive markets. It is one of the most integral components of successful sustainability performance in conjunction with social responsibility and technology development for the firm to create a more productive and supportive working system under the administrative awareness of growing customer demand for environmentally responsible products and services.

Although prior research is both limited and inconclusive, the impact of corporate sustainability, corporate reputation, and technological strengths and capabilities on various dimensions of firm performance, especially including sustained growth rate (SGR) are becoming the new progressive business directions not only for practitioners but also for academicians. With an aim to account for inconclusive results, further study should

investigate a firm's strategic components (or determinants) and also employ various aspects of the firm's dynamic economic performance measures as a benchmark.

Implications

As the data in this study covers three-year time, an empirical study with a more extended period of the time may confirm the results. The present study looked at an aggregated country setting. Notwithstanding the limitations, this study offers some insights. First, this study identifies the critical strategic ingredients that lead to the success of corporate social responsibility in diverse economic contexts. The findings are useful to managers in determining the level of commitment to a competitive strategy in a given economic context across countries. Through a comprehensive exploration of the relationships among corporate sustainability performance, corporate reputation, and technological innovation and strength and firm performance, this study seeks to enlighten researchers and practitioners with the efficient and effective operational use of scarce resources. The findings also contribute to new strategic implications of environmental strategy for corporate sustainability performance and the combined effect of technological strength and a firm's reputations for social image and responsibility for the firm's financial and market sustainability in business and economic research, particularly across two leading countries in the global markets. More importantly, the significant findings of this study will postulate some insightful paradigms of key strategic determinants in economic performance and sustainable growth for those industries and firms which are under growing competition in the strategic and economic global market.

As the models and data are improved, the findings of this study can be retested and extended with many countries. This study has just opened the door for additional research efforts that will serve to generalize the relationship between newly emerging environmental greening and technology capabilities and performance across countries. Follow up studies should further investigate comprehensive corporate sustainability in environmental-and social-issues and economic performance relations in a separate

industry and country settings if the same findings hold true in a broader industry and country spectrum.

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Table 1
Selected Samples by Country Groups and Industry Affiliation

Industry Classification	Country Groups		Total	SIC Code
	U.S. & Canada	European Countries		
Mining & Drilling including Oil &Gas	4	2	6	1000-1499
Construction and Related	1	1	2	1500-1699
Food, Drink, & Tobacco	9	0	9	2000-2199
Textile and Apparels	0	1	1	2200-2399
Lumber and Wood Products	3	1	4	2400-2699
Chemicals and Related	14	13	27	2800-2899
Petroleum Refining	6	5	11	2900-2999
Rubber, Plastic, & Stones	1	1	2	3000-3199
Glass, Cement, & Stones	0	1	1	3200-3299
Pimary Metals	2	1	3	3300-3399
Fabricated Metals	1	0	1	3400-3499
Machinery and Computer Equipment	13	1	14	3500-3599
Electric and Electronic Products	9	5	14	3600-3699
Transportation & Equipments	7	9	16	3700-3799
Measurement & Science Intruments	4	3	7	3800-3899
Gas, Electric, & Sanitary	8	9	17	4000-4799
Wholes & Retail Trade	6	2	8	5000-5199
Tech Related Business Services	5	3	8	7370-7376
Medical Service Related	2	1	3	8000-8099
Other Service Related Business	1	1	2	8100-8999
Conglomerates	1	1	2	9000-9999
Total	97	61	158	

Table 2 (A)

Descriptive Statistics of Major Variables by Country Groups

Major Variables	U.S. & Canada		European Countires		Total	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Environmenatal Green Score by						
Overall Green Score	58.03	10.23	60.79	11.08	59.41	29.85
Environmental Impact Score	54.74	13.07	56.25	13.52	55.49	13.19
Environmental Management Score	60.97	13.80	64.38	11.83	62.67	13.03
Environmental Disclosure Score	49.35	22.54	68.02	15.06	58.69	25.98
Corporate Reputation Index	6.54	1.30	5.97	0.74	6.26	1.20
Technological Capabilities						
R&D Intensity	4.54	4.54	4.39	4.69	4.46	4.34
Number of Patents	248.96	198.67	206.54	178.56	227.75	189.32
Citation of Patents	0.29	0.27	0.22	0.20	0.26	0.24
Current Impact Index (CII)	1.21	1.63	0.63	0.33	0.92	1.40
Technological Strength	301.24	323.94	130.12	58.93	209.53	265.05
Accounting-based Performance						
EBIT based Return on Assets (E-ROA)	0.15	0.07	0.09	0.09	0.12	0.07
EBIT based Return on Equity (E-ROE)	0.25	0.15	0.15	0.16	0.20	0.15
EBIT based Return on Sales (E-ROS)	0.19	0.10	0.15	0.15	0.17	0.11
Market-based Performance						
Market Value (Ln)	11.48	6.25	10.35	13.26	10.92	10.23
Tobin's Q	1.81	1.00	1.13	0.56	1.47	0.96
Sustained Growth Rate	10.06	6.98	6.43	5.12	8.25	7.18

Note:

1. **Green Score:** Overall Green Score is derive from three component scores (Env. Impact score, Env. Management score, and Environmental Disclosure Score; weighted at 45 percent, 45 percednt, and 10 percent, respectively).
2. **Environmental Impact Score** is a comprehensive, quantitative and standardized measurement of the overall environmental impact of a company's global operations.
3. **Environmenatal Management Score** is an assessment of how a company manages its environmental performance through policies, programs, targets and initiatives of both its own operations and its suppliers and contractors, as well as the impact of its products and services
4. **Environmental Disclosure Score** is a stand-alone score to assess each company's transparency performance with regard to the quality of company sustainability reporting and involvement in key transparency iniatives such as the Global Reporting Initiative and Carbon Disclosure Project/
5. **Number of Patents**: Number of Patents granted by (or registered to) the US Patent Office
6. **Citations of Patent** (Citations received per Patent) is a measure of innovation value and knowledge flows
7. **Current Impact Index (CII)** is normalized measure of citations received from other patents company's (e.g., CII of 1.2 indicates this patentss are cited 20% more than average).
8. **Technological Strength** (=CII x number of patents) indicates the frequency by which a given patent was cited (e.g., A value of 1. represented the average ciatation frequency). This citations indicated the technological, scientific or marketing importance of a given patent.

Table 2 (B)

Descriptive Statistics for Selected Variables by Industry Affiliation

		Green: Environmental Focus by					Technological Capabilities				
Industry Classification	Sales ($mil)	Impact	Management	Disclouser	Overall Green Score	**Corporate Reputation**	R&D Intensity	No. of Patent	Citations of Patent	Current Impact	Technology Strength
Mining and Drilling	21,117.38	38.56	52.71	70.67	48.16	6.84	0.29	52.43	0.19	1.10	57.67
Construction Related	24,264.52	61.55	51.90	30.85	54.15	6.15	0.37	0.00	0.00	0.35	0.00
Food, Drink, & Tobacco	42,332.27	29.67	67.47	36.14	44.63	6.16	0.58	12.82	0.10	0.51	6.52
Textile and Apparels	26,962.60	46.90	62.10	39.80	53.00	5.89	0.32	7.00	0.01	0.29	2.03
Lumber and Wood Products	21,769.02	41.45	64.30	83.52	55.93	6.63	1.90	198.50	0.25	0.73	143.91
Chemicals and Related	32,074.30	51.71	63.95	65.54	58.60	6.21	4.24	81.13	0.16	0.60	48.95
Petroleum Refining	128,277.00	46.36	52.58	81.47	52.67	6.63	1.41	28.00	0.25	1.39	38.98
Rubber, Plastic, & Stones	25,758.09	46.47	69.27	16.70	53.73	6.73	2.01	97.33	0.30	0.93	90.84
Glass, Cement, & Stones	18,085.65	31.05	58.85	78.70	47.45		0.37	62.00	0.15	0.65	40.30
Pimary Metals	44,670.71	30.54	59.28	63.84	46.80	6.82	0.37	20.60	0.40	0.30	6.18
Fabricated Metals	12,345.87	53.10	45.10	39.80	48.10	6.58	0.62	42.00	0.20	0.60	25.20
Machinery and Computer	39,719.00	62.02	57.81	68.74	62.02	6.06	5.51	358.05	0.26	0.91	324.04
Electric and Electronic	46,540.20	59.17	69.14	62.89	64.01	6.01	6.10	984.00	0.24	0.75	735.05
Transportation & Equipments	61,863.84	55.76	69.51	49.12	61.29	5.20	5.12	174.29	0.17	0.52	91.29
Measurement & Science	20,387.11	62.99	65.88	38.86	61.88	6.33	6.39	100.13	0.14	1.50	150.19
Gas, Electric, & Sanitary	50,359.96	68.09	63.99	61.42	65.58	6.38	6.72	37.32	0.28	1.29	48.11
Wholes & Retail Trade	119,068.00	62.07	52.82	29.54	54.61	6.90	0.48	9.00	0.39	1.68	15.10
Tech Related Business Services	40,601.21	73.47	74.49	59.13	72.49	6.51	10.43	1279.22	0.29	1.43	1833.51
Medical Related Services	23,165.09	70.80	47.25	12.50	54.40	5.86	0.53	1.00	0.00	0.10	0.10
Other Service Related Business	27,352.91	78.60	78.90	31.60	74.00	7.40	13.25	10.00	0.30	10.30	103.00
Conglomerates	86,592.33	59.43	73.47	68.33	66.63	5.76	5.88	1183.00	0.20	0.60	709.80
											0.00
Total Average	50,648.57	55.49	62.67	58.69	59.41	6.26	4.46	227.78	0.21	0.92	209.56
(Standard Deviation)	(53,675)	(13.186)	(13.027)	(25.982)	(29.851)	(1.200)	(4.341)	(189.32)	(0.236)	(1.401)	(265.293)

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Table 3

Descriptive Statistics and Correlations[a]

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Overall Green Score																				
2. Environmental Impact	.53 ***																			
3. Environmental Mangement	.15 *	.32 ***																		
4. Environmenatl Disclosure	.49 ***	.39 ***	.37 ***																	
5. Corporate Reputation	.21 **	.19 **	.20 **	.27 ***																
6. R&D Intensity	.36 ***	.32 ***	.16 *	.18 **	.14 *															
7. Number of Patents	.13 *	.27 ***	.15 *	.16 *	.16 *	.26 ***														
8. Citation of Patents	.15 *	.18 **	.16 *	.11 *	.13 *	.28 ***	.30 ***													
9. Technology Strength	.23 **	.24 **	.18 **	.18 **	.14 *	.24 **	.13 *	.25 ***												
10. EBIT based ROA	.12	.01	.03	.07	.25 ***	.13 *	.12 *	.11 *	.13 *											
11. EBIT based ROE	.11 +	.08	.04	.06	.21 **	.14 *	.04	.04	.12 *	.47 ***										
12. EBIT based ROS	.13 *	.03	.12 *	.11 *	.22 **	.19 **	.20 **	.18 **	.10 +	.34 ***	.17 **									
13. Market Value (ln)	.18 **	.17 **	.15 *	.14 *	.34 ***	.14 *	.15 *	.16 *	.20 **	.24 ***	-.02	.03								
14. Tobin's Q	.19 **	.20 **	.15 *	.17 **	.32 ***	.20 **	.23 **	.26 ***	.12 *	.15 *	.12 *	.50 ***	.32 ***							
15. Sustained Growth Rate	.17 **	.22 **	.22 **	.20 **	.14 *	.28 ***	.14 *	.19 **	.15 **	.34 ***	.18 **	.37 ***	.13 *	.42 ***						
16. Frim Sized: Ln Sale	.15 *	.08	.16 *	.16	.24 **	.18 **	.25 **	.20 **	.15 *	.21 **	.14 *	.25 ***	.23 **	.21 **	.21 **					
17. Selling & Admin. Efficiency	.18 **	.11 +	.13 *	.11 +	.13 *	.15 *	-.04	.12 *	.18 **	-.23 ***	-.07	-.10 +	.20 **	.22 **	.21 **	-.06				
18. Capital Intensity	.17 **	.13 *	.09	.10 *	.03	.16 *	-.15 *	-.15 *	-.02	-.10 +	-.02	.18 **	.17 *	.16 *	.13 *	-.06	.10			
19. Debt Leverage	-.07	-.07	-.05	-.05	-.02	-.20 **	-.12 *	-.12 *	-.09	-.16 **	-.01	-.08	.02	-.18 **	-.02	.21 **	-.11 +	.12 *		
20 Newness in Plant & Equip.	.23 **	.20 **	.19 **	.17 **	.13 *	.08	.05	.03	.10 +	-.06	-.09	.09	.16 *	.05	.16 *	.08	.07	.31 **	-.17 **	

[a.] N= 158 .

+ P < 0.01; * P < 0.05; ** P < 0.01; *** P < 0.001

Table 4 (A)

Results of Hierarchical Multiple Regression Analysis: Accounting- Based Performance[a]

	Return on Asset (E-ROA)			Return on Equity (E-ROE)			Return on Sales (E-ROS)		
Independent Variables	**Step 1**	**Step 2**	**Step 3**	**Step 1**	**Step 2**	**Step 3**	**Step 1**	**Step 2**	**Step 3**
(Constant)	.059 (.06) **	.167 (.06) **	.210 (.07) **	.495 (.15) ***	.529 (.16) ***	.534 (.17) ***	.103 (.08)	.114 (.08)	.170 (.09) +
Dummy: US (& Canada) vs. EU	.027 (.01) *	.028 (.01) *	.023 (.01) +	.006 (.03)	.005 (.03)	.003 (.03)	.023 (.02)	.023 (.02)	.018 (.02)
Firm Size	.014 (.01) *	.014 (.01) *	.013 (.01) *	-.044 (.01) ***	-.056 (.01) ***	-.054 (.01) ***	-.017 (.01) **	-.017 (.01) *	-.016 (.01) *
Administrative Cost Efficiency	.103 (.05) *	.102 (.05) *	.107 (.05) *	-.079 (.12)	-.061 (.12)	-.054 (.13)	-.189 (.07) **	-.181 (.07) **	-.184 (.07) **
Capital Intensity	-.023 (.01) **	-.027 (.01) **	-.025 (.01) *	-.017 (.02)	-.015 (.02)	-.013 (.02)	.024 (.01) **	.024 (.01) **	.025 (.01) **
Debt Leverage	-.023 (.04)	-.028 (.04)	-.029 (.04)	-.013 (.09)	-.036 (.09)	-.042 (.09)	-.045 (.05)	-.046 (.05)	-.051 (.05)
Newness in Plant & Equipment	-.002 (.00)	-.002 (.00)	-.003 (.00)	.004 (.01)	.005 (.01)	.005 (.01)	-.005 (.01)	-.004 (.01)	-.005 (.01)
Corporate Reputation	.021 (.00) ***	.019 (.01) ***	.021 (.01) ***	.037 (.01) ***	.037 (.01) **	.038 (.01) **	.021 (.01) **	.021 (.01) **	.020 (.01) **
R&D Intensity		.004 (.00) *	.003 (.00) *	.006 (.00) *	.005 (.00) +	.006 (.00) *	.004 (.00) *	.004 (.00) *	.005 (.00) *
Number of Patents		.021 (.03)	.015 (.03)		-.026 (.07)	-.052 (.07)		.023 (.01) *	.021 (.01) *
Citations of Patents		.014 (.02)	.015 (.03)		-.018 (.07)	-.050 (.06)		.011 (.01)	.012 (.02)
Technology Strength		.018 (.01)	.021 (.01)		.014 (.00)	.017 (.00)		.021 (.01) +	.023 (.02) +
Overall Green Score			.001 (.00)			.001 (.00)			.020 (.01) +
Environmental Impact			.000 (.00)			.001 (.00)			.002 (.00)
Environmental Management			.000 (.00)			.001 (.00)			.001 (.00)
Environmental Dislosure			.000 (.00)			.002 (.00)			.010 (.01)
Model R^2	0.2856	0.2903	0.2943	0.2465	0.2501	0.2684	0.3551	0.3587	0.3892
Adjusted R^2	0.2312	0.2401	0.2478	0.2248	0.2324	0.2257	0.3948	0.3889	0.3932
Δ in R^2		0.0047	0.0041		0.0036	0.0183 +		0.0036	0.0305 **
F-Ratio	6.8945 ***	6.1245 ***	6.0124 ***	5.6232 ***	5.2413 ***	5.0312 ***	10.7846 ***	8.8112 ***	7.7287 ***
F-ratio forΔ in R^2		0.5136	1.07546		1.1312	0.1458		0.3956	1.4357

a. n= 158 . Unstandardized regression coefficients, with standard errors in parentheses, are shown

b. + P < 0.01; * P < 0.05; ** P < 0.01; *** P < 0.001

Table 4 (B)

Results of Hierarchical Multiple Regression Analysis: Market - Based Performance & Sustained Growth [a]

	Market Value			Tobin's Q			Sustained Growth Rate		
Independent Variables	**Step 1**	**Step 2**	**Step 3**	**Step 1**	**Step 2**	**Step 3**	**Step 1**	**Step 2**	**Step 3**
(Constant)	1.587 (.79) *	1.657 (.84) *	1.757 (.87) *	1.105 (.57) +	1.265 (.49) *	1.473 (.57) ***	24.1 (14) *	47.4 (14) ***	25.5 (15) *
Dummy: US (& Canada) vs. EU	.185 (.20)	.186 (.19)	.151 (.23)	.416 (.16) **	.501 (.16) **	.468 (.16) **	.603 (4.4)	3.37 (4.0)	5.23 (3.8)
Firm Size	.534 (.07) ***	.531 (.07) ***	.543 (.07) ***	.042 (.05)	.043 (.05)	.040 (.05)	2.91 (1.3) *	4.11 (1.2) ***	4.42 (1.1) ***
Administrative Cost Efficiency	1.98 (.49) ***	1.69 (.40) ***	1.90 (.50) ***	1.79 (.46) ***	1.69 (.44) ***	-2.04 (.46) ***	3.44 (1.4) ***	3.69 (12) ***	3.28 (12) ***
Capital Intensity	.268 (.12) *	.279 (.12) *	.295 (.13) *	-.297 (.09) ***	-.268 (.09) **	-.234 (.08) **	-1.78 (.79) **	-1.85 (.93) *	-2.31 (1.2) *
Debt Leverage	-.424 (.48)	-.458 (.48)	-.459 (.48)	-.219 (.35)	-.149 (.34)	-.142 (.32)	2.80 (9.6)	9.07 (8.6)	9.06 (8.2)
Newness in Plant & Equipment	-.064 (.07)	-.063 (.07)	-.075 (.07)	.000 (.05)	.003 (.05)	-.015 (.04)	.271 (1.1)	.562 (1.0)	.946 (.94)
Corporate Reputation	.285 (.07) ***	.287 (.07) ***	.282 (.07) ***	.169 (.05) ***	.155 (.05) **	.139 (.05) **	2.99 (1.4) **	2.73 (1.2) **	2.52 (1.1) **
R&D Intensity		.176 (.02) *	.066 (.03) *		.031 (.01) *	.039 (.01) ***		.765 (.34) *	.768 (.33) **
Number of Patents		.147 (.07) *	.156 (.07) *		.258 (.13) *	.325 (.18) *		12.4 (6.3) *	13.5 (6.2) *
Citations of Patents		.167 (.09)	.138 (.08)		.144 (.09)	.143 (.09)		10.5 (5.8) *	11.3 (4.9) *
Technology Strength		.031 (.02) *	.030 (.01) *		.030 (.02) *	.032 (.02) *		.036 (.02) *	.035 (.02) *
Overall Green Score			.041 (.01) **			.032 (.01) ***			.822 (.22) ***
Environmental Impact			.021 (.01) *			.165 (.07) *			.362 (.16) *
Environmental Management			.019 (.01) *			.170 (.07) *			.306 (.16) *
Environmental Disclosure			.018 (.01) *			.176 (.08) *			.301 (.17) *
Model R^2	0.3854	0.3863	0.3986	0.3489	0.3713	0.4257	0.3849	0.4121	0.4593
Adjusted R^2	0.3213	0.3242	0.3301	0.3102	0.3189	0.3452	0.3471	0.3688	0.4023
Δ in R^2		0.0009	0.0123 *		0.0224 **	0.0544 **		0.0282 *	0.0472 **
F-Ratio	13.4253 ***	12.5864 ***	11.2342 ***	10.89456 ***	11.64253 ***	12.45213 ***	13.1285 ***	11.8321 ***	11.9095 ***
F-ratio forΔ in R^2		0.09356	1.65243		4.35642 *	8.65423		3.579	6.5309

[a.] n= 158 . Unstandardized regression coefficients, with standard errors in parentheses, are shown

[b.] + P < 0.01; * P < 0.05; ** P < 0.01; *** P < 0.001

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The Impact of Weather and Climate Change on Autos Fatal Accidents

Abstract

This study explores the impact of weather and climate change on auto's fatal accidents. Accidental crash data is extracted from Fatal Analysis Reporting System (FARS). Weather data is extracted from selected National Climate Data Center's weather stations. Accidental data is first analyzed and modeled by logistic regression model to find the contributing factors. Then weather data are modeled by multiplicative seasonal autoregressive integrated moving average (ARIMA) model to check climate change. Weather condition is a pivot role for fatal auto accidents, but there is no significant weather change during the past 25 years that will cause significant fatal accident increase or decrease in the next several decades.

Introduction

In this paper, we studied all the accidents happened in the U.S. that involved at least one death between 1991 and 2015. Fatal accident information was extracted from Fatality Analysis Reporting System (FARS). The contributing factors such as vehicle traveling speed and weather conditions are analyzed. Weather stations are selected from the National Climate Data Center. Number of stations in each state is proportional to the fatal accidents frequency. 25 years of daily weather data such as precipitation, maximum daily temperature, and minimum daily temperature are studied and modeled through multiplicative seasonal autoregressive integrated moving average (ARIMA) model. There are numerous studies on global climate change and how it may lead to the increase of catastrophic events. This study tries to test whether climate change could be an independent contributing factor causing the increase of auto fatal accidents rather than merely a catastrophic events predictor. This paper focuses on how weather and climate change impact auto insurance by analyzing the experience of fatal accidents and historical weather data that are related with these fatal accidents.

Literature Review

The impacts of catastrophic weather-related events and climate change will cause significant increase of insurance cost. This cost will impact insurance industry directly in term of higher premium and deductibles, lower coverage limits and heavier underwriting restriction (Mills, Roth and Lecomte 2005). Almost all industries are vulnerable to the impacts of climate change, particularly, insurance companies which have coverages of property (such as structures, automobile and aircraft), crops, and livestock (Mills, 2005).

There is an extensive amount of literature on the relationship between weather condition and vehicle accidents. Certain adverse weather conditions, such as severe winter storms, can bring as much as 25 times higher risk compared with speeding or drunk driving (Maze, Agarwal and Burchett 2006). Precipitation is a contributing factor

for crash rate; snow has 84% greater effect on crash rate and 75% greater effect on injury rate than rain (Qiu and Nixon 2008).

Although weather condition is an important factor in relation with fatal accidents, another way to look at this issue is to take driving behavior into consideration. That is to say, instead of looking at the cause and effect reciprocal relation between weather condition and auto accidents, this paper looks at the nexus between weather condition, driver's driving behavior, and auto accidents. Free-flow speed or driving speed not only affected by the traffic, but also affected by pavement conditions, visibility, and wind speeds (Kyte, Khatib, Shannon and Kitchener 2001). Both visibility and wind speeds heavily depend on the weather condition. A study in Netherlands finds that precipitation affected non-professional travel the most, and weather sensitive mode professional travel such as bicycle and moped were also affected in a lesser extent (Bijleveld and Churchill 2009).

There is also longitudinal driving behavior analysis under adverse weather conditions (Hoogendoorn et al. 2010) as well as weather and road geometry impact on longitudinal driving behavior (Hamdar, Qin and Talebpour 2016).

In this study, we used a logistic regression to find the contributing factors for the injury severity. Other models such as ordered probit models was used for the injury severity estimation (Khattak, Kantor and Council 2014). Unordered mixed multinomial logit model had been used to analyze the crash data (Zeng et al. 2017). A multilevel model is used to predict the road accident outcomes in Norway (Jones and Jorgensen 2003). A Box-Jenkins approach is used to model and forecast the time series of road accidents in Britain (Scott, 1986).

Weather Impact on Auto's Fatal Accidents

In 2015 there were 32,166 accidents involving at least one fatality in the U. S. There are many factors that contribute to accidents, for instance, light condition, route type, and road condition. We explored how the weather impacts fatal accidents, and how climate change in a long run affects the future of the driving condition.

There are three datasets we extracted from Fatal Analysis Reporting System, dataset by accident, dataset by vehicle and dataset by person. Because accidents could involve with multiple vehicles, and each vehicle could involve with multiple people including driver, passengers and pedestrians, we merged all three data by person which provided a valid data frame for regression modeling.

In order to test weather impact, we first constructed a generalized linear model (GLM) with logit link function to predict whether people died in a fatal accident without weather as independent variable. 2013-2014 data was used to train the model. Because the fatal information is a binary data thus a cutoff point that maximized the sum of specificity and sensitivity that is selected. Specificity is the probability that fatal status is

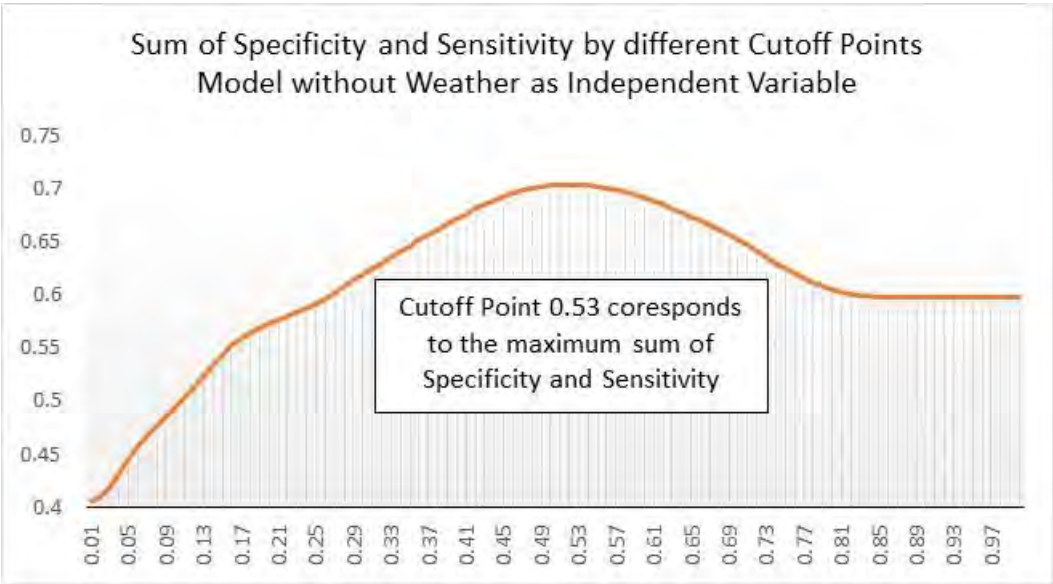
no and predicted status is also no, sensitivity is the probability that fata status is yes and predicted status is also yes.

The following graph presents the GLM model based on 2013-2014 training data, then the model is tested for fitting. It generated an overall 100% actual over expected fatal status.

```
Call:
glm(formula = Fatal ~ Region + Age + Sex + InvolvedPersonType +
    Drinking + Deformed + Route + LightCondition, family = binomial(),
    data = DataTrain)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.0463  -0.9672  -0.4593   1.0021   3.6908

Coefficients:
                                   Estimate Std. Error z value Pr(>|z|)
(Intercept)                       0.5571224  0.0347345  16.039  < 2e-16 ***
RegionNortheast                  -0.2183899  0.0245628  -8.891  < 2e-16 ***
RegionSouth                       0.0127002  0.0167732   0.757   0.4489
RegionWest                       -0.1081340  0.0198280  -5.454 4.94e-08 ***
Age                               0.0129368  0.0002929  44.173  < 2e-16 ***
SexMale                           0.1274203  0.0137356   9.277  < 2e-16 ***
SexUnknown                       -4.2947575  0.3210885 -13.376  < 2e-16 ***
InvolvedPersonTypeOther          -0.1021058  0.1517613  -0.673   0.5011
InvolvedPersonTypePassenger      -1.2218403  0.0162866 -75.021  < 2e-16 ***
DrinkingNo Alcohol Involved      -1.1282895  0.0222574 -50.693  < 2e-16 ***
DrinkingNo Reported or Unknown   -0.2259482  0.0229820  -9.832  < 2e-16 ***
DeformedFunctional Damage        -1.6466489  0.0224612 -73.311  < 2e-16 ***
DeformedMinor Damage             -2.7643484  0.0415408 -66.545  < 2e-16 ***
DeformedNo Damage                -1.9933448  0.0640611 -31.116  < 2e-16 ***
DeformedOther                    -0.8913371  0.0312374 -28.534  < 2e-16 ***
RouteInterstate                  -0.3895066  0.0241596 -16.122  < 2e-16 ***
RouteLocal Street                -0.2495406  0.0224864 -11.097  < 2e-16 ***
RouteOther                       -0.0791929  0.0366432  -2.161   0.0307 *
RouteState Highway               -0.3402193  0.0206699 -16.460  < 2e-16 ***
RouteU.S. Highway                -0.4920531  0.0227957 -21.585  < 2e-16 ***
LightConditionDark - Not Lighted  0.2078476  0.0207854  10.000  < 2e-16 ***
LightConditionDawn                0.2461200  0.0488910   5.034 4.80e-07 ***
LightConditionDaylight            0.0937633  0.0189888   4.938 7.90e-07 ***
LightConditionOther               0.0318989  0.0395185   0.807   0.4196
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 177119  on 131413  degrees of freedom
Residual deviance: 149330  on 131390  degrees of freedom
AIC: 149378

Number of Fisher Scoring iterations: 6
```

Because the data is binary, thus a cutoff point is needed for binary prediction. All numbers from 0 to 1 with 0.01 increment are tested for the training data. 0.53 is selected

as the cutoff point, because it corresponds with the maximum summation of specificity (50.52%) and sensitivity (19.87%), which is 70.39%.

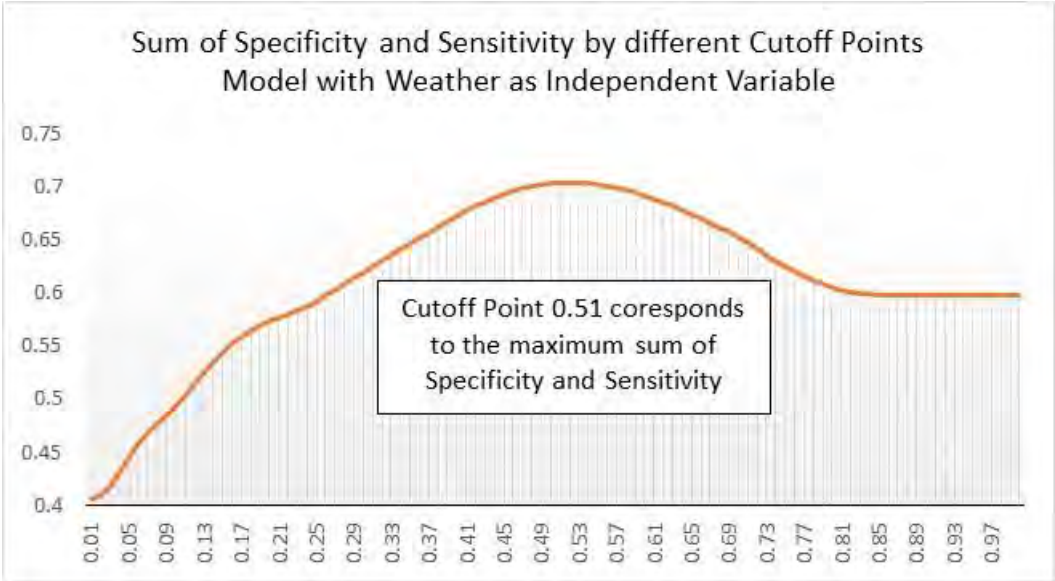


Next, we constructed a GLM with all other variable same but included weather as independent variable. Weather data was captured in a detailed format such as clear, cloudy, rain etc. We have grouped the weather condition into three categories so that each group is statistically different from each other. For example, we found out that when there is no precipitation, temperature will not impact fatality probability when there was fatal accident happened.

Weather Condition	Grouped Weather Condition
Blowing	Precipitation - No
Clear	Precipitation - No
Cloudy	Precipitation - No
Fog, Smog, Smoke	Precipitation - No
Freezing Rain or Drizzle	Precipitation-Yes, Temperature Low
Other	Precipitation - No
Rain	Precipitation-Yes, Temperature High
Severe Crosswind	Precipitation - No
Sleet	Precipitation-Yes, Temperature Low
Snow	Precipitation-Yes, Temperature Low

```
Call:
glm(formula = Fatal ~ Region + Age + Sex + InvolvedPersonType +
    Drinking + Deformed + Route + LightCondition + WeatherGrouped,
    family = binomial(), data = DataTrain)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.0491  -0.9670  -0.4587   1.0011   3.6876

Coefficients:
                                                Estimate Std. Error z value Pr(>|z|)
(Intercept)                                    0.5696534  0.0348026  16.368  < 2e-16 ***
RegionNortheast                               -0.2196458  0.0245871  -8.933  < 2e-16 ***
RegionSouth                                    0.0042166  0.0169190   0.249  0.80319
RegionWest                                    -0.1195874  0.0199397  -5.997 2.00e-09 ***
Age                                            0.0129447  0.0002929  44.192  < 2e-16 ***
SexMale                                        0.1270462  0.0137377   9.248  < 2e-16 ***
SexUnknown                                    -4.2960206  0.3211145 -13.378  < 2e-16 ***
InvolvedPersonTypeOther                       -0.1071618  0.1517796  -0.706  0.48017
InvolvedPersonTypePassenger                   -1.2205195  0.0162893 -74.928  < 2e-16 ***
DrinkingNo Alcohol Involved                   -1.1232842  0.0222744 -50.429  < 2e-16 ***
DrinkingNo Reported or Unknown                -0.2232654  0.0229889  -9.712  < 2e-16 ***
DeformedFunctional Damage                     -1.6483223  0.0224660 -73.370  < 2e-16 ***
DeformedMinor Damage                          -2.7673376  0.0415450 -66.611  < 2e-16 ***
DeformedNo Damage                             -1.9970182  0.0640607 -31.174  < 2e-16 ***
DeformedOther                                 -0.8916923  0.0312459 -28.538  < 2e-16 ***
RouteInterstate                               -0.3825678  0.0241950 -15.812  < 2e-16 ***
RouteLocal Street                             -0.2515716  0.0224903 -11.186  < 2e-16 ***
RouteOther                                    -0.0783370  0.0366481  -2.138  0.03255 *
RouteState Highway                            -0.3385639  0.0206737 -16.377  < 2e-16 ***
RouteU.S. Highway                             -0.4879919  0.0228103 -21.394  < 2e-16 ***
LightConditionDark - Not Lighted               0.2094969  0.0207910  10.076  < 2e-16 ***
LightConditionDawn                             0.2471651  0.0489232   5.052 4.37e-07 ***
LightConditionDaylight                         0.0929198  0.0189961   4.892 1.00e-06 ***
LightConditionOther                            0.0389489  0.0395722   0.984  0.32499
WeatherGroupedPrecipitation-Yes, Temperature High -0.0938882  0.0244135  -3.846  0.00012 ***
WeatherGroupedPrecipitation-Yes, Temperature Low  -0.1867646  0.0401986  -4.646 3.38e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 177119  on 131413  degrees of freedom
Residual deviance: 149295  on 131388  degrees of freedom
AIC: 149347

Number of Fisher Scoring iterations: 6
```

Similarly, a cutoff point 0.51 is selected because it corresponds to the maximum summation of specificity (49.15%) and sensitivity (21.26%), which is 70.41%.



Based on the training data, we have created two models and selected its corresponding cutoff points. Then we have applied both model and selected cutoff points to the 2015 data (testing dataset).

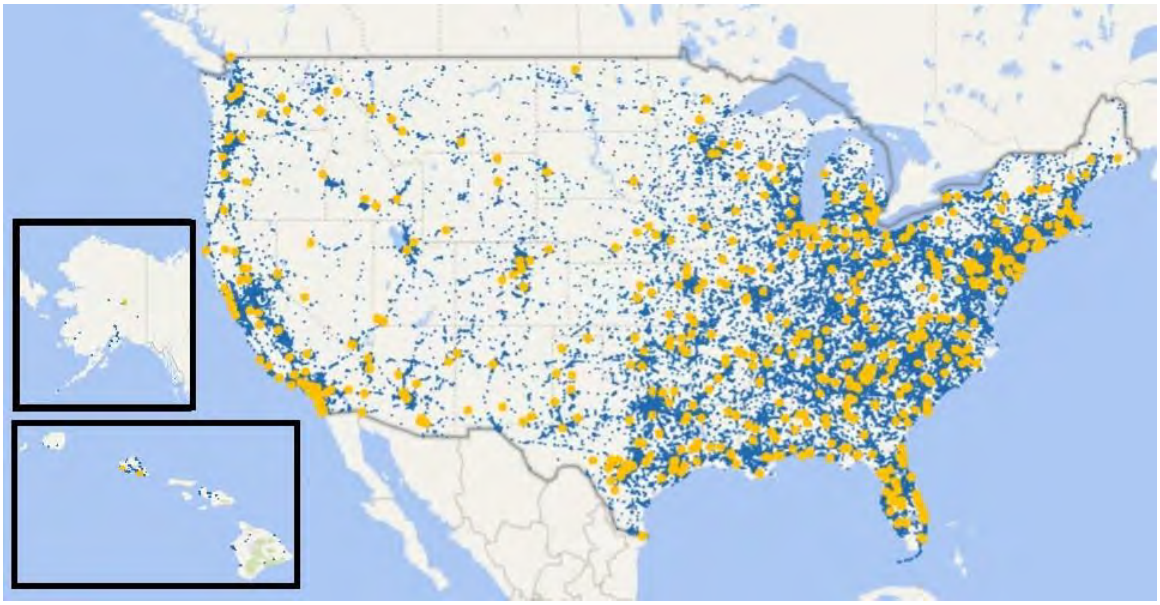
Without cutoff points, expected value will be probabilities for each exposure. Overall there is no significant difference between the two models' A/E ratios. However, if cutoff point is applied so that each exposure has a binary prediction, then model with weather condition performs (71.99%) better than model without weather (64.72%). We conclude that weather is a significant variable that impacts the auto's fatal accidents. In particular, precipitation and temperature in combination impacts the fatal probability when a fatal accident happens.

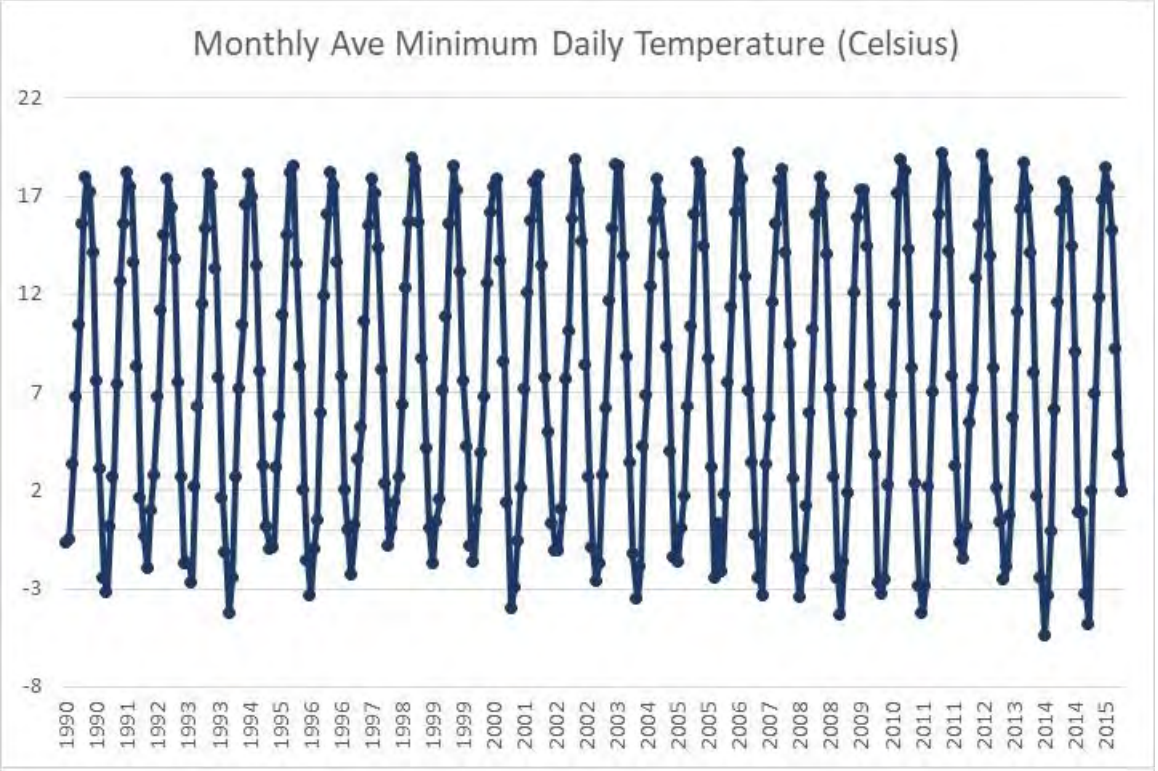
	Actual / Expected			
	Model w/ Weather No Cutoff	Model w/o Weather No Cutoff	Model w/ Weather With Cutoff	Model w/o Weather With Cutoff
Training Data Fitting	100.00%	100.00%	126.14%	138.08%
Testing Data Prediction	93.83%	93.82%	71.99%	64.72%

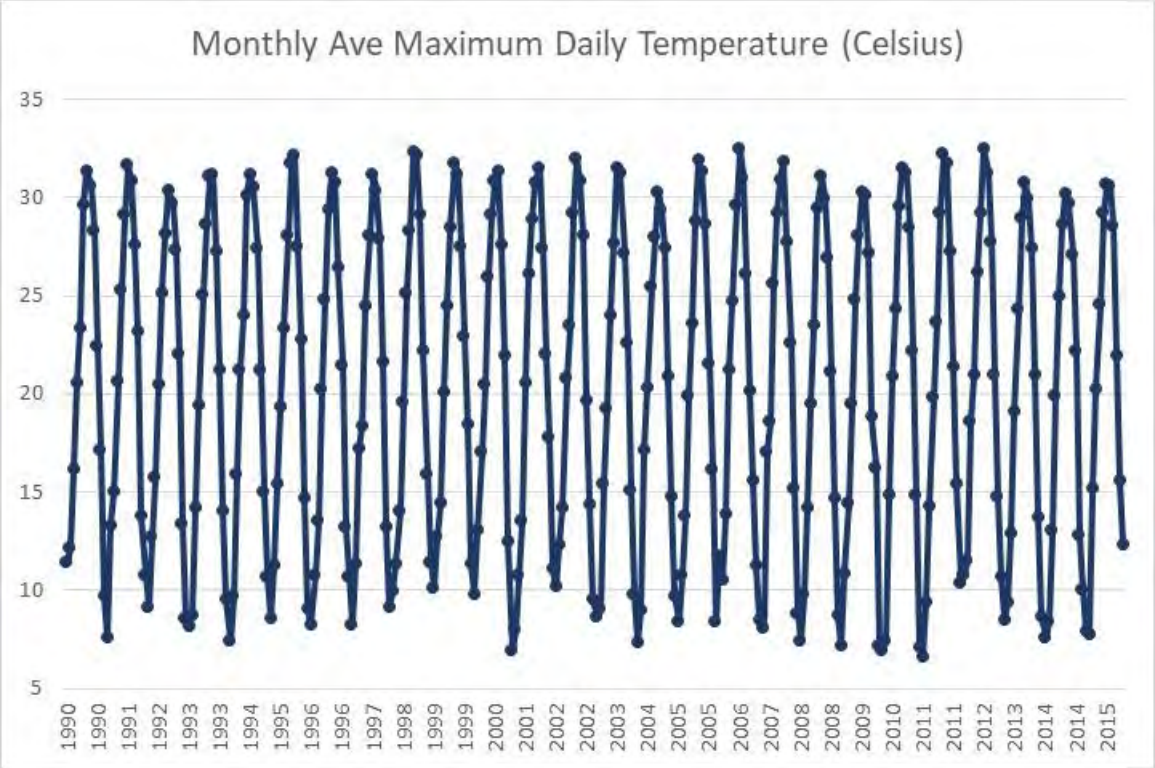
Climate Change Analysis

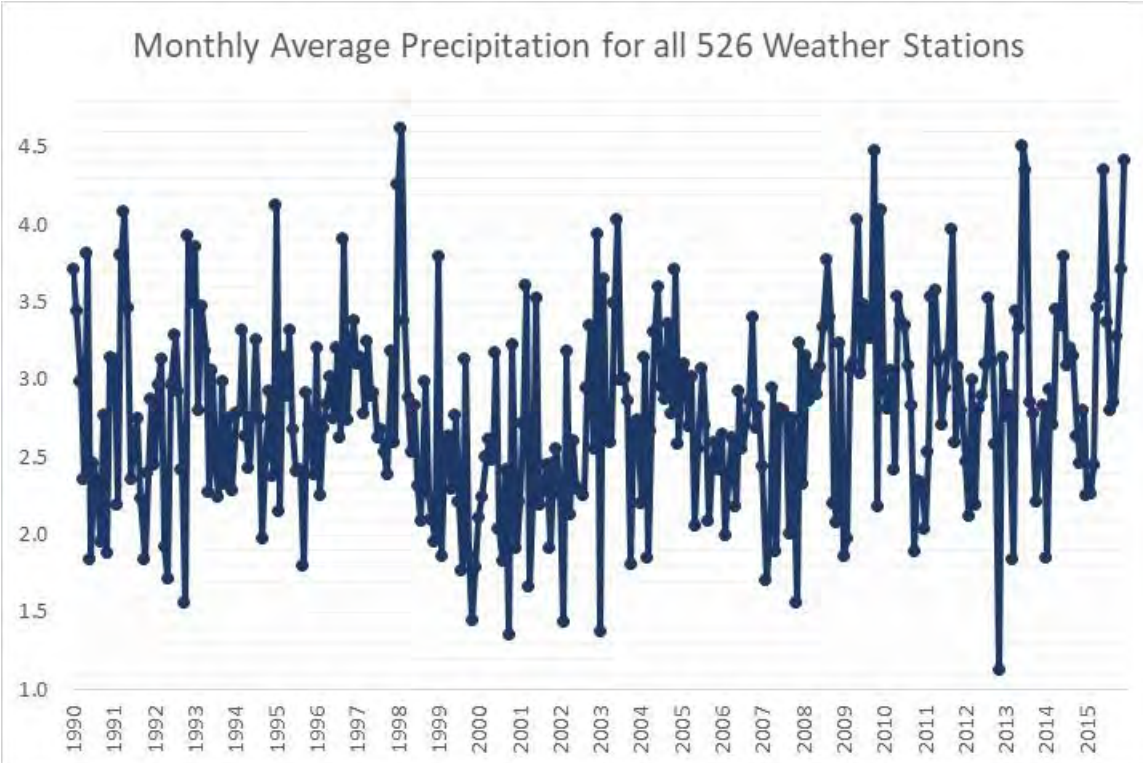
In this study, weather is defined as a short time weather condition, and climate change is defined as a long-time ad-hoc weather condition trend. Weather is micro level perspective and climate change is macro perspective. The impact of weather is direct and instant, and impact of climate change is long term and gradual. Next, we test whether the precipitation and temperature changes in the past 35 years, and both of them are key evidence of climate change.

526 National Climate Data Center weather stations were randomly selected. Number of stations in each state is proportional to the number of fatal accidents in 2015. In the following graph, each blue point represents a fatal accident happened in 2015, and each yellow point represents a weather station selected for the climate change analysis. This study focuses on how climate change impacts vehicle accidents, this weather data selection approach will minimize the bias. Because climate may have significant change in areas less vehicle operated, and it will distort the result if too much weather station data collected from these areas.




Monthly Ave Minimum Daily Temperature (Celsius)
22
17
12
7
2
-3
-8
1990 1990 1991 1992 1993 1993 1994 1995 1996 1996 1997 1998 1999 1999 2000 2001 2002 2002 2003 2004 2005 2005 2006 2007 2008 2008 2009 2010 2011 2011 2012 2013 2014 2014 2015


Monthly Ave Maximum Daily Temperature (Celsius)
35
30
25
20
15
10
5
1990 1990 1991 1992 1993 1993 1994 1995 1996 1996 1997 1998 1999 1999 2000 2001 2002 2002 2003 2004 2005 2005 2006 2007 2008 2008 2009 2010 2011 2011 2012 2013 2014 2014 2015



Among the selected 526 weather stations, we further selected 10 stations and each one representing a geographical region for a detailed time series modeling to illustrate whether there is a climate change effect. We used multiplicative seasonal autoregressive integrated moving average (ARIMA) model for the 10 stations precipitation, maximum daily temperature and minimum daily temperature. Multiplicative seasonal ARIMA model is particularly good for data that have obvious seasonal pattern. The model captures the seasonal as well as trend in an explicit format which make the climate change identification easy.

The following is the descriptive formula for the Multiplicative Seasonal ARIMA model:

$$Multiplicative\ Seasonal\ ARIMA(p,d,q) \times (P,D,Q)_s$$

$$\phi(B) * \Phi(B^s) * ((1-B)^d * (1-B^s)^D * X_t - \mu) = \theta(B) * \Theta(B^s) * w_t$$

$$where\ w_t \sim Gausian\ White\ Noise\ (0, {\sigma_w}^2)$$

$$\mu = E((1-B)^d * (1-B^s)^D * X_t)$$

$${\sigma_w}^2 = Variance\ (w_t)$$

X_t is the dependent variable we are modeling, such as precipitation, monthly average maximum daily temperature and monthly average minimum daily temperature.

s is seasonal period, there is an obvious annual seasonal effect, for example, every year's January has a similar low temperature. In the data, I aggregated the daily data into monthly, thus s is pre-defined as 12.

d is called non-seasonal integer degree of differencing, this is the key parameter that are tested, if the best model created has a more than 0 d value, then there is a climate trend.

D is called seasonal integer degree of differencing, since s is defined as 12, thus D is expected to be 1 to reflect that the data does show a seasonal annual pattern.

$\phi(B)$ is non-seasonal autoregressive polynomial of order p

$$\phi(B) = 1 - \phi_1 * B - \phi_2 * B^2 - \cdots - \phi_p * B^p$$

$\theta(B)$ is non-seasonal moving average polynomial of order q

$$\theta(B) = 1 + \theta_1 * B + \theta_2 * B^2 + \cdots + \theta_q * B^q$$

$\Phi(B^s)$ is seasonal autoregressive polynomial of order P

$$\Phi(B^s) = 1 - \Phi_1 * B^s - \Phi_2 * B^{2s} - \cdots - \Phi_P * B^{Ps}$$

$\Theta(B^s)$ is seasonal moving average polynomial of order Q

$$\Theta(B^s) = 1 + \Theta_1 * B^s + \Theta_2 * B^{2s} + \cdots + \Theta_Q * B^{Qs}$$

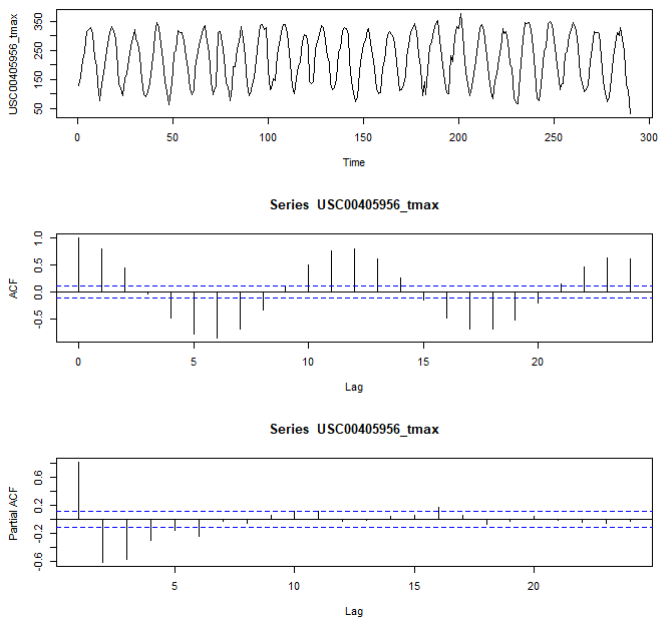
The following is the graph of the ten stations selected to represent ten geographical regions of the U.S. Not all of the weather station data have completed daily data, thus ten stations are carefully selected such that they have the highest data coverage from 1990 to 2015.

The following table shows the result of the ten weather stations' multiplicative seasonal ARIMA model parameters, where they are tested to have lowest BIC values. Most of the D values are 1 which represents there is annual seasonal pattern, and most of d values are 0 which represent there is no climate change pattern.

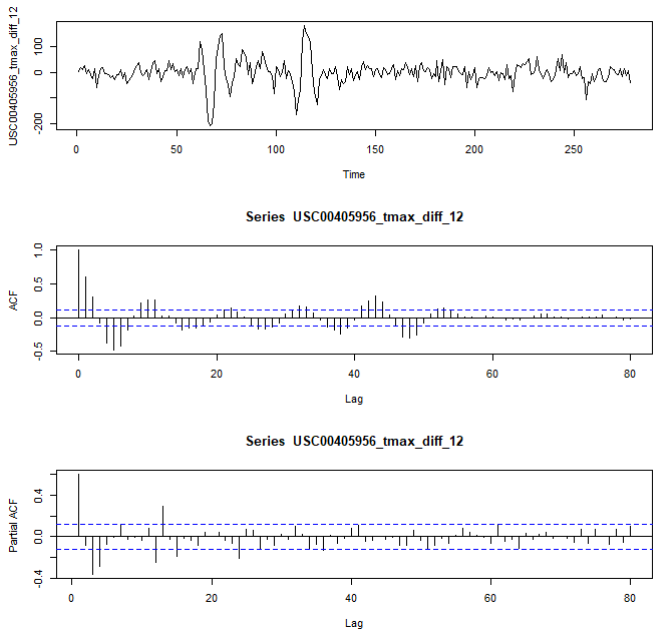
Multiplicative Seasonal ARIMA Model Parameters

		Monthly Average Daily Maximum Temperature						Monthly Average Daily Minimum Temperature						Precipitation					
Station Name		p	d	q	P	D	Q	p	d	q	P	D	Q	p	d	q	P	D	Q
Station 1	USC00041194	2	0	2	0	1	1	0	0	2	0	1	1	1	1	1	0	0	2
Station 2	USC00085275	2	1	2	0	0	0	2	1	2	0	0	0	0	1	1	1	0	1
Station 3	USC00233601	1	0	1	0	1	1	2	0	0	0	1	1	0	0	0	0	1	1
Station 4	USC00361354	1	0	0	1	1	2	2	0	2	0	1	1	0	0	0	0	1	1
Station 5	USC00396947	2	0	2	0	0	2	1	0	2	0	0	2	2	0	2	0	1	1
Station 6	USC00405956	0	0	2	0	1	1	0	0	2	1	0	1	0	1	1	0	0	0
Station 7	USC00419175	1	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	1	1
Station 8	USC00422385	1	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	1	1
Station 9	USW00094746	1	0	1	0	1	1	1	0	1	0	1	1	0	1	1	0	0	0
Station 10	USC00519231	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	1	1

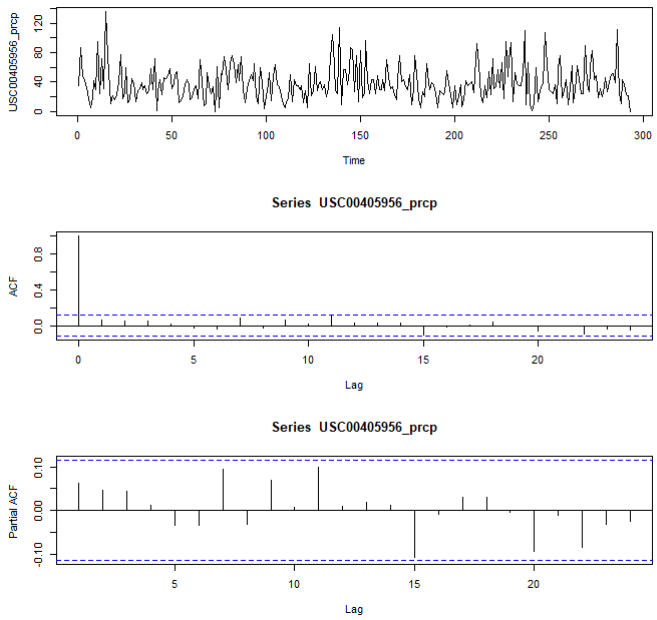
For example, for station 6's monthly average daily maximum temperature, there is a seasonal pattern, and no obvious increasing or decreasing trend.



It is also verifiable to see why the model is particularly fit for this scenario, because temperature patterns are much less seasonable in the following graphs after differencing by 12 months.



For precipitation, the seasonal impact is much less significant, that's why some of the stations shows D = 0. Although there is d = 1 for the selected model, it is still very difficult to identify a climate change from the data. For example, station 6 has precipitation D = 0 which indicates there is no seasonal effect, but d = 1 which indicates there is precipitation change. However, from the graphs below, it shows that the change is not systematic nor significant.



Conclusion

Weather condition is a significant factor for both commercial and personal auto fatal accidents happened in the U.S. However, after studying the weather information, we found that there is no significant increase or decrease of precipitation, monthly average maximum daily temperature, and monthly average minimum daily temperature. Therefore, weather change will not impact auto insurance industry in the near future. However, it is still an important factor for insurance industry to fully understand how weather conditions effects their portfolio because they may have different exposure with different weather conditions, or they are exposed to catastrophic weather events.

The conclusion is based on weather stations that are closest to where vehicles are mostly driven instead of all of overall climate in the U.S. Also, precipitation and temperature are contributing factors of fatal accidents, and thus studied in the climate change content. This does not mean there is no other significant changes on other climate dimensions. This study did not consider catastrophic event which we do believe have a significant impact on property insurance coverages, and authors plan to research on this topic in the future.

Next step

Weather data will be studied more in depth. For example, data that reflects catastrophic events will studied, and then test whether there is systematic or climate change, such as hurricanes. The next step will be testing whether there is an impact on personal and commercial auto insurance. Also test how much houses are affected by weather condition and climate change so that home-owner insurance industry could benefit from the study.

Another perspective to improve the study is to work with insurance company or department of transportation to get exposure data. The fatal accidents data within this study is parallel to claims data within insurance industry, exposure data will improve the understanding on the frequency and severity of the fatal accidents.

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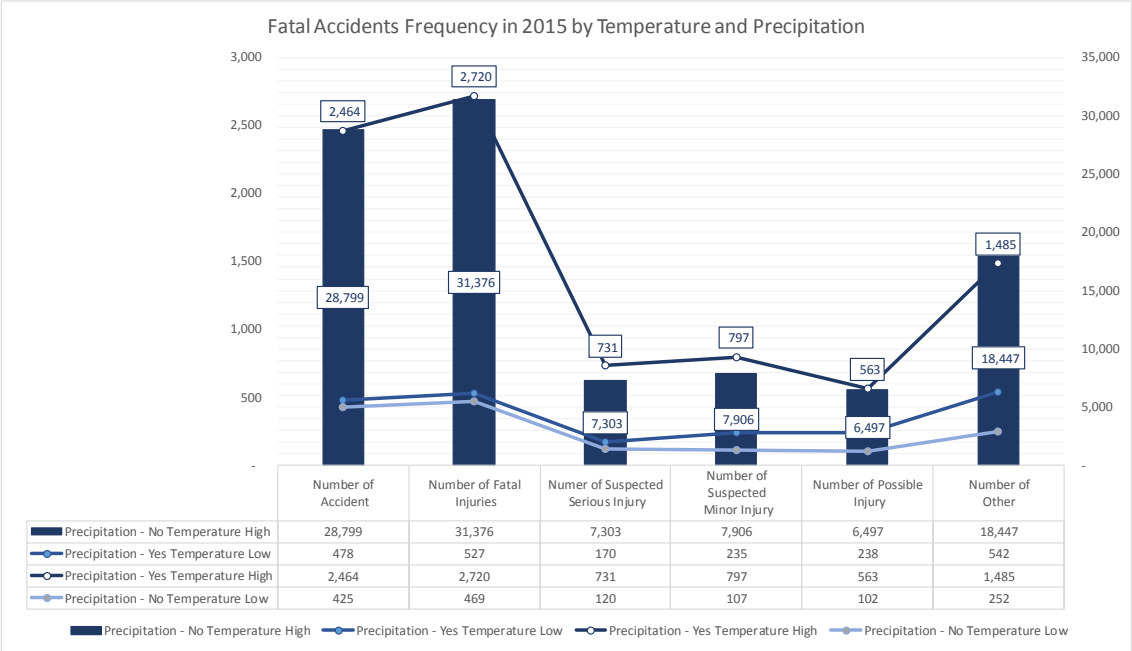
Appendix

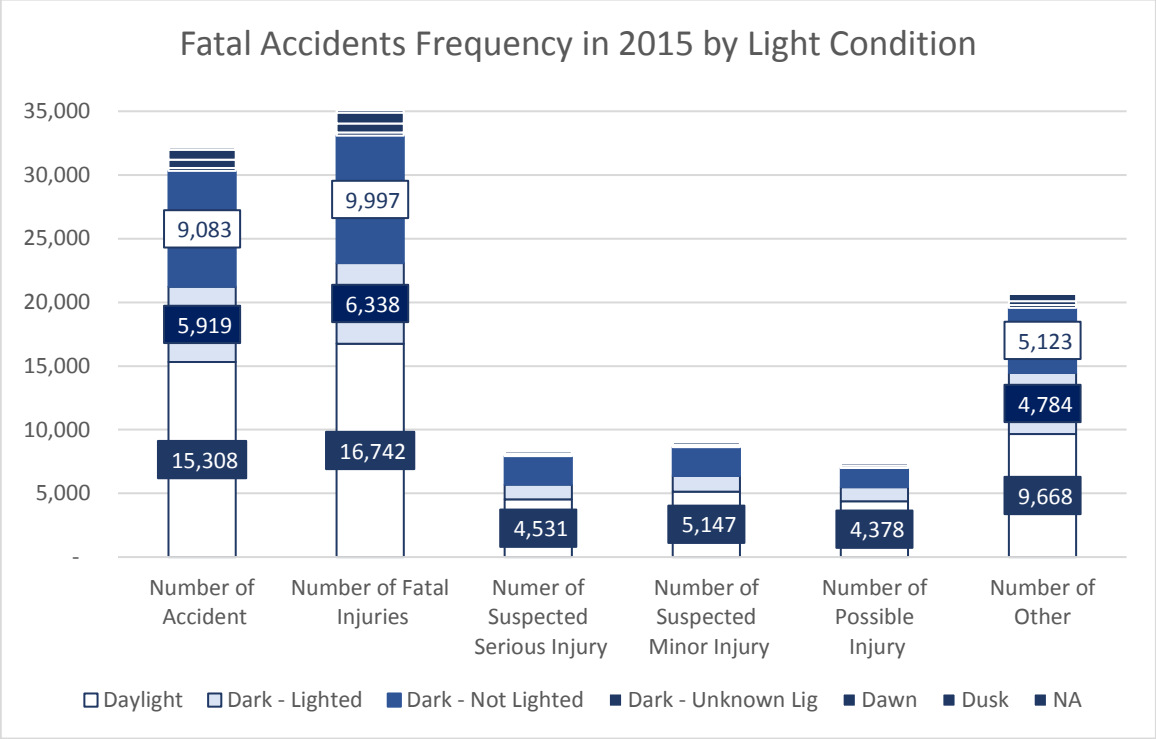
By Accident

Frequency of the accidents by different categories (weather condition and injury severity) is demonstrated here to build an overall picture of fatal accident. There are numerous studies on this topic which have tried to explain factors affecting the accident frequency in the literature (Anastasopoulos and Mannering 2009). In 2015, 28,799 (89.53%) fatal accidents happened on a cloudy or clear day. we categorized this weather condition as no precipitation and high temperature day. In the logistic modeling section no precipitation – high temperature and no precipitation – low temperature are combined into one group, no precipitation, because these two groups are not statistically different as fatal accidents contributing factors.

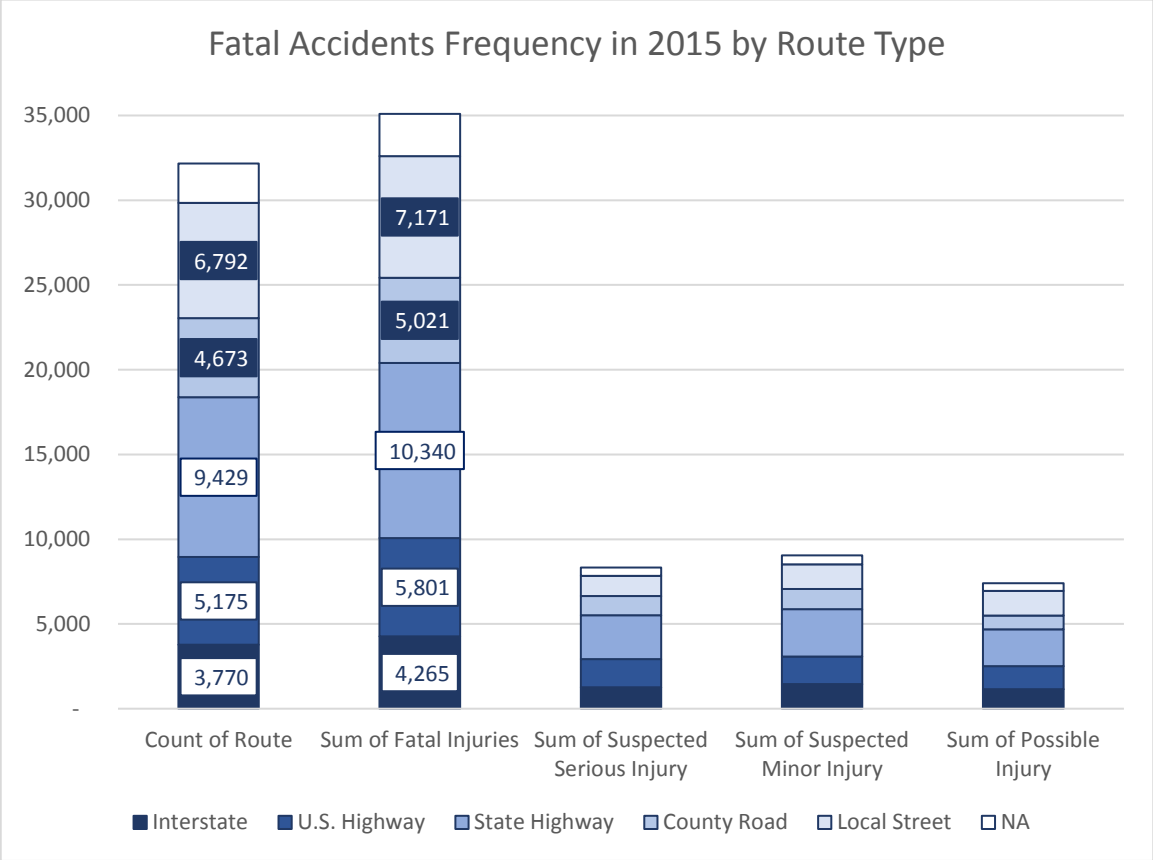


	Number of Accident	Number of Fatal Injuries	Numer of Suspected Serious Injury	Number of Suspected Minor Injury	Number of Possible Injury	Number of Other
Precipitation - No Temperature High	28,799	31,376	7,303	7,906	6,497	18,447
Precipitation - Yes Temperature Low	478	527	170	235	238	542
Precipitation - Yes Temperature High	2,464	2,720	731	797	563	1,485
Precipitation - No Temperature Low	425	469	120	107	102	252

Light condition is a contributing factor for fatal accidents. Although most of the accidents happened while there is daytime, but there is significant amount of fatal accidents happened during the nighttime. Light is a significant factor in this perspective especially considering the weather condition of a given time. Not lighted dark condition with precipitation impacts the overall driving condition and increases the risk of fatal accidents.



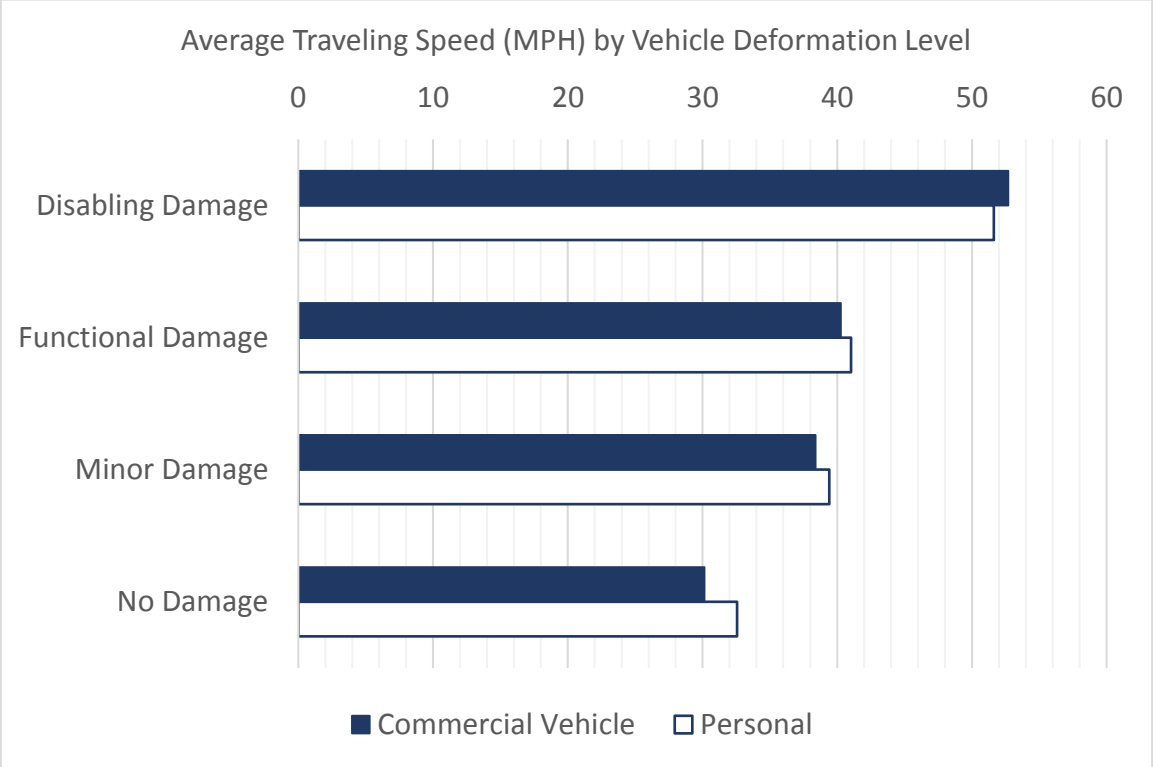
Route types such as interstate and US highway have a higher speed limit compared with county roads and local streets. The speed limit has a positive correlation with the vehicle traveling speed which also impacts the fatal accidents.



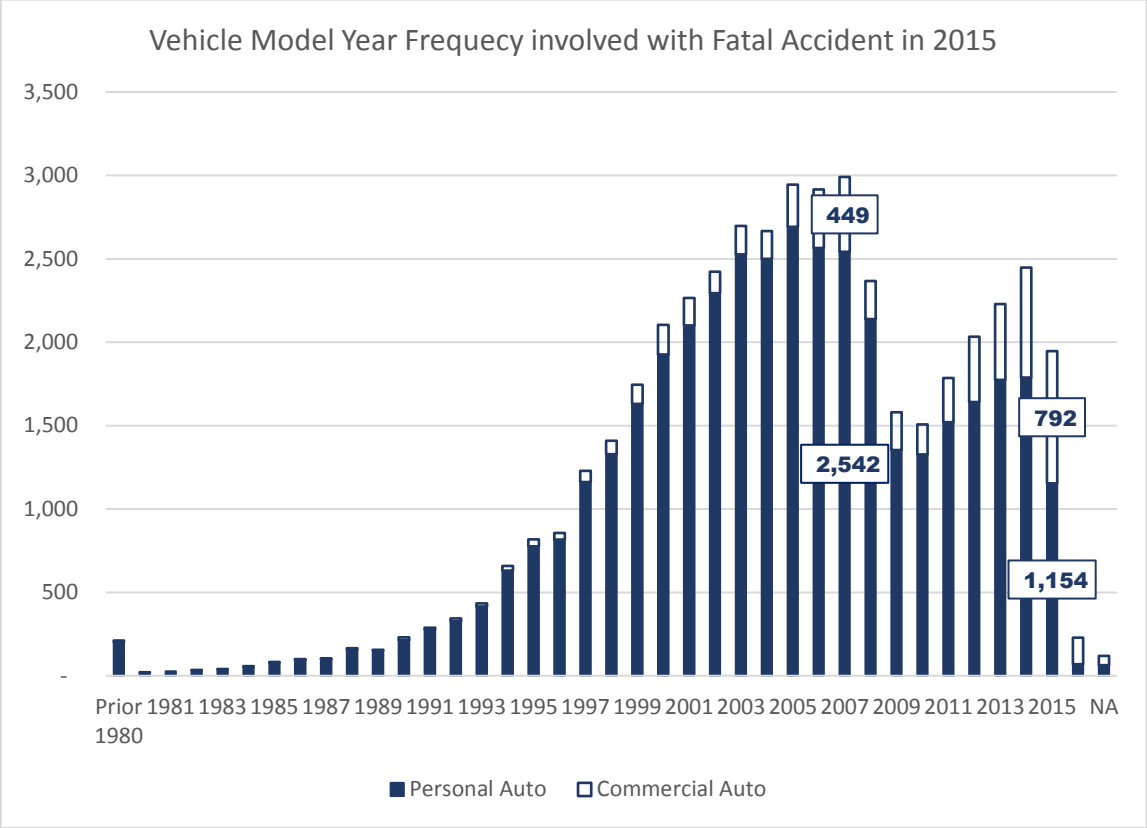
By Vehicle

The FARS database has detailed information on vehicle owners. The vehicles registered as Business, Company, Government or Rental vehicles are considered as commercial vehicles. All other vehicle owners such as driver registered as owner, other private owner registered as owner, driverless cars, parked cars etc. are considered as personal vehicles in this study.

There is an obvious trend that higher traveling speeds cause more severe vehicle damage. For example, average speed that causes personal auto's disabling damage is 51.62 miles per hour (MPH), compared with average speed of 41.02 MPH that causes personal auto's functional damage. However, there is no significant traveling speed difference between the commercial auto and personal auto.



Among all of the vehicles involved with fatal accidents, commercial auto has more new vehicle models than the personal models. In 2015, there are 40,496 (73.30%) personal auto, 5,757 (10.42%) commercial auto and 8,996 (16.28%) other vehicles involved with fatal accidents.



It is notable to observe that the average traveling speed is higher for both commercial auto and personal auto while there is precipitation and low temperature such as snow, blowing snow, sleet, freezing rain or drizzle compared with other weather conditions. Weather condition is affecting the driving behavior and ultimately impacts the commercial and personal auto accidents.

Average Traveling Speed of the Vehicle Involved with Fatal Accident by Weather Condition and Route Type

Commercial Auto		Interstate	U.S. Highway	State Highway	County Road	Local Street	Other
Precipitation - Yes	Temperature Low	63.6	42.7	59.8	56.8	55.0	NA
	Temperature High	46.6	48.9	47.0	62.7	55.6	80.0
Precipitation - No	Temperature Low	44.4	46.7	47.5	51.7	55.0	NA
	Temperature High	47.1	49.3	48.0	56.6	48.8	59.1
Total		48.8	48.9	48.0	56.9	49.7	61.3

Personal Auto		Interstate	U.S. Highway	State Highway	County Road	Local Street	Other
Precipitation - Yes	Temperature Low	61.2	50.4	56.3	60.0	44.0	62.6
	Temperature High	42.9	49.7	45.7	46.0	41.3	57.8
Precipitation - No	Temperature Low	40.4	47.3	47.0	45.6	41.5	55.0
	Temperature High	47.7	50.4	48.8	50.9	47.2	58.0
Total		47.7	50.3	48.7	50.6	46.7	58.1

Other Auto		Interstate	U.S. Highway	State Highway	County Road	Local Street	Other
Precipitation - Yes	Temperature Low	56.8	59.2	61.7	67.6	49.2	69.0
	Temperature High	34.2	56.5	41.1	61.7	49.2	63.9
Precipitation - No	Temperature Low	37.5	42.5	61.1	36.7	25.0	NA
	Temperature High	49.6	50.7	50.8	49.9	50.4	63.6
Total		48.6	51.3	50.0	51.0	50.2	63.8

By People

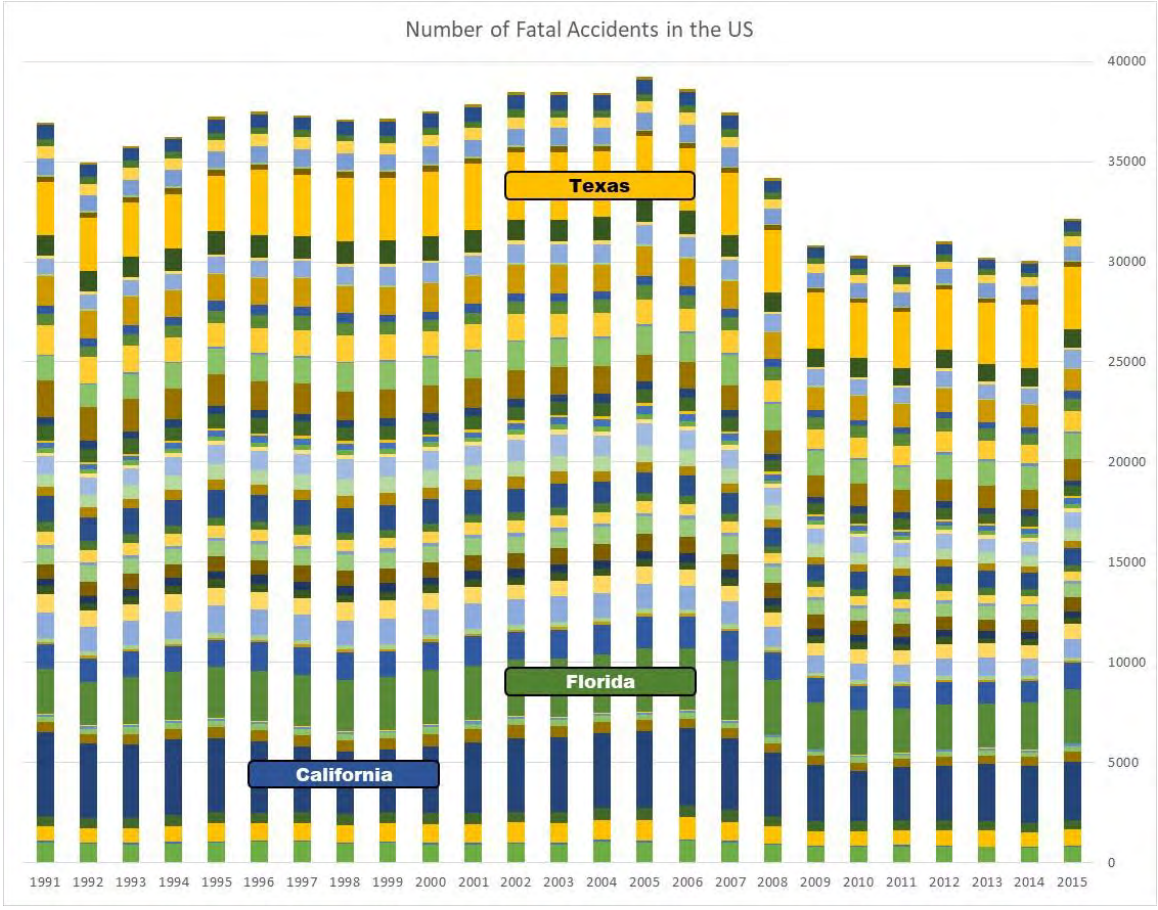
22,150 (63.12%) fatal injuries happened to drivers of a motor vehicle, which is the highest among all types of people who involved with fatal accidents. All the other people who are involved with fatal accidents could be treated as proxy of auto insurance liability coverage which has 12,942 (36.88%) fatal injuries.

Number of Injuries by the Types of Individuals Involved with the Fatal Accidents in 2015

	Number of Fatal Injuries	Number of Apparent Injury	Numer of Suspected Serious Injury	Number of Suspected Minor Injury	Number of Possible Injury	Number of Other	Total
Driver of a Motor Vehicle In-Transport	22,150	13,576	3,774	4,590	3,813	710	48,613
Passenger of a Motor Vehicle In-Transport	6,447	5,941	4,268	4,237	3,470	283	24,646
Pedestrian	5,376	15	205	128	63	8	5,795
Bicyclist	817	1	16	13	3	1	851
Persons on Personal Conveyances	154	-	7	3	3	-	167
Unknown Occupant Type in a Motor Vehicle	74	2	18	16	4	17	131
Occupant of a Motor Vehicle Not In- Trans	34	161	17	41	30	3	286
Occupant of a Non-Motor Vehicle Transport	24	8	14	11	9	-	66
Persons In/On Buildings	15	-	5	6	4	-	30
Other Cyclist	1	-	-	-	-	-	1
Unknown Type of Non-Motorist	-	-	-	-	1	-	1
Total	35,092	19,704	8,324	9,045	7,400	1,022	80,587

By Year

There is a significant decrease in the number of fatal accidents after 2008. There was a systematic factor that caused the drop in each state, because the proportion of the fatal accident is consistent before and after the drop. The economic crisis may be one direct or indirect contributing factor for the overall drop.


Number of Fatal Accidents in the US
40000
35000
30000
25000
20000
15000
10000
5000
0
Texas
Florida
California
1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

TEACHING AND INNOVATIVE EDUCATION - ABSTRACTS

A Practitioner's Guide to Transitioning to Academia

The purpose of this abstract and associated paper will be to provide a professional who has performed services in industry (i.e. business world) guidance when making a seamless transition to academia.

As a former professional with experience in Big 4 public accounting and Fortune 500 companies, we assume the challenge of "making it to the top" at all possible costs. We put in painless hours and time to expand our knowledge of the business process, embrace cultural differences in business, and are anxious to determine what is in our imminent future.

It is evident as we get "long in the tooth and greyer in the hairs", we realize that we want (and in most cases, need) to find our calling in the form of an educator and mentor to students in academia. The key question which peers ask me all the time is the following: How did you transition from industry to academia? How did you get into the schools where you teach? Who did you contact to express your interest in teaching?

This abstract and associated paper will be a "blueprint" for yearning practitioners who aspire to make the transition from industry to academia. Through my experiences and also gathering of information from peers who have made the successful transition, the goal is to provide a "best practices" roadmap for those professional that seek to transition into academia. For example, what are the tools and technologies (e.g. Blackboard, Publisher Portals, and Remote Proctoring) that a practitioner must use and learn to be successful in modern academia? Technology disruptors (e.g. cell phones, laptops, internet, texting, chats, and blogs) are commonplace in class rooms today, how does a newly transitioned practitioner embrace this behavior and create adaptive learning strategies for the 21st century student?

I look forward to submitting this abstract and working on a comprehensive and informative paper to present at your conference!

ESSENTIAL SKILLS DEVELOPMENT STRATEGIES FOR MBA MODELS

Emerging professional skills include analytical and critical thinking, innovation and creativity, and leadership and social influence. It is well documented that employers are stressing the importance that graduates possess these skills, especially those with MBA degrees. It is also increasingly common that MBA programs are identified as falling short of these expectations. The researchers will address the evolving imperative of incorporating professional and leadership skills development opportunities into emerging MBA models. The goal of the research is to define and document trends in the professional needs of employers, outline theoretical and actual approaches, and compare and contrast effectiveness. This research project also entails the review of more than 100 US-based MBA programs and identifies common and emerging strategies – this project highlights the various strategies as they relate to different programs and university emphases, in an effort to outline best practices in different delivery systems for MBA programs.

Keywords: MBA, leadership skills, innovation

Exploring Curricular Strategies for Improving the Ability of Students to Use Technology in the Workplace

By John Weber, Ph.D., DeVry University; Bhupinder S. Sran, Ph.D., DeVry University

ABSTRACT

Use of technology is commonplace in education these days in colleges and universities. Instructors have used it to enhance the delivery of course material as well as to implement new strategies for facilitating collaboration and active learning. Examples include use of video lectures, online discussions, and interactive online sessions for lectures and office hours.

Just as instructors need to use technology to do their work, students need to be prepared to work with technology in the modern workplace to carryout day-to-day functions. For example, organizations might use various technologies for online meetings, multimedia and video creation, collaborative authoring, analysis and presentation of information, and decision making. It is important that colleges and universities address the need of students to have experience with such technologies.

In this presentation, a model for comprehensive integration of technology into all courses, both technical and non-technical, will be introduced. This model is currently being used at a university with multiple locations across the country. The purpose of the model is to help students gain the necessary technical skills they might need to be successful in their careers after graduation. The model consists of a framework for identifying needs of the workplace and for defining and selecting curricular strategies. Initial feedback from instructors and students will also be discussed.

IMPACT OF ASSESSMENT GAMIFICATION ON STUDENT SATISFACTION AND ATTITUDE IN O&SCM COURSE

Hee Yoon Kwon

Koray Ozpolat

In this study, we explore the effects of assessment gamification on student's attitude and satisfaction. We apply gamification elements on the assessment throughout the course. The course preparation, attendance, quizzes, classroom activities, and team projects have game elements that accumulate to team advantages in the collaborative midterm and final exam.

This research empirically examines the effects of gamification on student's attitude and satisfaction, focusing on assessment activities. At the same time, it explores a way to implement gamification in an undergraduate course without heavily relying on technology, which may be hindering the proliferation of gamification in higher education. By adopting the design philosophy of meaningful gamification, we divert from the much-criticized stock approach of gamification and focus on the benefits for students in the gamified classroom.

State-funded business schools usually have an impressive image of the ratio of the quality of human assets and capital resources to the tuition costs. Nevertheless, the perspective does not remain the same when the 2-dimensional space of quality and cost expands to the 3-dimensions of Quality, Cost, and Time. Graduation rates are low and time-to-graduation is prolonged. In this study, we will have an Operations Management and Business Analytics review of the 16-year performance of a state-funded business school on graduation rate and time-to-graduation. We have implemented operations management tools such as systems thinking, operations strategy, process flow analysis, waiting line analysis, predictive analytics, inventory management, confidence interval, and tests of hypothesis, etc. to describe the problem in order to think about potential solutions. In this process, we have experienced that the students' interest in quantitative and analytical courses will increase if the course material is tied to real-world applications. Accordingly, the results of this study have been brought into the classroom and have been melded into the teaching material as problems and assignments. This approach may also have a positive impact on the time the students assign to their education, and, more importantly, on the mental presence and engagement of students inside actual or virtual classrooms.

INNOVATIONS IN STUDENT PROFESSIONAL AND CAREER PREPARATION

The Personal and Professional Development (PPD) program at the Jay S. Sidhu School of Business and Leadership at Wilkes University adopts an integrative, reflective and experiential approach. Its aim is to provide students with authentic and challenging experiences to acquire knowledge and skills that are necessary to make career choices, enter a career and become successful in their future career. By taking a one-credit experiential course (four in total) every year, students learn about various industries and their context. They also engage in practical activities in which they conduct observations and reflect on what they observe. By doing so, students engage in self assessments that help them identify their blind spots and unique strength. As a result, they gain greater self awareness that better positions them to explore opportunities to engage with others. Gradually, students gain personal and professional knowledge. The PPD program has two advantages. First, it helps them to integrate the multiple areas of knowledge that they acquire from many foundational and disciplinary courses. Second, it encourages them to have access to various companies and network with professionals, hiring firms and companies. Exit surveys reveal that the program is extremely successful in raising students' confidence to apply and interview for jobs and quickly socialize into corporate lives.

Keywords: Professional Development, Innovation, Career Development

NEWSVENDOR GAME: A BEHAVIORAL EXERCISE IN DECISION MAKING UNDER RISK

Chirag Surti and Anthony Celani

Abstract:

Newsvendor problem is a classic inventory ordering problem that is both taught in traditional Operations and Supply Chain Management classes as a problem of single period decision making under risk. In this paper, we cover two basic aspects that would of interest to any instructor tasked with teaching this topic: a) how to make better sense of the newsvendor problem for undergraduate and graduate students and b) how to turn it into an active learning exercise that is easy to administer in traditional classroom setting or online before, during or after class. Furthermore, research on newsvendor behavior shows that students do not behave in manner that is consistent with what is being taught in class and thus this exercise can help segue into a broader discussion on human behavior and perceptions of risk. This active learning exercise is a quick and effective way of demonstrating variety of different concepts in class in a meaningful manner: a) the rational economic method of calculating optimal order, b) the inherent risk in forecasting and ordering decisions as they relate to surplus and shortages and c) the cognitive limitation in decision making that often results in an irrational but predictable behavior. Overall, it should provide the student with an improved understanding of the operational and behavioral issues of decision making under risk.

Key words: *Teaching with Games, Behavioral Operations Management, Prospect Theory, Decision Making under Risk, Games and Simulations*

STUDENTS' PERCEPTIONS OF PROBLEMATIC SMARTPHONE USE ON EXPERIENTIAL AND REFLECTIVE COGNITIVE PROCESSES

Smartphones are ubiquitous and have become an integral part of everyday lives of university students. These devices provide quick access to the Internet and a multitude of applications including social networking and gaming apps. Recent data from the EDUCAUSE Center for Analysis and Research indicates that 95% of university students have access to smartphones (Galanek, Gierdowski, & Brooks, 2018). The rapid increase in smartphone adoption among university students has prompted research in order to examine the impact of smartphone use in learning contexts.

An increasing number of students attribute the importance of smartphones to academic success, such as access to educational resources and collaboration (Chan, Walker, & Gleaves, 2015). Meanwhile, several researchers have found that problematic smartphone use, including chronic media multitasking is detrimental to academic performance (Aljomaa, Al.Qudah, Albursan, Bakhiet, & Abduljabbar, 2016; Hawi & Samaha, 2016; Samaha & Hawi, 2016). Chronic media multitasking has been found to increase cognitive overload, impede the cognitive processes required for learning, and impede the level of focused attention required to achieve a state of flow (Duke & Montag, 2017). As a result of the unintended consequences, 70% of university students indicated that faculty ban or discourage the use of smartphones in class (Galanek et al., 2018).

The purpose of this research-in-progress is to understand students' perspectives on how smartphone use affects the experiential and reflective cognitive processes required for learning. The first phase of this research involves a systematic review of the literature to examine the current state-of-the-art in research with respect to the antecedents of smartphone use and the

consequences on university student performance. The second phase of this research will involve a survey of undergraduate students' perceptions of how problematic smartphone use affects experiential and reflective cognitive processes required for learning and the impact on academic performance. The survey will use the Smartphone Addiction Inventory (Lin et al., 2014) in order to identify the risk of problematic smartphone use. In addition, a second instrument will be developed in order to assess the impact of problematic smartphone use on experiential and reflective cognitive processes.

This study will conclude with implications for research and practice. In terms of research, this study will shed light on the link between smartphone use and academic performance. The implications for practice includes developing best practices to motivate the responsible use of smartphones in academic environments. This will include strategies to capitalize on the benefits of smartphone use and mitigate the disadvantages. Moreover, this study seeks to analyze and assess new teaching approaches in order to engage students in learning activities.

Keywords: Smartphone use, Multitasking, Academic performance, Cognitive processes

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TEAM-BASED EDUTAINMENT LEARNING USING FLIPPED CLASSROOM AND 'IDEAS'

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nahmad@aus.edu

As classrooms are inevitably evolving from the traditional approach, educational systems seek an approach that can holistically cater to the visual, auditory, and kinesthetic learning needs of students with different strengths. This paper thus aims to utilize the current technological advancements towards a virtual environment for learning along with an approach engrained in theories such as the flipped classroom method of teaching, team based learning and the IDEAS methodology. The research supporting the paper proposes a detailed framework on what needs to be inculcated into the classroom setting by both the instructor and the student and what results can be expected. A case study on graduate level students in the classroom in the UAE shows numeric coherence to the research in order to support the objectives of incorporating the IDEAS method with existing flipped classroom and team-based learning methods to enhance overall student performance through the academic calendar.

USING ERPSIM TO EXAMINE THE EFFECTS OF STUDENT ENGAGEMENT AND TEAM DYNAMICS ON LEARNING OUTCOMES

Abstract

Student engagement has been a primary focus of many higher education institutions as a means to enhance and improve learning (Csikszentmalalyi et al., 2014; Whitton, 2011; Wolfe, 2016). Team-based learning has been linked to enhanced student engagement as well as to improved learning outcomes (Eder et al., 2019). In this research, we study the effects of student engagement and team dynamics on learning outcomes with the aim of understanding what factors contribute to different levels of learning complexity.

This study uses ERPsim, the continuous-time simulation game that enables students to learn about ERP by managing their own companies in a competitive environment (Léger, 2006) to teach ERP concepts in an introductory MIS course at two different U.S. universities.

Using validated scales, pre- and post-game surveys are administered to determine student knowledge of ERP concepts and skills both before and after the simulation game learning experience. In addition, the post-game survey collects data from students about their experience participating in the game. Prior research validated the survey instruments and also confirmed factor loadings for the three areas of study: student engagement, team dynamics, and learning outcomes (Eder et al. 2019). An adapted model based on Bloom's Taxonomy (Anderson and Krathwohl, 2000; Charland et al., 2015; LaBonte-LeMoyne et al., 2017) is used to examine the effects of student engagement and team dynamics on three levels of learning complexity: basic knowledge, applied knowledge, and problem-solving.

The next step in this research is to perform model selection on the data. Using Lasso, a regression analysis technique suitable for three or more factors, we seek to find the variables associated with different levels of knowledge generated from playing the ERPsim game. The benefits of using a Lasso regression is that the complexity of the model may be reduced to include only those variables which are most important, preventing overfitting that might occur with a simple linear regression (James et al, 2013).

This research explores the relationship of student engagement, team dynamics, and learning outcomes when using ERPsim to understand what aspects of student engagement and team dynamics affect different levels of learning outcome complexity. It contributes to educators'

endeavors to further student engagement, an important requirement of the current AACSB Standards for Business School Accreditation (AACSB, 2013), in the area of management information systems, and it validates the use of an ERP simulation game to promote learning through engagement and team collaboration.

Keywords: *Student engagement, Team dynamics, Learning outcomes, ERPsim*

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TEACHING AND INNOVATIVE EDUCATION - PAPERS

A PRELIMINARY STUDY OF CHANGING BUSINESS STUDENT PERCEPTIONS OF PROGRAM FACTORS IN ONLINE VERSUS FACE-TO-FACE EDUCATION

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Abstract

Over 6 years ago at an AACSB Jesuit, Catholic University with a strong focus on teaching, business student perceptions regarding online versus face-to-face (FTF) courses were surveyed and results indicated that students prefer face-to-face classes. Since research indicates that student perceptions change over time, this study evaluates whether for this population, perceptions changed. In this paper program factors, such as difficulty, student-to-student interaction, student-to-instructor interaction, cheating and program preference, are presented. Student preferences for certain technology in online versus FTF courses are analyzed. This research has implications for instructors and administrators.

Keywords: Student Perceptual Changes, Online, Face-to-face

Literature Review: Program Characteristics

Upper administrators perceive online education to be equivalent to face-to-face (FTF) (Allen & Seamen, 2013). Assuming that this is the case, then students should be indifferent to all educational factors. However, prior research on student perceptions are mixed, and results at a teaching university clearly demonstrate that students preferred FTF education over online education for most factors (Fish & Snodgrass, 2014). Other researchers found similar results to ours (Platt, Raile & Yu, 2014). Several researchers indicated that student perceptions to online education have changed over time (e.g. Allen & Seaman, 2013; Benbunan-Fich & Hiltz, 2003; Perreault, Waldman, Alexander & Zhao, 2008; Tanner, Noser, and Langford, 2003; Tanner, Noser, Fuselier & Totaro, 2004-1; 2004-2; Tanner, Noser, Totaro & Birch, 2006; Tanner et al., 2009). Also, differences between cultures exist as research at the turn of the century indicated differences between Australians and Asian students in student perceptions (Smith & Smith, 1999; Ramburuth & McCormick, 2001). However, a more recent study found no significant differences existed on many factors for these groups (Chew & Yee, 2015). Yet, another study reported changes in Chinese students' motivation and learning strategies after an online collaborative experience towards a social-constructivist learning approach (Zhu et al., 2009). A recent study on instructor attitudes with respect to instructor online presence noted that studies into instructor and student perceptions will continue to evolve as technology evolves (Richardson, Besser, Koehler, Lim. & Strait, 2016).

In our original literature review, two streams of literature emerged: studies that concentrate on students characteristics and studies that concentrate on program characteristics. In this research, we continue to explore student perceptual changes for students at the same University as 6 years

ago and focus on the program characteristics. In the original study, results indicated that both populations – students who only experienced FTF and students who experienced at least one online course, felt that FTF education was more difficult than online, preferred the interaction with students and the instructor in the FTF environment, felt that it was easier to cheat online than FTF, and both online and FTF students preferred the FTF classroom (Fish & Snodgrass, 2014). Additionally, the original research showed that as students acquire more online experience, their perceptions of online education become more positive (Fish & Snodgrass, 2014). With an increase in the number of online courses and technology changes at the University, *have the students' perceptions changed?*

Student perceptions regarding the online learning experience should be realistic (Tanner, Noser & Totaro, 2009). Theoretically, the more someone is exposed to and uses a particular technology or method, the more adept they become (Tanner et al., 2003; Tekinarslan, 2011; Dobbs et al., 2009), and as indicated in the original study, students acceptance of online education may increase (Fish & Snodgrass, 2014). In a study performed over a decade ago, students' perceptions changed as course activities and student interactions with others were satisfied (Mortagy & Boghikian-Whitby, 2010). As students acquire more online experience, their perception of online courses is more favorable (Tanner et al., 2003). Researchers initially indicated that at least 5 online courses are necessary for students to perceive that they learn more in the online environment than FTF (Dobbs et al., 2009). Other researchers found that graduates grew to accept online education as being equal to or better than traditional FTF education over time (Perrault et al., 2008).

In the original study, students were surveyed in the fall of 2012. Since that time, online courses have increased in number at the University, and instructor methods to teach online and available technologies have changed. For instance, original instructor training was through a group cohort online exposing instructors to available technology. Changes since the original study for online technology include a change to Desire2Learn at the University, from face-to-face interaction through 'GoToMeeting' to Zoom, the increase in Youtube, Google, and other videos availability, and additional access to database management systems such as Python and 'R'.

The decisions that are made in the delivery of an online and FTF course impact upon student perceptions. Barriers to distance education include: faculty, organization and course structure; physical distance; difficulties in dealing with media; time constraints; lack of background knowledge, distance education experience or technology skills; and low interactivity with the communication process (Olesova, Yang & Richardson, 2011). We continue with a discussion of various program characteristics and their impact upon student perceptions of online education.

*Course Organization & Technologies***.** Students perceive the course organization as key to student learning and success – particularly the learning environment structure and online assessment (Armstrong, 2011). Ambiguous instructions in the online learning environment contribute to student distress (Perreault et al., 2008) and as students want concise, specific directions on everything (Armstrong, 2011). Validated online frameworks with benchmarks and a student-centered model are favored in online education (Mortagy & Boghikian-Whitby, 2010). Flexibility and convenience are often cited by students as relevant factors for choosing an online course (Fish & Snodgrass, 2014; Horspool & Lange, 2012; Perreault et al., 2008).

Online offers greater access to additional learning resources (Sener & Stover, 2000), however, it requires additional student and instructor skills (Tekinarslan, 2011). Technically, online and FTF students appear technically well-equipped and comfortable in taking online courses as few report significant communication issues (Hospool & Lange, 2012). Students perceive a tool's value by how it's implemented, and the negative technology attributes are not as important as the communication quality (Armstrong, 2011). Unfortunately, faculty weak in technology appear to utilize technology in a manner that creates confusion (Armstrong, 2011). Students utilize non-academic resources, such as Google, more readily due to familiarity than academic resources (which they consider to be cumbersome and difficult to navigate) in completing assignments (Armstrong, 2011). Most used and valued elements include accessing unit information, accessing lecture/lab notes, interacting with unit learning resources, reading online discussions, contacting lecturers/tutors and submitting assignments online (Palmer & Holt, 2010). Students indicate that receiving feedback on assignments and reviewing unit progress as needing attention by the instructional provider (Palmer & Holt, 2010). Students perceived video modules, quizzes and the textbook as valuable to the learning environment regardless of online or FTF (Horspool & Lange, 2012). Instant messaging may be used as a technique to increase dialogue and reduce distance between students in an online course (Wang & Morgan, 2008).

In our original study, online students preferred discussion boards, homework and videos to increase their understanding, and felt that in-class sessions and instructor lectures decreased their understanding of course materials (Fish & Snodgrass, 2014). FTF students preferred instructor lectures, discussion boards and in-class sessions as increasing their understanding in the FTF classroom, and discussion boards, in-class sessions, instructor chat and readings as decreasing their understanding. Essentially, the groups tended to 'self-select' toward the environment that they favored for their learning style. FTF students tended to prefer the in-class interaction with other students and the instructor. Therefore, we pose research question #1: *Have student perceptions of academic activities changed over the past 6 years? Have student preferences remained the same for online and FTF or have they changed?* We pose the following hypothesis:

H_{1oA}: In the online environment, student preferences for academic activities have not changed over the past 6 years.
H_{11A}: In the online environment, student preferences for academic activities have changed over the past 6 years.

H_{1oB}: In the FTF environment, student preferences for academic activities have not changed over the past 6 years.
H_{11B}: In the FTF environment, student preferences for academic activities have changed over the past 6 years.

*Academic Rigor***.** Student perceptions on academic rigor vary, with some studies finding FTF courses easier than online (Dobbs et al, 2009; Asunka, 2008), while other finding online courses easier than FTF (Armstrong, 2011). In our original study, online students felt that online courses tended to be easier than FTF courses, while FTF students were relatively indifferent (Fish & Snodgrass, 2014). Therefore, we pose research question #2: *Over the past 6 years, have students*

perceptions of the rigors of online education changed, or do they still feel online education is 'easier' than FTF? We pose the following hypothesis:

H_{2oA}: In the online environment, over the past 6 years, students' perceptions of online education difficulty versus FTF have remained the same.
H_{21B}: In the online environment, over the past 6 years, students' perceptions of online education difficulty versus FTF have changed.

H_{2oB}: In the FTF environment, over the past 6 years, students' perceptions of online education difficulty versus FTF have remained the same.
H_{21B}: In the FTF environment, over the past 6 years, students' perceptions of online education difficulty versus FTF have changed.

Program Preference. Chief academic officers claim that the quality of traditional courses and online learning are the same (Allen & Seaman, 2013). However, student quality perceptions are mixed as some favor online over FTF (Hannay & Newvine, 2006), while others indicate the opposite (Asunka, 2008). One study indicated that first-time online students felt online quality was lower, but students with prior experience felt online quality was comparable (Dobbs et al., 2009). In our original study, online students preferred to be in the FTF classroom or were indifferent, while FTF students overwhelmingly preferred the FTF classroom. Therefore, we pose research question #3*: Over the past 6 years, have students' perceptions of preference for an educational medium changed?* We pose the following hypotheses:

$H_{30}A$: In the online environment, over the past 6 years, students' perceptions of their educational preference in a particular learning environment remain unchanged.
H_{31A}: In the online environment, over the past 6 years, students' perceptions of their educational preference in a particular learning environment changed.

H_{30B}: In the FTF environment, over the past 6 years, students' perceptions of their educational preference in a particular learning environment remain unchanged.
H_{31B}: In the FTF environment, over the past 6 years, students' perceptions of their educational preference in a particular learning environment changed.

Academic Integrity. Rumors surrounding online cheating abound, and the generally feeling from many is that students are more inclined to cheat in the online environment. In the original study, FTF and online students perceived cheating to be easier online than in the FTF classroom (Fish & Snodgrass, 2014). In a study of criminal justice students over a decade ago, students felt cheating was more common online, but they indicated that did not cheat (Lanier, 2006). However, many good students indicated that they felt they had to cheat to compete with others whom they felt were cheating, and some online students (40%) admitted helping others with exams (Lanier, 2006). Students with higher gpa's, females, married and older students are reportedly less inclined to cheat (Lanier, 2006). Therefore, we pose research question #4*: Over the past 6 years, have students' perceptions of cheating changed? Do they still feel it's easier to cheat online than in the FTF classroom?* We pose the following hypotheses:

H_{40A}: In the online environment, over the past 6 years, students' perceptions of cheating remain unchanged.
H_{4A1}: In the online environment, over the past 6 years, students' perceptions of cheating changed.

H_{40B}: In the FTF environment, over the past 6 years, students' perceptions of cheating remain unchanged.
H_{41B}: In the FTF environment, over the past 6 years, students' perceptions of cheating changed.

Student-to-Student Interaction. Student-to-Content, Student-to-Instructor and Student-to-Student interactions impact upon the student perceptions and effectiveness in the FTF and online classroom. However, research results are not clear on these constructs. Empirical research indicates that Student-to-Instructor interactions followed by Student-to-Student interactions were equally or more important relative to Student-to-Content interactions as they mitigated the sense of isolation of online courses (Campbell et al., 2008; Lou et al., 2006; Means et al., 2009). However, other studies indicate that when Student-to-Instructor and Student-to-Student interactions were low, increasing Student-to-Content interactions, increased course effectiveness (Bernard et al., 2009). Another study demonstrates that Student-to-Content interactions are the most preferred interaction, followed by Student-to-Instructor and Student-to-Student interactions (Mann & Henneberry, 2014).

Communication speed and consistency are shaping students' perceptions and approaches to learning (Armstrong, 2011). However, results on student-to-student communication and interaction are mixed. Some studies indicate online courses enhance learner participation and interactivity (Fredericksen, Pickett, Shea, Pelz, & Swan, 2000; Maeroff, 2004; Wang & Morgan, 2008), and others highlight student distress (Hara & Kling, 2003) or general feeling of 'disconnect' due to the lack of FTF interactions (Stodel, Thompson & MacDonald, 2006). In our original study, FTF students liked the FTF student interaction compared to online classes (Fish & Snodgrass, 2014). The inability to interact (for example, through posing questions, sharing opinions, engaging in dialogue, or a sense of belonging to a group) influences student perceptions as to how well they perform in an online class (Picciano, 2002; Song, Singleton, Hill & Koh, 2004). Students report communication issues with other students (Horspool & Lange, 2012) along with a general unwillingness of other online learners to participate in group activities (Dirkx & Smith, 2004; Maeroff, 2004). Online students report meeting with their peers less often than FTF students and form fewer study groups than FTF students (Horspool & Lange, 2012).

Therefore we pose research question #5: *Over the past 6 years, have students' perceptions on student-to-student interaction changed? Do they still feel it's easier to interact in the FTF classroom than online?* We pose the following hypotheses:

H_{50A}: In the online environment, over the past 6 years, students' perceptions of student-to-student interaction remain unchanged.
H_{51A}: In the online environment, over the past 6 years, students' perceptions of student-to-student interaction changed.

H_{50B}: In the FTF environment, over the past 6 years, students' perceptions of student-to-student interaction remain unchanged.
H_{51B}: In the FTF environment, over the past 6 years, students' perceptions of student-to-student interaction change.

Faculty Involvement. With respect to the student-to-instructor perceptions, research results are again 'mixed'. When students perceive faculty as missing from the conversation, students perceived the course quality as poor and vice versa (Armstrong, 2011). The degree of social presence and perceived learning and perceived quality of the instructor are positively correlated (Richardson & Swan, 2003). Some studies indicate that online interaction with the instructor is equal or even more positive than FTF (Boyd, 2008; Mortagy & Boghikian-Whitby, 2010), indifferent (Horspool & Lange, 2012) or weaker (Fish & Snodgrass, 2014; Wuensch, Aziz, Ozan, Kishore & Tabrizi, 2008; Wang & Morgan, 2008). In the original study, regardless of their respective environment, students perceived the student-to-instructor interaction to be better in the FTF environment than the online one (Fish & Snodgrass, 2014). Therefore we pose research question #6: *Over the past 6 years, have students' perceptions on student-to-instructor interaction changed? Do they still prefer the interaction with the instructor in the FTF environment instead of online?* We pose the following hypotheses:

H_{60A}: In the online environment, over the past 6 years, students' perceptions of student-to-instructor interaction remain unchanged.
H_{61A}: In the online environment, over the past 6 years, students' perceptions of student-to-instructor interaction remain changed.

H_{60B}: In the FTF environment, over the past 6 years, students' perceptions of student-to-instructor interaction remain unchanged.
H_{61B}: In the FTf environment, over the past 6 years, students' perceptions of student-to-instructor interaction remain changed.

Salient Conclusions for Our Study. While not intended to be a comprehensive review of literature in this area, it serves to clearly indicate that ambiguity currently exists in the debate between online and FTF education. Research results on student satisfaction with online versus FTF formats are mixed as some studies indicate that the courses are equally effective across formats (Fowler, 2005; Topper, 2007; Horspool & Lange, 2012), while others show a preference to FTF over online environments (Mullen & Tallent-Runnels 2006), and others show a higher satisfaction for online learning (Connolly, MacArthur, Stansfield & McLellan, 2007). Studies differ in the audience (e.g. scientific versus social sciences, business versus non-business, and graduate versus undergraduate), size (small, medium, large universities), and method of research (e.g. interview, survey). Several online perception studies were completed at large universities or in a public forum (Tanner et al., 2003; Tanner et al., 2004-1; 2004-2; Tanner et al, 2006; Tanner et al., 2009) or in non-business fields (e.g. Dobbs, Waid, & delCarmen, 2009; Lanier, 2006; Leasure, Davis & Theivon, 2000; Reilly et al., 2012; Tekinarslan, 2011; Wang & Morgan, 2008). Thus, the study's context may be an important factor to consider. Most business student perceptions research was published over 10 years ago (e.g. Perreault et al., 2008; Tanner et al.,

2003; Tanner et al., 2004-1, 2004-2), and similar to other studies (Mortagy & Boghikian-Whitby, 2010; Perreault et al., 2008), perceptions may have changed.

We conducted our study at a mid-sized, Jesuit, Catholic, business school with a focus on teaching. The research focus lies in uncovering changes in student perceptions since our original study in 2012. Traditionally, FTF class sizes average 17 students, and online classes have a maximum of 24 students. Online education is a growing educational method; however, not all students have experienced this medium (Allen & Seaman, 2013). Based upon the literature, the research intent of this paper is to explore the changes in graduate and undergraduate students' perceptions of the online experience for those with and without online experience at a teaching university for program factors. Specifically, we will address changes in student perceptions between the prior study and now for program factors of difficulty, student-to-student interaction, student-to-instructor interaction, cheating and program preferences, as well as student preferences and dislike for program activities. Theoretically, students should perceive the environments equally and not favor either traditional or online education.

Method

At an AACSB accredited, Jesuit, Catholic University in the northeast, undergraduate and graduate business students completed the online Qualtrics-administered survey. The surveys were administered during the month of November 2018 and student participation was completely voluntary. The survey link was sent to business students via a list serve twice over the month. 74 undergraduates and 60 graduates participated in the 2018 survey. A similar survey was administered directly in class to students in FTF classes in fall of 2012, and 64 undergraduate and 47 graduates participated (Fish & Snodgrass, 2014).

Based upon the above research, the instructors previously designed a survey to test student perceptions of difficulty, motivation, student-to-student interaction, student-to-instructor interaction, discipline, cheating, self-directed, independence, schedule flexibility, time investment, cost investment, preference for online or FTF environments, happiness with online or FTF education, and appropriateness of online at the University (See Appendix). Students were also questions as to which activities increased or decreased the understanding of course material. The selection of activities included additional readings, assignments/homework, course surveys, discussion boards, in-class sessions, instructor chat, instructor (live or taped) lectures, instructor office hours, instructor posted notes, laboratory/ experiential activities, other students, problem hints & scaffolding examples, textbook, video of relevant course, material, or 'other'. In the original 2012 study, background information gathered included class level, gender and online experience. In the 2018 study, background information included class level (undergraduate – freshmen, sophomore, junior, senior or graduate), age, gender, major (undergraduate) or concentration (graduate), self-described level of technological understanding, and whether the student was a transfer student.

Students who experienced at least 1 online course completed Section A ("Online"), while students who had never taken an online course completed Section B ("Traditional FTF"). Sections A and B had corresponding questions, but Section A statements were specific to "I found" versus Section B statements were "I perceive". The last questions in each section asked

the student if they would prefer the opposite environment, their emotional happiness with the learning environment, and whether online courses were appropriate for the institution. For students with online experience, the last question inquired why they chose to take an online course. For students without online experience, the survey included an open-ended question inquiring 'why not'. Information from the surveys was codified as Significantly Less (1), Less (2), The Same (3), More (4) and Significantly More (5), and the data was entered into an SPSS for analysis.

Analysis

As shown in Table 1, the number of students who have taken at least one online course virtually doubled by 2018 (82) from 2012 (44). The number of students who reported never taking an online course in 2012 (67) decreased slightly by 2018 (52).

Table 1. Number of Students Online and FTF in 2012 & 2018 Surveys

# of Students	Online	FTF	Total
2012	44	67	111
2018	82	52	134
Total	126	119	245

In the prior study (Fish & Snodgrass, 2014), the average responses and response for each of the program factors under consideration are shown in Table 2. Given the survey setup, responses positively viewed the environment that a student was part of. For example, if an online student felt that online was more difficult than FTF, he or she would indicate a significant 'positive' for the online environment. The scale for the FTF students was similar for their environment. Therefore, if the two groups perceive the learning environment differently than their own environment, a significant difference between the two groups would be detected. As shown in Table 3, in 2012 students perceptions of online and FTF were significantly different for preference (p=.000), cheating (p=.000), interaction between students (p=.000), and interaction with the instructor (p=.000). A slightly significant difference existed with respect to course difficulty (p=.062).

Table 2. 2012 Student Results (Fish & Snodgrass, 2014)

Metric	Average Response		Online Response					Face-To-Face Response				
	OL	FTF	1	2	3	4	5	1	2	3	4	5
Difficulty	2.43	2.69	7	17	14	6	0	5	32	10	19	1
Preference	1.64	2.47	21	18	5	0	0	6	23	37	0	0
Cheat	2.45	3.93	6	19	13	5	1	1	1	15	35	15
Interact between students	2.64	4.22	2	21	13	7	1	1	1	6	33	26
Interact instructor-student	2.61	4.40	4	20	10	9	1	1	0	3	30	33

Table 3. Chi-Square Analysis FTF Program Factors 2012: OL vs. FTF (Fish & Snodgrass, 2014)

Metric	Pearson Chi-Square Value	Df	Asymptotic Significance (2-sided)	Pearson's R	Spearman Correlation
Difficulty	8.971	4	.062 **	.127	.105
Preference	30.129	4	.000 *	.523	.522
Cheat	52.137	4	.000 *	.643	.649
Interact between students	59.906	4	.000 *	.685	.688
Interact instructor-student	65.020	4	.000 *	.725	.722

* $p \leq .05$, ** $p \leq .10$

For the 2018 student study, the average responses and response for each of the program factors under consideration are shown in Table 4. Similar to the 2012 analysis, responses positively viewed the environment that a student was part of, and therefore, if the two groups perceived the learning environment differently than their own environment, significant differences between the groups would be detected. As shown in Table 5, significant differences in student preferences exist for every program factor – difficulty (p=.018), preference (p=.026), cheating (p=.000), interaction between students (p=.000), and interaction with the instructor (p=.000).

Table 4. 2018 Student Results

Metric	Average Response		Online Response					Face-To-Face Response				
	OL	FTF	1	2	3	4	5	1	2	3	4	5
Difficulty	2.57	2.94	8	29	35	10	0	2	18	14	17	1
Preference	1.74	2.08	35	33	14	0	0	15	16	19	0	0
Cheat	2.34	3.87	15	27	37	3	0	1	3	10	26	12
Interact between students	2.59	3.92	13	29	22	15	3	2	2	11	20	17
Interact instructor-student	2.62	3.96	5	33	34	8	2	2	0	13	20	17

Table 5. Chi-Square Analysis FTF Program Factors 2018: OL vs. FTF

Metric	Pearson Chi-Square Value	Df	Asymptotic Significance (2-sided)	Pearson's R	Spearman Correlation
Difficulty	11.868	4	.018 *	.201	.182
Preference	7.329	2	.026 *	.208	.202
Cheat	74.205	4	.000 *	.659	.673
Interact between students	41.108	4	.000 *	.528	.535
Interact instructor-student	56.783	4	.000 *	.593	.610

* $p \leq .05$, ** $p \leq .10$

Analysis comparing the online students of 2012 and 2018 did not reveal any significant differences between the two groups for any of the program factors studied, as shown in Table 6. As shown in Table 7, analysis comparing the FTF students of 2012 and 2018 revealed significant differences for preference (p=.012) and interaction with the instructor (p=.007). In general, the

2012 students favored the FTF environment more, while the 2018 FTF students were more indifferent to the environments. Similarly, in 2012 FTF students were extremely positive with regard to the student-to-instructor interaction, however, they were not as positive about the interaction with the instructor in 2018.

Table 6. Chi-Square Analysis Online Program Factors 2012 vs. 2018

Metric	Pearson Chi-Square Value	Df	Asymptotic Significance (2-sided)	Pearson's R	Spearman Correlation
Difficulty	1.911	3	.591	.078	.082
Preference	.786	2	.675	.072	.067
Cheat	7.489	4	.112	-.063	-.026
Interact between students	4.521	4	.340	-.024	-.027
Interact instructor-student	5.855	4	.210	.003	.024

* $p \leq .05$, ** $p \leq .10$

Table 7. Chi-Square Analysis FTF Program Factors 2012 vs. 2018

Metric	Pearson Chi-Square Value	Df	Asymptotic Significance (2-sided)	Pearson's R	Spearman Correlation
Difficulty	4.159	4	.385	.128	.134
Preference	8.861	2	.012 *	-.255	-.239
Cheat	1.799	4	.773	-.035	-.017
Interact between students	5.405	4	.248	-.164	-.146
Interact instructor-student	12.003	3	.007 *	-.255	-.252

* $p \leq .05$, ** $p \leq .10$

In addition to the 2012 list of activities, the 2018 survey included course surveys, instructor office hours, instructor posted notes, laboratory/experiential activities, textbook and 'other'. As shown in Table 8, these activities were rarely chosen and student preferences for activities changed over the six year period. With respect to the actual number of responses, in 2012 the online students indicated 158 activities increased their understanding and 57 decreased their understanding, while FTF students indicated that 316 activities increased their understanding and 121 activities decreased their understanding. In 2018, the number of online student responses for increasing their understanding indicated 428 activities and 92 activities decreased their understanding, while FTF students highlighted 231 activities that increased their understanding and 75 activities that decreased their understanding.

With respect to online students, the most selected activities to increase their understanding were assignments/homework, discussion boards and videos of relevant course material, which were the same three most indicated activities in the 2012 survey. As for decreasing their understanding, in the 2012 study, online students indicated that in-class lectures, instructor lectures, other students, and additional readings were the main activities that decreased their understanding. The 2018 study changed slightly as in-class sessions and instructor lectures were no longer viewed as negatively as six years prior. In general, online students indicated that

assignments/homework, discussion boards and videos of relevant course material increased their understanding, while additional readings, in-class sessions and other students decreased their understanding.

As for the FTF students, their preferences in 2012 indicated that instructor lectures, discussion boards, and in-class sessions were their preferred educational activities. However, by 2018, the instructor lectures and discussion boards were no longer preferred as assignments/homework and other students were favored. As for activities that decreased their understanding, FTF students in 2012 indicated that additional readings, discussion boards, in-class sessions and instructor chat decreased their understanding. By 2018, this changed slightly as instructor lectures and the textbook were among the most commonly sighted activities but discussion boards and additional readings were still among the top 4 most common activities to decrease their understanding. In general, FTF students in both surveys value in-class sessions, activities/homework, and other students. They do not value additional readings, discussion boards or instructor lectures.

Comparing online and FTF students in the 2018 survey indicates that in many ways, online and FTF students have some similar preferences. For example, both groups indicate that assignments/homework increase their understanding, and additional readings and the textbook decrease their understanding. However, while FTF students feel that in-class sessions and other students increase their understanding, online students indicated that these activities decrease their understanding.

Table 8. Online and FTF Student Preference For Activities: "In the _____ environment, I feel these activities _____ my understanding of the course material."

Activity	2012 Percentage of Students				2018 Percentage of Instructors			
	Online Students		FTF Students		Online Students		FTF Students	
	Increase	Decrease	Increase	Decrease	Increase	Decrease	Increase	Decrease
Additional Readings (not including textbook)	45.24	19.05	37.31	26.87	8.88	11.96	6.49	12.00
Assignments/ Homework	76.19	9.52	59.70	14.93	15.65	3.26	16.02	4.00
Course Surveys					3.04	6.52	1.30	6.67
Discussion boards	71.43	7.14	73.13	22.39	11.92	9.78	2.60	14.67
In-class sessions (live sessions that are not lectures)	16.67	23.81	67.16	32.84	3.04	9.78	13.42	2.67
Instructor chat	33.33	9.52	62.69	22.39	7.01	3.26	6.93	4.00
Instructor (live or taped) lectures	28.57	23.81	73.13	20.90	7.71	6.52	5.19	12.00
Instructor Office Hours					4.91	3.26	8.66	1.33
Instructor Posted Notes					8.18	3.26	5.63	9.33
Laboratory / experiential activities					1.40	6.52	3.03	6.67
Other students	35.71	21.43	64.18	19.40	4.91	10.87	13.85	6.67
Problem Hints & Scaffolding Examples	19.05	14.29	1.49	1.49	4.44	2.17	6.49	2.67
Textbook					7.94	10.87	6.49	10.67
Videos of Relevant Course Material (not instructor-lead	50.00	7.14	32.84	19.40	10.98	6.52	3.90	5.33
Other					0.00	5.43	0.00	1.33

Discussion

*Course Organization & Technologie*s. Since the types of activities changed over the six year period and students could indicate more than one activity as increasing or decreasing understanding, its statistically difficult to test the changes in activity preference. However, as noted in the discussion, online students did not change their preferred activities that increase their understanding, as the top three remained as assignments/homework, discussion boards and videos of relevant course material (not instructor led). The preferred list of activities corresponded with another study conducted in 2010 that indicated that online discussions and assignments were positively viewed by online students (Palmer & Holt, 2010).

However, there was a slight change in the indicated activities that decreased their understanding as in-class sessions and instructor-lectures were no longer indicated as amongst the top three activities that decreased online student understanding. Unlike the other study conducted in 2010 (Palmer & Holt, 2010), students did not perceive assignments as strongly decreasing their understanding. Hence, there appears to be support for the original hypotheses for a change in online activities that increase or decrease student understanding. Interestingly, online students

indicated only 5 'other' activities as decreasing their understanding – and the list included group projects, text, and exams/quizzes.

Similarly, as noted in the analysis, FTF student preferences for activities changed as instructor lectures and discussion boards were no longer the primary preferred method of learning. FTF students changed their perceptions of in-class sessions and instructor chat as decreasing their educational experience, but indicated that instructor lectures and the textbook decreased their understanding. Therefore, while not statistically tested, there appears to be a shift in FTF student preferences for FTF activities. In contrast to a 2012 study where online and FTF students favored the textbook (Horspool & Lange, 2012), students in this study perceived the textbook negatively.

It appears that over the six years online and FTF students have changed their perceptions of activities that increase and decrease their understanding. Also noteworthy is the relationship with other studies, where the favorable or unfavorable activities do not directly align with students in this population. The context of the study may hold a critical key to understanding the student preferences.

*Academic Rigor: Difficulty***.** In the original study in 2012, students viewed the difficulty between the educational environments as only slightly significantly different and tended to view FTF as more difficult. Six years later this result was more pronounced as students perceive difficulty differently. While FTF students in 2018 were more indifferent to the difficulty differences between the environments, online students felt that online was easier than FTF. However, analysis demonstrated that a significant shift in student perceptions between the two surveys did not occur, and results favored the null hypotheses (H_{2oA} and H_{2oB})**.** While a shift may be occurring, students at this University still perceive FTF as being more difficult than online courses.

Program Preference. For both studies, students – online and FTF – prefer to be in the FTF environment. However, a shift in the FTF students' perceptions of program preference may be occurring as a significant difference between the FTF 2012 and 2018 results for preference exists. That is, the results favor the null hypothesis for the online students ($H_{30}A$) but the alternative for the FTF students (H_{31B}). The 2012 FTF students overwhelmingly favored FTF, but the 2018 FTF students were more indifferent to the learning environments. Perhaps as the number of online courses increases – and students 'hear from other students about online', FTF students are more amenable to online education. Interestingly, for this population – even six years later and as more students have 'tried' online education, online students at this private teaching University – still do not see the online and FTF educational experiences as equal, a claim made by academic officers (Allen & Seaman, 2013).

Academic Integrity: Cheating. The results do not support a shift in student perceptions as the null hypotheses are still favored (H_{40A} and H_{40B}). As in the original study, FTF and online students still perceived cheating to be easier online than in the FTF classroom (Fish & Snodgrass, 2014).

Student-to-Student Interaction. While prior studies indicated 'mixed' results with respect to student-to-student interaction (Campbell et al., 2008; Fredericksen, Pickett, Shea, Pelz, & Swan, 2000; Hara & Kling, 2003; Lou et al., 2006; Mann & Henneberry, 2014; Means et al., 2009; Maeroff, 2004; Stodel, Thompson & MacDonald, 2006; Wang & Morgan, 2008), for this population, online and FTF students still prefer the interaction with other students in the FTF environment as the null hypotheses were favored (H_{50A} and H_{50B}). Regardless of changes in online activities and an increase in the number of online courses offered at the University, this population still prefers to interact with other students in the FTF classroom instead of online.

Student-to-Instructor Interaction. Other studies have shown mixed results with respect to student-to-instructor interaction (Boyd, 2008; Fish & Snodgrass, 2014; Horspool & Lange, 2012; Mortagy & Boghikian-Whitby, 2010; Richardson & Swan, 2003; Wang & Morgan, 2008; Wuensch, Aziz, Ozan, Kishore & Tabrizi, 2008). While in the original study, online and FTF students overwhelmingly perceived the student-to-instructor interaction to be better in the FTF environment, a shift for the FTF population in their perception occurred. That is, the alternative hypothesis (H_{61B}) was favored for the FTF students as the current students favor but not 'strongly favor' the FTF interaction. However, online students still perceived the interaction to be better in the FTF environment as the null hypothesis was held (H_{60A}).

Conclusions

With respect to preference for program activities, student appear to have changed their perceptions of activities that increase or decrease their understanding from the prior study, and these activities do not directly correspond to other studies on activities. The context of the study may be a critical factor to consider in understanding student activity preferences. For the program factors surveyed at this teaching University, both online and FTF students find FTF classes to be more difficult, perceive cheating to be easier online than in the FTF classroom, prefer the interaction between students and instructors in the FTF environment, and tend to prefer to be in the FTF classroom than online. Online students did not change their perceptions on any of the program factors studied; however, the FTF students perceptions on preference and student-to-instructor interaction. The FTF students did not favor the FTF classroom as strongly as they did in the prior study. While other studies noted changes over time (e.g. Allen & Seaman, 2013; Benbunan-Fich & Hiltz, 2003; Perreault, Waldman, Alexander & Zhao, 2008; Tanner, Noser, and Langford, 2003; Tanner, Noser, Fuselier & Totaro, 2004-1; 2004-2; Tanner, Noser, Totaro & Birch, 2006; Tanner et al., 2009), and this study noted changes on two factors – preference and student-to-instructor interaction – but only for the FTF students and not the online students. Perhaps a longer time is needed before other perceptions are changed for both groups.

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Appendix A Student Perceptions Survey

With the rise in online education, we are interested in gathering information as to student perceptions of educational methods. We would greatly appreciate you completing this anonymous form. Thank you!

Background Information:

What is your class level?	Freshman (1) Sophomore (2) Junior (3) Senior (4) Graduate (5)
Are you a transfer student to Canisius College?	Yes (1) No (2)
What is your major?	Accounting (1) Accounting Information Systems (2) Economics (3) Entrepreneurship (4) Finance (5) International Business (6) Management (7) Marketing (8) Other (9)
Which program are you pursing your MBA in:	Flexible (part-time evening) MBA One-Year MBA MBA in Professional Accounting
Do you have a concentration? (MBA)	Yes, I have a concentration. (1) Undecided on a concentration. (2) No, I will not be completing a concentration (3)
If you are pursuing a concentration, what concentration are you pursuing?	Financial Services (1) Global Supply Chain Management (2) International Business (3) Marketing in the New Economy (4)
Are you:	Male (1) Female (2)
How old are you?	
Would you classify your technology understanding as:	• Do not use technology. (1) • Beginner/Novice (e.g. use Microsfot Office Powerpoint and EXCEl (or similar projection software) as part of communicating and email). (2) • Advanced Beginner (e.g. use 'some' Powerpoint (or similar projection software), some Desire2Learn features, Microsoft Office or similar to communicate). (3) • Intermediate (e.g. Use Microsoft Office Suite and other computer applications (such as SPSS, R, etc.) to communicate and program). (4) • Extensive (e.g. extensive knowledge and use of

	various computer software programs) (5)
Have you taken an online course at Canisius College?	Yes (SECTION A) (1) No (SECTION B) (2)

SECTION A - AT LEAST ONE ONLINE COURSE AT CANISIUS COLLEGE

How many online courses have you taken:	
Have you taken an online course at a school other than Canisius College?	Yes (1) No (2)
How many online courses have you taken at a school other than Canisius College?	
Prior to taking an online course, did you take a course to prepare you for the online environment?	Yes (1) No (2)
If 'yes', was the course offered by Canisius College or the book publisher?	Canisius College (1) Book Publisher(2) Other (3)
With respect to the online courses that you have taken at Canisius College compared to face-to-face (traditional classrooms), please rate the following responses:	
I perceive online courses to be_____in difficulty than face-to-face courses.	(1) Significantly Easier (2) Easier (3) The Same Difficulty (4) Harder (5) Significantly Harder
I am _____ motivated in online courses than face-to-face courses.	(1) Significantly Less (2) Less (3) Equally (4) More (5) Significantly More
I _____the interaction with other students in the online environment compared to the face-to-face course environment.	(1) Significantly Dislike (2) Dislike (3) Equate (4) Like (5) Significantly Like
I _____the interaction with the instructor in the online environment compared to the face-to-face course environment.	(1) Significantly Dislike (2) Dislike (3) Equate (4) Like (5) Significantly Like
I find the discipline required in taking online courses to be ____ than in face-to-face courses.	(1) Significantly Less (2) Less (3) The Same (4) More (5) Significantly More
I find its' _____to cheat in the online environment than in face-to-face courses.	(1) Significantly Easier (2) Easier (3) The Same

	(4) Harder (5) Significantly Harder
I enjoy the self-directed online learning environment___than the interaction in face-to-face courses.	(1) Significantly Less (2) Less (3) The Same (4) More (5) Significantly More
I enjoy the independence associated with the online learning environment_____than the interaction in face-to-face courses.	(1) Significantly Less (2) Less (3) The Same (4) More (5) Significantly More
I enjoy the schedule flexibility associated with the online learning environment_____than the interaction in face-to-face courses.	(1) Significantly Less (2) Less (3) The Same (4) More (5) Significantly More
I find online courses require_____time investment in the course than face-to-face courses	(1) Significantly Less (2) Less (3) The Same (4) More (5) Significantly More
I find online courses total costs are _____than face-to-face courses.	(1) Significantly Less (2) Less (3) The Same (4) More (5) Significantly More
In the online environment, I feel these activities <u>increase</u> my understanding of the course material. (Circle all that apply)	(1) Additional Readings (Not including textbook) (2) Assignments/Homework (3) Course Surveys (4) Discussion boards (5) In-class sessions (live sessions) (6) Instructor chat (7) Instructor (live or taped) lectures (8) Instructor Office Hours (9) Instructor Posted Notes (10) Laboratory/ experiential activities (11) Other students (12) Problem Hints & Scaffolding Examples (13) Textbook (14) Video of Relevant Course

	Material (not instructor-lead) (15) Other_____
In the online environment, I feel these activities decrease my understanding of the course material. (Circle all that apply)	(1) Additional Readings (Not including textbook) (2) Assignments/Homework (3) Course Surveys (4) Discussion boards (5) In-class sessions (live sessions) (6) Instructor chat (7) Instructor (live or taped) lectures (8) Instructor Office Hours (9) Instructor Posted Notes (10) Laboratory/ experiential activities (11) Other students (12) Problem Hints & Scaffolding Examples (13) Textbook (14) Video of Relevant Course Material (not instructor-lead) (15) Other_____
Would you prefer to take the class in a traditional face-to-face environment?	Yes (1) Undecided(2) No (3)
I am ____with the online course environment for learning.	(1) Not very happy (2) Not happy (3) Okay (4) Happy (5) Very happy
Given this institution, do you think online courses are appropriate?	Yes (1) Undecided(2) No (3)
Why did you choose to take the course online?	

Thank you for your time! It is greatly appreciated.

SECTION B - NEVER TAKEN AN ONLINE COURSE AT CANISIUS COLLEGE.

With respect to the face-to-face (traditional) courses that you have taken at Canisius College compared to your perception of online courses, please rate the following responses:	
I perceive face-to-face courses to be_____in difficulty than online courses.	(1) Significantly Easier (2) Easier (3) The Same Difficulty (4) Harder (5) Significantly Harder
I perceive that I would be _____ motivated in face-to-face courses than online courses.	(1) Significantly Less (2) Less (3) Equally (4) More (5) Significantly More
I perceive the interaction with other students in the face-to-face environment to be _____compared to the online course environment.	(1) Significantly Worse (2) Worse (3) Equal (4) Better (5) Significantly Better
I perceive the interaction with the instructor and students in the face-to-face environment to be _____compared to the online course environment.	(1) Significantly Worse (2) Worse (3) Equal (4) Better (5) Significantly Better
I perceive the discipline required in taking face-to-face courses to be_____than in online courses.	(1) Significantly Less (2) Less (3) The Same (4) More (5) Significantly More
I perceive that it would be _____to cheat in the face-to-face environment than in online courses.	(1) Significantly Easier (2) Easier (3) The Same (4) Harder (5) Significantly Harder
I believe that I would enjoy the self-directed face-to-face learning environment_____than the interaction in online courses.	(1) Significantly Less (2) Less (3) The Same (4) More (5) Significantly More
I believe that I would enjoy the independence associated with the face-to-face learning environment_____than the interaction in online courses.	(1) Significantly Less (2) Less (3) The Same (4) More (5) Significantly More
I believe that I would enjoy the schedule flexibility associated with the face-to-face learning environment_____than in online courses.	(1) Significantly Less (2) Less (3) The Same

	(4) More (5) Significantly More
I believe that face-to-face courses require_____time investment in the course than online courses.	(1) Significantly Less (2) Less (3) The Same (4) More (5) Significantly More
I believe face-to-face courses total costs are _____than online courses.	(1) Significantly Less (2) Less (3) The Same (4) More (5) Significantly More
In the face-to-face environment, I feel these activities increase my understanding of the course material. (Circle all that apply)	(1) Additional Readings (Not including textbook) (2) Assignments/Homework (3) Course Surveys (4) Discussion boards (5) In-class sessions (live sessions) (6) Instructor chat (7) Instructor (live or taped) lectures (8) Instructor Office Hours (9) Instructor Posted Notes (10) Laboratory/ experiential activities (11) Other students (12) Problem Hints & Scaffolding Examples (13) Textbook (14) Video of Relevant Course Material (not instructor-lead) (15) Other_____
In the online environment, I feel these activities decrease my understanding of the course material. (Circle all that apply)	(1) Additional Readings (Not including textbook) (2) Assignments/Homework (3) Course Surveys (4) Discussion boards (5) In-class sessions (live sessions) (6) Instructor chat (7) Instructor (live or taped) lectures (8) Instructor Office Hours (9) Instructor Posted Notes

	(10) Laboratory/ experiential activities (11) Other students (12) Problem Hints & Scaffolding Examples (13) Textbook (14) Video of Relevant Course Material (not instructor-lead) (15) Other_____
Would you prefer to take the class in an online environment?	Yes (1) Undecided(2) No (3)
If 'no', why not?	
I am ____with the face-to-face environment for learning.	(1) Not very happy (2) Not happy (3) Okay (4) Happy (5) Very happy
Given this institution, do you think online courses are appropriate?	Yes (1) Undecided(2) No (3)
Have you taken an online course at a school other than Canisius College?	Yes (1) No (2)

Thank you for your time! It is greatly appreciated.

AN INNOVATIVE INFORMATION TECHNOLOGY EDUCATIONAL FRAMEWORK THAT EMBRACES DIVERSITY AND INCLUSION

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Abstract

This paper describes and implements an innovative framework for information technology (IT) education. The proposed framework extends the model developed by Rappaport et al. (2018) which creates metaphors for various IT topics using popular music videos and is based upon the theory of embodied cognition. A similar model developed by Rappaport et al. (2016) was applied to the topic of robotics and automation. The proposed model extends the conceptual framework by considering a component of situated learning. This component is based upon the theory proposed by Lave and Wenger (1991) that assumes that social interaction and collaboration are essential components of situated learning as learners become involved in a community of practice. Our model assumes that the students are engaged in a community of practice involving popular culture as the learning of IT topics is facilitated by metaphors based upon popular music videos. We propose that various outcomes of learning IT such as attitude and retention are enhanced by the model. The model will be implemented at either the primary school or secondary school level and the results of an outcome assessment will be reported at the conference.

Keywords: Diversity, Embodied Cognition, Information Technology (IT), Metaphors, Neuroscience, Popular Culture, Situated Learning

Introduction

In this paper, we propose an innovative framework that enhances the understanding of Information technology (IT) based upon popular culture. The proposed framework is an extension of the frameworks proposed by Rappaport et al. (2016, 2018) which are based upon the theory of embodied cognition or grounded cognition which argues that all aspects of cognition, including decision making, are shaped by aspects of the body. These models were applied to the topics of robotics and automation and information technology.

The model proposed in this paper extends the models of Rappaport et al. (2016, 2018) by considering two components. The first component is essentially the same as their model, which assumes a process of grounded cognition whereby the comprehension of the material is grounded in the multi-modal stimuli (including perception, action, music and dance) of the music videos. A multi-modal PowerPoint presentation uses metaphors to link the IT topics to popular music videos. The theory of metaphors and various theories of neuroscience (the study of the brain) provide the theoretical foundation for this component of the model.

The main contribution of this paper is to propose a second component to the theoretical framework of the previous models proposed by Rappaport et al, (2016, 2018). This component is based upon the theory of situated learning which was first proposed by Jean Lave and Etienne Wenger (1991). Their theory proposes that learning, as it normally occurs, is embedded within activity, content and culture and is also usually unintentional rather than deliberate. Social interaction and collaboration are essential components of situated learning- learners become involved in a "community of practice" with certain behaviors and beliefs to be acquired.

In our model, it is assumed that the students are part of a community of practice (called COP) that involves the shared common interest of popular culture which can be viewed in broad terms and offers creativity, challenges, participation and engagement. COP exhibits the three crucial aspects that, according to Wenger (2007), distinguishes a community of practice from other groups and communities: namely, domain, community and practice. COP has an identity which is defined by young people's shared domain of interest of music, art, media, internet, TV, radio and fashion. COP is defined by a sense of community whereby the members engage in joint activities such as attending social dances and concerts and sharing songs and videos via electronic interchange. Finally, the members of COP are practitioners, as popular culture has become a pervasive force in young people personal lives and often plays a crucial role in shaping their experiences and ways

that they address their personal problems and challenges.

The influence of popular culture on learning IT is studied using metaphors that link popular music videos to IT topics. We select music videos from many different styles and genres including pop, R&B, hip-hop/rap, heavy metal, hard rock, synth rock, glam metal, dubstep, techno, electronic dance, Europop and various popular street dance styles such as krumping and cribbing. The metaphors that link the IT topics to the videos are developed with respect to the specific cultural aspects of the music, dance or subject matter of the videos. Thus, the model considers the cultural bonds that create a "community of practice" for our youth experienced via popular music videos.

There is a strong and justifiable link between the two components of the model, represented by embodied cognition and situated learning, respectively. As Nunez et al. (1999) point out, there is a natural connection between the theories of embodied cognition and situated learning. They argue that the nature of situated learning and cognition cannot be fully understood by focusing only on social, cultural and contextual factors. These factors are themselves situated and made comprehensible by the fundamental bodily experiences of human beings. By the same token, the biological basis for grounded cognition does not deny the role of culture, upbringing and ethnicity in the cognitive process. Popular music videos often depict the beliefs and habits of different races and cultures, such as hip-hop.

Metaphors play an essential role in both components of our model. The theory of metaphors as expounded by cognitive linguists Lakoff and Johnson (1980, 1999) believe that all or nearly all thought are essentially metaphorical and thus provide a philosophical basis for the concept of embodied cognition. Both their earlier work *Metaphors We Live By* (1980) and their later work *Philosophy in the Flesh* (1999) had an extraordinary influence in emphasizing the role of the body in thought, language and knowledge, a subject now at the center of neuroscience, cognitive science, linguistics and philosophy.

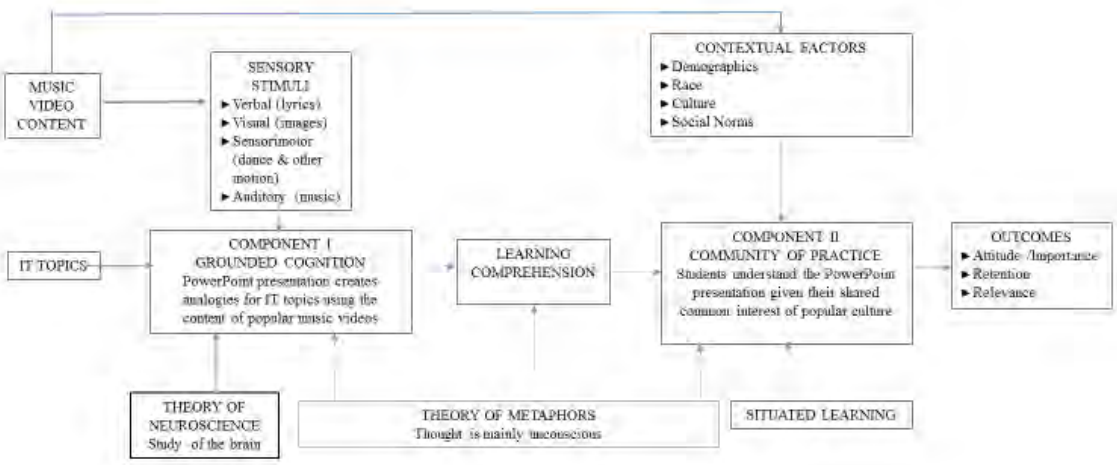
Our model considers situated learning by considering various contextual factors such as race, ethnicity, culture, and the vehicles for socialization used by our youth. Music videos are generally targeted to the youth and contain many social and cultural manifestations of their real- life experiences. Integrating these into the educational process allows students to reflect on their own experiences and direct their own learning based upon these experiences. Our model also has the potential to engage students with diverse cultural backgrounds and particular demographic groups, including African Americans, Latinos or females. The model has the potential to reach out to

underserved youth or to demographic groups that do not traditionally show a proclivity or motivation to learn science and technology.

In addition, our model can be used to integrate students with diverse cultural backgrounds within the same learning environment. For example, hip-hop/rap music is generally enjoyed by youth from all socio-economic and ethnic classes.

Figure 1 represents the conceptual framework of our model. As explained above, the model extends the ones presented in Rappaport et al. (2016, 2018) by considering two components of the educational process, namely embodied cognition and situated learning implemented by a community of practice COP. Note that both components are driven by the music video metaphors and facilitated by the PowerPoint presentation.

FIGURE 1: Conceptual Framework



Diversity and Science Education

The underlying objective of our model is to provide a platform for learning that motivates students from all demographic groups to understand the importance and relevance of learning IT as well as science and engineering in general. The model can be particularly effective as a learning support and a tool to motivate low income and minority students to study science and engineering.

Our instructional strategy builds on students' interests and backgrounds to engage them more meaningfully and support them in sustained learning.

Indeed, many educational experts and policy planners are concerned about the equitable access to science and engineering occupations among different demographic groups. A more equitable achievement of science and engineering literacy is necessary to provide a more equitable access to these occupations (Moses and Cobb 2001, National Research Council 2011).

Unfortunately, low learning expectations and biased stereotypical views about the interests or abilities of particular students or demographic groups often contribute to curtailed educational experiences and learning supports (Malcom 1994, Brantlinger 2003, Steele 1997). Students' own motivation and interest in science and engineering can also play a role in their achievement and pursuit of these fields in secondary school and beyond. Thus, it is important to design instruction and develop innovative approaches to learning in ways that motivate students from particular demographic groups.

It would be wrong to conclude that low income and minority students are not capable of engaging in sophisticated learning. In fact, psychological and anthropological studies of human learning show broadly that all individuals, with a small number of exceptions, can engage in and learn complex subject matter when supportive conditions and feedback mechanisms are in place and it connects to areas of personal interest (National Research Council 1999, Nisbett 2009). Similarly, a growing set of studies in science education show that students from across social classes and other demographic groupings can learn science when provided with supportive conditions to learn over an extended period (Banks et al. 2007, Lee and Braton 2010, National Research Council 2007, 2009).

One approach that can be used to reach out to minority and low-income groups is to leverage the cultural funds of knowledge that students bring with them by combining them with other concepts and transform them into scientific concepts over time. Indeed, much of the literature suggests that people enter into the practices of science or engineering in the context of their cultural worldviews.

For example, science has been described as being "heavily dependent on cultural contexts, power relationships, value systems, ideological dogma, and human emotional needs" (Harding 1998). "A culturally mediated way of thinking and knowing suggests that learning can be defined as engagement with scientific practices" (Brickhouse et al. 2000). Calabrese Barton (1998) therefore argues for allowing science and science understanding to grow out of lived experiences. In doing so, people "remove the binary distinction from doing science or not doing science and being in science or being out of science, [thereby allowing] connections between [learners'] life worlds and science to be made more easily [and] providing space for multiple voices to be heard and explored" (Calabrese 1998). This view can have a profound impact on how scientific instruction is delivered, but it may be successful only if the instructors can engage in a culturally mediated way of thinking and knowing.

A large body of literature suggests that instruction that is crafted to reflect cultural aspects and in ways that link to the students' personal interests influence not only the students' repertoire of practice but also are likely to support their complex cognitive skills (Bang et al. 2007, Nasir 2000, 2002, Nasir and Saxe 2003, Rose 2004, Rosebery et al. 2005, Warren et al. 2005, Zimmerman et al. 2010, National Research Council 2009, Rosebery et al. 2005, McIntyre et al. 2001, Moje et al. 2001, Warren et al. 1996).

Many studies have focused on the discourse (i.e. sense-making) practices of youth to productively engage them in the learning of science. For students from historically nondominant groups (such as lower-class and non-European/American homes) traditional classroom practices may be an obstacle to learning because their community's sense-making practices may not be acknowledged (Kurth et al. 2002, Moje et al. 2001, Lee and Fradd 1998. Lemke 1990, Brown 2006).

Researchers point to the importance of accepting and encouraging students' classroom use of informal or native language and familiar models of interaction (Lee and Fradd 1996, Warren et al. 2001, Moschkovich 2002, Banks et al. 2007, Brown 2006, Rosebery et al.1992) As these studies indicate, diverse linguistic practices for making sense of scientific phenomena can generate learning and be leveraged in instruction. The challenge for teachers is to know enough about their students' relevant linguistic practices to be able to support a transition in the classroom from using their vernacular language to using disciplinary terminology for scientific phenomena.

Learning science depends not only on the accumulation of facts and concepts but also on the development of an identity as a competent learner of science with motivation and interest to learn

more. As Lave and Wenger (1991) explain, "Learning involves the construction of identities. [It is] an evolving form of membership". Such identity formation is valuable not only for the students who will eventually become scientists or engineers, but also for the great majority of students who do not follow these professional paths.

Research suggests that personal interest is an important factor in children's involvement in learning science (Hidi and Renninger 2006, Jolly et al. 2004). Many studies have shown that educational experiences designed to leverage the personal interests of learners have increased their participation (Luehmann 2009, Calabrese 1998, Tzou and Bell 2010, Tai et al, 2006). All students can profit from this approach, but the benefits are particularly salient for those who would feel disenfranchised or disconnected from science should instruction neglect their personal inclinations.

Educational Model: Blending Popular Culture, Diversity and Science Education

Our model attempts to address many of the deficiencies in our educational system cited above with respect to achieving an equitable access to scientific and engineering education to students from diverse groups, particularly low income minority students.

Using metaphors that link topics the contents of popular music videos to topics in science and technology, we hope to capture the imagination of the students by engaging them in aspects of popular culture presented in the music videos.

Our approach reaches out to primary and secondary level students who for whatever reason lack the motivation to study math and science, whether they are students with low income, students with poor training in math and science, students with low interest in school, racial minorities, or at- risk students.

Ultimately, our model is targeted to the heterogenous mix of all primary and secondary level students (and perhaps first year college or university students), even those with a strong motivation to learn science and math, and students from successful middle and upper-class families. By blending diverse groups into the same learning environment, we acknowledge the vast diversity that exists amongst the student population and hope to achieve a more equitable access to scientific knowledge and practices.

Indeed, the model addresses many of the points cited above with respect to diversity in science and engineering education, because it is more inclusive and motivating than traditional forms of instruction, can dispel biased stereotypical views about the interests or abilities of particular

students or demographic groups and provides a supportive mechanism for students to engage in and learn complex subject matter. As cited above, a growing number of studies show that students across social classes and other demographic groupings can learn science when provided with supportive conditions over an extended period.

Most importantly, our model is consistent with the views cited above than science is heavily dependent on cultural content, values and human emotional needs. The music video metaphors are immersed in cultural funds of knowledge that can be leveraged, combined with other concepts, and transformed into scientific concepts over time.

The music videos also encourage students' classroom use of informal and familiar modes of interaction. The lyrics of popular songs provide a medium to use diverse linguistic practices for making sense of scientific phenomena that can generate learning and be leveraged in instruction. The lyrics of many popular music videos are filled with urban slang phrases, not to mention hip-hop and rap videos which conform to their own form of linguistic discourse.

Dance plays an important role in many popular music videos and can be considered a form of nonverbal communication (Hanna 1983,1987). The observation of dance can therefore be regarded as playing a similar role in the learning process as the use of diverse linguistic practices. Thus, the use of dance metaphors is another way to encourage the students' classroom use of informal and familiar modes of interaction which can be leveraged in instruction.

Many students often develop a sense of identity with their favorite popular music celebrity or song. As mentioned above, instruction that builds on prior interest and identity is likely to be as important as instruction that builds on knowledge alone. All students can profit from this approach, but the benefits are particularly salient for those who would feel disenfranchised or disconnected from science should instruction neglect their personal inclinations.

The use of dance metaphors is another way to create a process of creative constructions and reconstructions of self-identities (Hanna, 2015). This process of self-identification supports provides a sense of personalization of the subject matter and therefore can improve the attitude and the awareness of the importance and relevance of the material, as well as the retention.

The following table summarizes the ways in which are model addresses many of the concerns about diverse groups having an equitable access to STEM education.

Table I: Addressing Concerns of Equity in STEM Education

Concerns About Diversity and STEM Education	How the Model Addresses these Concerns
Lack of inclusion, particularly for low income minority students.	Popular culture can be a great equalizer of diverse demographic groups. Popular music is enjoyed equally by youth from diverse demographic groups.
Stereotypical views about the interests or abilities of particular students or demographic groups.	The model transforms the learning environment by embracing the world of popular culture, this erasing any preconceived stereotypical views.
Lack of motivation to learn STEM, particularly for low income minority students.	The model captures the imagination of the students.
Students across social classes and other demographic groupings can learn science with supportive conditions.	The presentations provide a unique vehicle for the instructors to bond with the students thus providing for a uniquely supportive learning environment.
STEM learning is heavily dependent on cultural content, values and human emotional needs.	The music video metaphors are immersed in cultural funds of knowledge that can be leveraged, combined with other concepts and transformed into scientific concepts.
Diverse linguistic practices can generate learning and be leveraged into instruction.	Metaphors based upon the lyrics of popular songs as well as dance metaphors can be leveraged into instruction.
Instruction based on prior interest and identity is as important as instruction that builds on knowledge alone.	Students can form a sense of self identity with their favorite music and dance celebrities; dance can create a sense of self identity.

Popular Culture in Education

The influence of music on teenagers has been enormous through different times and has affected them economically, physically and psychologically. However it is used, music has been a powerful

tool to impact teens of all times. It has been estimated that on average American youth listen to music and watch music videos four to five hours a day, which is more time than they spend with their friends outside of school or watch television. Common slang, when used in popular songs, have slipped into the vocabulary of teenagers. Popular phrases such an “Yah-yeah” and “crunk” are now used by teenagers in everyday conversations.

Tim Weedon, a popular educator who specializes in popular culture with a focus on Hip-Hop, explores some examples of music and lyrics that can be used in education in his blog “Exploring Popular Culture in Education” by developementeducation.ie (June 11, 2009). His approach for implementing music is not only focused on basic educational skills but also on the more complex life-long learning development skills that present themselves in daily life. For example, he cites the example of a young person who was having difficulty understanding the historical geography and Sierra Leone in Africa and he was able to make a link between researching the country and a specific theme within the rapper Kanye song, “Diamonds Are Forever”.

Recently, pop culture has taken some traction in college classrooms, such as course at the University of Virginia called ‘GaGa for Gaga: Sex, Gender and Identity’ which covers the title topics while examining the enigmatic performer’s influence in culture. Many other performers, films and television shows have been made the subject of college courses. For example, Georgetown University has a course called ‘Philosophy and Star Trek’ and Yale features ‘Christian Theology and Harry Potter’. ‘Watching the Wire’, “America Pro Wrestling’, ‘Lil Kim, Twilight, 2Pac, The Simpsons, Bruce Springsteen and South Park are some of the other pop culture phenomena to get their own classes.

Pop culture has become a fixture in college classrooms, and not merely in the presence of one-off 'novelty' classes. On many college campuses, the value of scholastic inquiry into pop culture phenomena is widely accepted. Bowling Green has a Department of Popular Culture and offers a pop culture major. Some classes in the academic program include 'Popular Entertainments,' 'Youth in Popular Culture,' 'Black Popular Culture' and 'Contexts of Popular Music.'

Western Kentucky University also features a popular culture studies major. Students enrolling in the program have the opportunity to 'examine the multiple uses and meanings of the arts and culture of everyday life' through 'innovative interdisciplinary coursework.' Some colleges do not feature majors in pop culture, but they do offer minors. Ohio State, Virginia Tech and USC are only a few examples of widely respected schools that offer a minor in pop culture.

Opinions vary considerably on whether pop culture merits inclusion in academia. Some higher education observers suggest that offering classes on pop culture phenomena is a misguided attempt to increase student interest. Others believe that such courses represent a frivolous ploy to garner attention for an institution. Still others say that classes on pop culture subjects are often nothing more than an opportunity for professors to explore pet areas of study and that students gain little from them.

Examples of the Model

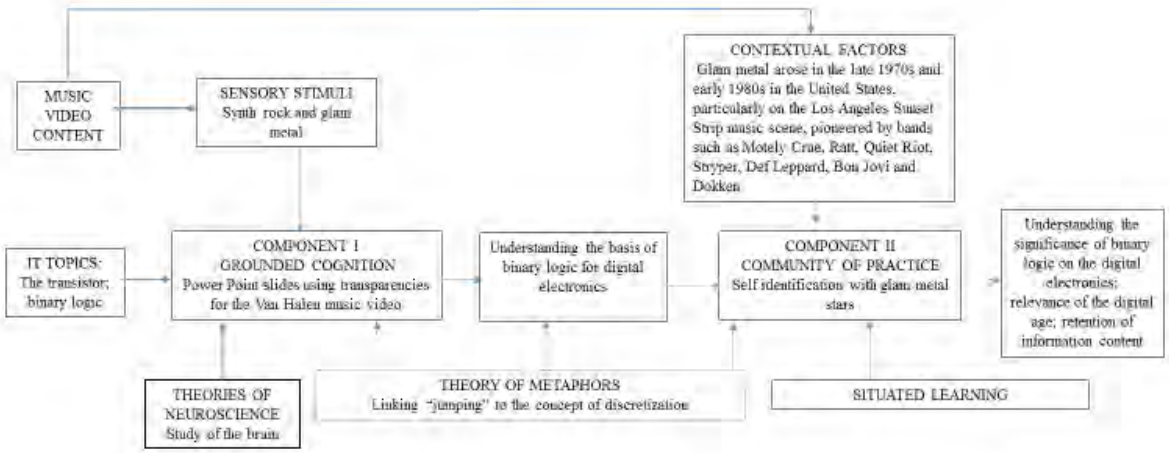
We use the metaphor of "Jumping" to describe the discretization property of binary logic which is the basis of digital electronics. Similarly, it can be used to describe the capability of the transistor to switch electronic signals (i.e. "on/off" switch) based upon various properties of semiconductors. In this way complex and abstract concepts of digital electronics are embodied or grounded in action and perception (i.e. an example of semantic embodiment).

In our example we use the popular music video "Jump" to derive a notion of jumping based upon popular culture. This video is based upon the single "Jump" which was an international hit of the rock music band Van Halen, who by the early 1980s were one of the most successful rock acts of the time.

Figure 2 shows how the conceptual framework of our model is applied to this particular example. In the first component the comprehension of the discretization property of binary logic is obtained by the process of grounded cognition facilitated by the music video and the metaphor of Jumping". Theories of neuroscience play a crucial role in explaining how the dance and other bodily movements of the music video can play an essential role in understanding the notion of discretization.

In the second component the importance and relevance of the topic is enhanced by the process of situated learning. The student becomes part of a community of practice that involves the shared interest in popular culture and explores the relevance and meaning of popular culture in one's daily lives. In this example, the video can be interpreted as an expression of having courage and taking decisive action in one's personal life.

Figure 2: Model Example



We have created many visual metaphors that rely heavily on pop culture. For example, the magnetic image of Lil Wayne's brain in the video "I Am Not a Human Being" is used to symbolize artificial intelligence. The rapper appears to be irrepressibly wacked-out (i.e. not a human being) in the video and has the feel of the rapper's many mixtapes. This music video metaphor introduces a sense of humor into the study of artificial intelligence, with the potential of providing insightful understanding of some of the salient features of artificial intelligence.

Many of our metaphors are derived from music videos where dance plays a central role. For example, the song "Straight Up" is used as a metaphor for the construction of knowledge from information in IT planning. In the song, Paula Abdul speaks about her romantic partner being more honest with her concerning the status of their relationship; she states, "give me some information please". The music video displays the dazzlingly dance routines of Paula Abdul and forms the basis for an emotional and pop culture based view of an important concept for IT applications, namely, transforming data into information and eventually into knowledge.

In just about every metaphor we have developed, popular music plays a critical role in enhancing the learning and understanding of the concepts. For example, the crescendos and intensity of

"Ain't No Mountain High Enough" provide an effective backdrop to understand the breadth and depth of the world's information storage, transmission and computational capacity. The fast-paced music of "Turn Up the Music" can enhance the imagination while studying how transistors can be used to amplify electronic signals.

IT Metaphors and Popular Culture

In this section we provide of some of the IT metaphors that we have created using popular music videos. This list is similar to one given in Rappaport et al. (2016), which shows how these metaphors are based upon the theory of embodied cognition and various theories of neuroscience. However, here, we explain how particular aspects, characteristics and artifacts of popular culture are evinced for each of the metaphors.

Table 2: Music Video Metaphors

IT Topic or Content	Metaphorical Meaning	Characteristics of Popular Culture
The Information Age; " E.T."	Information connects people and things outside of their immediate geophysical space	A hip-hop ballad which draws heavily from dubstep and techno
Digital Communication; Transistors; "Turn Up the Music"	The dance choreography and music display speed, agility, energy and intensity	An uptempo song that draws on electronic dance and house music
Binary or Boolean Logic; "Jump"	Binary Logic is based upon the discretization (Os and 1s)	This synth rock and glam metal song was dedicated by David Lee Roth to martial artist Benny Urquidez, of whom he was a student
The transistor as a switch; Binary Logic; Logic Gates; "Hot N Cold"	The song uses antonyms to describe a partner's mood swings	A Tiffany-style 80's pop number
The transistor as a switch; Binary Logic; Logic Gates;	The switching process of a transistor is like a mood swing	Demi Lovato published a trio of pictures in her Instagram

"Sorry Not Sorry"	or a change of opinion	and Twitter account showing an acronym titled "SNS"
The transistor as a switch; "DJ Got Us Fallin' In Love"	The video uses special effects to start and stop the dancing	A Europop, electronic dance track, the video shows Usher krumping and cribbing walking in a club environment
The Worldwide Web; "International Love"	Pitbull is Mr. Worldwide	A dance-pop song with dancefloor-scorching synth grooves and a boastful tone
Computer Networks; Integrated Circuits; "Run It!"	Teenagers make new connections in an underground dance in a school gym	A crunk style hip-hop song with a slinky synth beat and a mix of smooth seduction and cunning come-ons
Transistors versus Vacuum Tubes; "Dinosaur"	Like the old man in the song who is hitting on younger females, vacuum tubes can be considered dinosaurs, an outdated technology	The song is composed in a jungle beat tempo and incorporates a whistle-synth. The lyrics discuss an older man attempting to flirt with younger females
Microprocessors; "Control"	Janet Jackson wants control of her life, just like the microprocessor controls the central processing functions of the computer	The song is an example of dance, new jack swing and R&B genres
Computer Servers; "New Slaves"	Slaves become smarter than the masters	An industrial hip-hop song that has a sample of a song from Hungarian rock band Omega
Virtualization; "Just My Imagination"	The virtual server can be more effective than a real server	A soul song with a bluesy rhythm track
Virtual Reality; "Real As It	Jay Z is "real" just as things	The culture of the street

Gets”	and people in a virtual world	
Ecommerce and Data Analytics; “What Them Girls Like”	Reading minds: immediate service supported by relevant information	A slyly insightful song about love
Ecommerce and Customer Satisfaction; “That’s What I Like”	Bruno Mars dances to virtual images of what he desires	The song contains elements of hip-hop soul, new jack swing, R&B and modern trap
Advanced Pervasive and Invisible Analytics; Data Mining; “Lil Freak”	Usher and Nicki Minaj uncover new relationships in an underground club	The music video has a secret society concept, dealing with an underground club
Social Media; “Sorry”	The ReQuest Dance Crew show that there are many ways to say you are sorry	The song represents a mix of dance-hall pop, tropical house and moombahton
Computing Everywhere; “Cake by the Ocean”	Computing can be effective in the least expected places	A song in the style of disco-funk; the music video features the Fat Jew, an American Instagram celebrity
Internet of Things; Sensing Devices; “Break the Ice”	The anime-influenced animation video portrays the superheroine character of Britney Spears destroying a highly secured laboratory with several clones, including one of herself	The song is in the style of Electro-R&B with influences of rave and crunk
Internet Security; “Welcome to My Hood”	The Internet can be a dangerous place, just like the hood	The song is in the style of Gangsta rap and trap
Technology Disruptors; “Forgot About Dre”	The rappers are disruptors in both good and bad ways	In the style of hardcore hip-hop and Gangsta rap, Dre reminds his listeners of his significant influence on the

		genre
Big Data and Infinite Computing; "Infinity"	Symbolizes technologies riding Moore's Law	A mid-tempo R&B ballad whose content critics likened to Mariah Carey's separation from her entertainer husband
World's capacity for information storage, transmission and computation; "Ain't No Mountain High Enough"	Moore's Law predicts a literally fathomless and boundless capacity for the world's digital industry	This soul and R&B song became Diana Ross's first solo number-one hit on the Billboard Hot 100 chart
The MIS Challenge; "We Alright"	Lil Wayne is inundated with countless documents flying in the air at an office party	The hip-hop video features many cameo appearances of members of Young Money
IT Processes Data into Information and Knowledge; "Straight Up"	Paula Abdul wants to know the truth about her relationship	This one of the most popular R&B and dance-pop singles of 1989 remaining in the Top 10 seven weeks
Knowledge requires the access to information and the tools to analyze; "How Shall I Know"	Whitney Houston and her dancers express themselves within a setting of video screens and colored partitions	The music video gave Whitney Houston exposure to teens and MTV
IT combines management and technology to support decisions for the organization; "Decisions"	Miley Cyrus wants to eat the whole cake, just as IT encompasses the entire organization	The song is a dubstep track that lyrically discusses the general desire for wealth and success
Decision Support Systems and Artificial Intelligence; "I Am Not a Human Being"	Lil Wayne appears scary at first: machines can be humanized as they can assist human decision makers	The name of the album and this song is a reference to Wayne's assertation that he is a Martian

Deliverable Product

We developed two separate PowerPoint presentations on IT: a technical one and a business/applications oriented one. The topics selected for the technical presentation (TP- for "Technical Presentation") are given as follows:

- Semiconductors and Digital Electronics
- Transistors versus Vacuum Tubes
- Binary Logic as the Basis for Digital Electronics
- Logic Gates, Integrated Circuits and Microprocessors
- Moore's Law
- World's information storage, transmission and computational capacity

The presentation is introductory in nature, giving only a brief description of each topic. The main goal is to provide a basic understanding and appreciation of the technical/scientific foundations of digital electronics.

The presentation on the business/applications side (BAP- for "Business Application Presentation") is also introductory in nature and provides a basic understanding and appreciation of the importance and relevance of information technology in todays' society.

The topics selected for the BAP presentation are as follows:

- The Importance and Prevalence of Information in Our Society
- Big Data and Pervasive Analytics
- Transforming Data into Information and Knowledge
- IT and Globalization
- Staying Competitive using IT

PowerPoint slides provided the basis for the presentation and facilitated the links between the music videos and the IT topics. Each PowerPoint slide is dedicated to a particular topic and consists of the following six components (similar to the frameworks used in Rappaport et. al (2016, 2018)):

1. Play a section of a music video with no sound, while playing the corresponding iTunes song with sound. This allows the use of the most relevant and effective portion of the video.
2. Overlay a visual image from the video on top of component 1 using one of the animation functions, as well as the transparency function.
3. Overlay a visual image representing the particular IT topic on top of components 1 and 2, using the appropriate animation function, as well as the transparency function.

4. A short description of the IT topic, a description of the song and/or music video and an explanation of the metaphorical construct used to link the two domains.
5. A traditional PowerPoint presentation on the particular IT topic or concept. The length of the presentation, and the level of detail, rigor and sophistication of the presentation would depend upon the particular audience and educational goals.
6. Coordinate the above elements so as to take advantage of the sensory aspects of the videos and music, while at the same time obtaining the maximum educational value. For example the presenter can control the volume of the iTunes song in order to induce the appropriate emotional response from the students at the right time and the right place.

The entire exhibition is delivered by two presenters that work as a team and complement each other: one focusing on the music video portion of the presentation and the other one delivering the traditional educational material.

The presenter of the music video portion is responsible for developing the COP (community of practice) of the students based on their shared interest in popular culture. This is accomplished by engaging the students in the aspects of popular culture evinced in the videos and encouraging them to participate in a discussion on the significance and relevance of the metaphors. In some cases it would be appropriate to elicit their critique of the various videos, including their personal tastes of the music and the individual artists.

Implementation and Program Evaluation

We plan to implement the model with small groups of primary (mainly 8th grade) or secondary school students from the Philadelphia School District. An outcomes assessment consisting of both an informal assessment and an experimental design with statistical results will be obtained and results presented at the conference.

Informal Assessment

An informal assessment of the program will be obtained based on the observation of the project using the impacts frameworks for informal science projects developed by Dierking in the National Science Foundation's (NSF) Framework for Evaluating Informal Science Projects (Friedman, 2008 ch. 3). The impact categories in this report are: Knowledge, Engagement, Attitude, Behavior, Skills and Other specific to the topic. The results of this assessment will be presented at the conference.

Experimental Design and Statistical Results

Experimental designs are not always more appropriate than naturalistic methods, but they provide a structured framework that can make the results more plausible. We will use a randomized post-only design in which participants are randomly assigned to a group that experiences the TP and BAP presentations with the music videos and to a group that sees the TP and BAP presentations without the music videos.

A questionnaire will be developed to measure the effect of the model on three broad learning outcomes identified by the Defining Youth Outcomes for Stem Learning in the Afterschool (2013) study. These outcomes are reflected in the phrases: (a) I "I like to do this"; (b) "I can do this; (c) "I think this is important". These broad developmental outcomes and indicators of learning reflect constructs found in evaluation reports of afterschool STEM programs (Afterschool Alliance, 2011) as well as the research literature pertaining to human development Hidi & Renninger, 2006; Holland, Lachicotte, Skinner & Cain 1998; Lave & Wenger, 1991), youth development (Barber, Stone, Hunt & Eccles, 2005; Eccles, 2005) and science learning (NRC 2007 & 2009).

We designate the three outcome categories as: (a) Interest/Curiosity (b) Skills/Properties, where the term properties includes reference to the detailed, technical aspects; (c) Importance/Attitude.

The participants of the treatment groups (i.e. those experiencing the proposed model) and the control group (those experiencing a traditional lecture) will be given the same questionnaire for both the TP and BAP presentations. The statistical results of the surveys will be compared for the treatment and control groups and presented at the conference.

A separate questionnaire will also be given to the treatment groups for the TP and BAP presentations to validate the efficacy of the situated learning model involving the COP (community of practice). The result of these surveys will also be presented at the conference.

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OVERCONFIDENCE, ABSOLUTE CERTAINLY, AND JUNK SCIENCE: HALLMARKS OF LIVING IN A POST-TRUTH SOCIETY

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Abstract

We live in the age of post-truth and arrogance where lying has become so acceptable that we have numerous euphemisms for deceit. A major threat to the success of a society or organization is the feeling of certainty. It is clear that people overestimate how much they actually know. This paper will examine the dangers of certainty. People who have too much confidence in their opinions may actually have a mental flaw that can be dangerous. Moreover, much of the research in areas such as medicine and management cannot be replicated and turns out to be untrue. In fact, doctors only make about 15% of decisions using scientifically valid studies.

Keywords: Post-truth, Moral certainty, intellectual humility, evidence-based, replication crisis.

Introduction

Many scholars feel that we are living in the "age of post-truth." Indeed, the term "post-truth" became the Oxford Dictionaries Word of the Year in 2016 (Wang, 2016). Another important term that is being used all the time is "alternative facts." Keyes (2004: p. 5) asserts that "deception has become commonplace at all levels of contemporary life… It is now as acceptable to lie as it is to exceed the speed limit when driving." No president has told as many lies as Donald Trump. According to the Fact Checker database, Trump told 3,001 lies in his first 466 days in office, i.e., an average of 6.5 false or misleading claims per day (Kessler, Rizzo & Kelly, 2018). Jon Lovett, a former speech writer for Hillary Clinton and Barack Obama as well as a

stand-up comic and television writer had the following to say about deception (the term he actually used was bullsh--):

> We are drowning in it. We are drowning in partisan rhetoric that is just true enough not to be a lie; in industry-sponsored research; in social media's imitation of human connection; in legalese and corporate double speak. It infects every facet of public life, corrupting our discourse, wrecking our trust in major institutions, lowering our standards for the truth, making it harder to achieve anything (Davis, 2017, para 2).

It is becoming very easy to deceive people because the amount of information is increasing exponentially, mainly because of the internet and globalization. It took 1,800 years, from 100 BCE to 1700 CE, for the amount of knowledge in the world to double; currently, knowledge is doubling every 12 months (Lewis, 2016). Online information doubles every six months; technical knowledge doubles every 18 months (Lewis, 2016). One would think that with such a rapid growth in knowledge people would recognize the dangers of absolute certainty. Unfortunately, this has not been the case. We are observing arrogant people ranging from academics to doctors to politicians, who are arrogantly certain of their facts. Unfortunately, not all the information available to the public is reliable. There is a great deal of bad science, junk science, fake news, and erroneous research available to the public. Researchers speak of evidence-based medicine, evidence-based management, evidence-based practice; we shall see that the "evidence" is often unreliable.

The *Chronicle of Higher Education* identified 10 key trends in higher education. One of them was "a growing movement to teach students to separate fact from fiction." This is now known at many schools as "information literacy" (Najmabadi, 2017). With so much nonsense on the internet, it has become of utmost importance for students to be taught to know the difference between fiction and fact. Many scholars believe that the presidential election won by Donald Trump was influenced by false "news" (Najmabadi, 2007).

Carl T. Bergstrom and Jevin West at the University of Washington have proposed a course with the provocative title of "Calling Bullshit in the Age of Big Data." Their definition of bullshit is: "language, statistical figures, graphics, and other forms of presentation intended to persuade by

impressing and overwhelming a reader or listener with a blatant disregard for truth and logical coherence" (Kolowich, 2017). The University of Michigan plans to start offering a one-credit course with the title, "Fake News, Lies, and Propaganda: How to Sort Fact from Fiction" starting with the Fall 2017 semester (Hutchinson, 2017).

This paper will examine the dangers of absolute certainty combined with overconfidence.

The Danger of Certainty Combined with Overconfidence

Kolbert (2017) highlights the fact that "People believe that they know way more than they actually do." This overestimation of the knowledge we possess is known as the overconfidence effect. Sloman & Fernbach (2017) also speak of the "knowledge illusion"; we simply do not understand how little we actually know. With certain kinds of questions, answers that people feel that their response is "99% certain to be correct" turn out to be incorrect 40% of the time (Kasanoff, 2017). Robert A. Burton, a neurologist, examined the neuroscience behind being certain and came to the following conclusion:

> Despite how certainty feels, it is neither a conscious choice nor even a thought process. Certainty and similar states of "knowing what we know" arise out of involuntary brain mechanisms that, like love or anger, function independently of reason (Burton, 2008a: xi).

Burton believes that human beings cannot avoid certainty bias but can moderate its effect by an awareness that feelings of certainty are not based on logic and reasoning. These feelings are the result of "involuntary brain mechanisms" that have little to do with the correctness of a belief. This is why intuitions, hunches, premonitions, and gut feelings need to be empirically tested. Burton sees certainty bias as a "potentially dangerous mental flaw." Burton (2008b) explicitly makes the point that people should not believe in politicians that "sound too sure of themselves."

Bertrand Russell once said: "The whole problem with the world is that fools and fanatics are always so certain of themselves, but wiser people so full of doubts" (Chastain, 2017). Critchley (2014) relates the concept of uncertainty to tolerance of others. He states that "The relationship

between humans and nature and humans and other humans can take place only within a certain play of tolerance." He attributes the existence of Auschwitz to the certainty bias.

> The play of tolerance opposes the principle of monstrous certainty that is endemic to fascism and, sadly, not just fascism but all the various faces of fundamentalism. When we think we have certainty, when we aspire to the knowledge of the gods, then Auschwitz can happen and repeat itself. Arguably, it has repeated itself in the genocidal certainties of past decades (Critchley, 2014).

Lloyd (2017) also feels that moral certainty is dangerous. He posits "History overflows with misery inflicted by well-intentioned people who were convinced that they had seen the only true moral values, and who sought to convert or destroy those who would not agree." His examples include the Inquisition which was based on the moral certainty of the Roman Church which was certain that only its interpretation of Christian scriptures was correct. Similarly, Stalin's Russia, Mao's China, and Hitler's Germany were totalitarian societies built on the belief that they knew the truth and anyone who disagreed had to be exterminated.

Mao's "Cultural Revolution" resulted in the death of millions – one estimate is 30 million -- and was really a Chinese holocaust (Lewis, 2014: xviii). Communism is one social experiment that has failed miserably. White (2012: 453-457) lists 17 countries that became Communist; the total number of people that died in these countries from "execution, labor camps, famine, ethnic cleansing, and desperate flight in leaky boats." is about 70 million. White (2012: 453) underscores the fact that "when death and destruction have followed every single Communist regime ever established, there would seem to be a flaw in the system." It should be impossible for anyone to believe that this is an economic system that works. On the other hand, White (2012: 309-315) describes the effects of Adam Smith's opinion that "Famine has never arisen from any other cause but the violence of government attempting, by improper means, to remedy the inconvenience of death." This notion, that governments should not interfere with famine, resulted in the deaths of 26.6 million people in British-ruled India. Amartya Sen challenged this view and noted that famines do not take place in democracies; the action of government can prevent deaths from famines in poor as well as rich countries (White, 2012: 309).

Leaders – even of democratic countries – who are certain of their beliefs, will resort to lying if that is what it takes to accomplish what they want. The war in Vietnam which cost more than 58,000 American lives resulted from fabrications made by President Johnson (Lewis, 2014: 8-12). According to Lewis (2014: xiii), the war in Iraq came about because of 935 lies made by President George W. Bush and top officials of his administration regarding the Iraqi threat. President Obama told untruths about the Affordable Care Act when he repeatedly assured Americans that "If you like your health plan, you can keep it" (Lewis, 2014: xviii).

Overconfidence and Expert Predictions

Numerous websites discuss expert predictions which turned out to be wrong. Some of the worst predictions about technology include: "There is no reason anyone would want a computer in their home" — Ken Olson, founder of Digital Equipment Corp.; "Remote shopping, while entirely feasible, will flop." — Time Magazine; "There's no chance that the iPhone is going to get any significant market share." — Steve Ballmer, Microsoft CEO; "Fooling around with alternating current (AC) is just a waste of time. Nobody will use it, ever." — Thomas Edison, "The idea of a personal communicator in every pocket is a pipe dream driven by greed."—Andy Grove, then CEO of Intel; "No one will need more than 637KB of memory for a personal computer. 640KB ought to be enough for anybody."—Bill Gates (Dhiraj, 2017).

Kahneman (2011: 261-265) believes that one has to be very careful with people who are overconfident and assertive. They certainly believe that they have the expertise but they may not perform better than chance. He concludes that "an unbiased appreciation of uncertainty is the cornerstone of rationality — but it is not what people and organizations want…Acting on pretended knowledge is often the preferred solution" (Kahneman, 2011: 263).

Several books have been written about expert predictions which usually turn out to be wrong. According to Dobelli (2013):

> Experts suffer even more from the overconfidence effect than laypeople do. If asked to forecast oil prices in five years' time, an economics professor will be as wide of the mark as a zookeeper will. However, the professor will offer his forecast with certitude (Dobelli, 2013).

Kahneman (2011: 218-219) cites research conducted by Tetlock (2005) that demonstrates how poorly experts who make a living "commenting or offering advice on political and economic trends" actually perform. They do not do better than monkeys throwing darts on a board displaying the various possible outcomes (Kahneman 2011: 219). Virtually all economic models failed to predict the Great Recession of 2008 (Krugman, 2012; Smith 2015). The best economic models are not judged on predicting something new but on "how well the model fits the data on the phenomenon the model was created to describe." This, of course is almost worthless since you might end up with hundreds of contradictory models to describe hundreds of different phenomena (Smith, 2015).

Smith (2015) further states:

> Economists didn't just fail to see that monster recession; they routinely fail to see economic events coming. The best models we have -- the ones central banks use, which take graduate-level training in order to handle -- have about as much forecasting power as simple, naïve mathematical techniques that any undergraduate statistics major could whip up in a few minutes (Smith, 2015).

Kahneman (2011: 241) has this to say about expert intuition: "Claims for correct intuitions in an unpredictable situation are self-delusional at best, sometimes worse ... intuition cannot be trusted in the absence of stable regularities in the environment." If an environment is very stable and regular an expert does have the ability to understand the regularities by observing the right cues. In areas where there are no regularities and consistencies (e.g., stock market or political environment), people will not be able to develop any real expertise.

Predictions made by academics are especially suspect. Kahneman (2011: 219), citing Tetlock (2005), has the following to say about these kind of predictions:

> In the age of academic hypersegmentation, there is no reason for supposing that contributors to top journals — distinguished political scientists, area study specialists, economists, and so on — are any better than journalists or attentive readers of *The New York Times* in 'reading' emergency situations Kahneman (2011: 219).

Kahneman (2011: 222-233) believes that algorithms often do a better job at predictions than experts. He describes several situations in which one should rely on a simple checklist consisting of, say, six relevant characteristics rather than relying on an expert. In fact, Kahneman discusses a simple algorithm developed by Dr. Virginia Apgar in 1953 to determine whether a newborn infant was in distress. Her method is superior to the expert judgment of obstetricians since it focuses on several cues. Kahneman does point out the hostility towards using algorithms. Incidentally, Apgar's algorithm still in use has saved thousands of lives.

Kahneman (2011: 226) cites the work of Dawes (1979) and claims that a simple formula that uses predictors (i.e., independent variables) with equal weights are often superior to multiple regression models that use complex statistics to assign different weights to each of the predictor variables. The reason for this is that multiple regression models are often affected by "accidents of sampling." Of course, some common sense is needed to select the independent variables that are most likely to accurately predict the dependent variable. Dawes (1979) claims that the simple metric of "frequency of lovemaking minus frequency of quarrels" does an excellent job of predicting marital stability (Kahneman, 2011: 226). Bottom line is that we should not be overly impressed with the judgment of experts.

This is what can be said about expert predictions:

> When they're wrong, they're rarely held accountable, and they rarely admit it, either. They insist that they were just off on timing, or blindsided by an improbable event, or almost right, or wrong for the right reasons. They have the same repertoire of self-justifications that everyone has, and are no more inclined than anyone else to revise their beliefs about the way the world works, or ought to work, just because they made a mistake.
>
> Extensive research in a wide range of fields shows that many people not only fail to become outstandingly good at what they do, no matter how many years they spend doing it, they frequently don't even get any better than they were when they started. In field after field, when it came to centrally important skills—stockbrokers recommending stocks, parole officers predicting recidivism, college admissions officials judging applicants—people with lots of experience were no better at their jobs than those with very little experience (Eveleth, 2012).

Does it pay to be overconfident? There is evidence that individuals who are overconfident and certain of their abilities are overrated by others; individuals who are underconfident, are underrated by others as being worse than they actually happen to be (Lamba & Nityananda, 2014). Thus, it definitely pays to be overconfident. This may explain why politicians have no problem with being so sure of themselves and overpromising (Hutson, 2014). The importance of overconfidence is being used to explain why there is a gender gap in the corporate world. Men are more egotistical than women so this makes them appear more capable (Hutson, 2014).

Difficulty of Changing People's Minds with Facts: Confirmation Bias

Psychologists speak about confirmation bias as a major cognitive bias (Lockton, 2012). A cognitive bias is defined as:

> a systematic error in thinking that affects the decisions and judgments that people make. Sometimes these biases are related to memory. The way you remember an event may be biased for a number of reasons and that in turn can lead to biased thinking and decision-making. In other instance, cognitive biases might be related to problems with attention. Since attention is a limited resource, people have to be selective about what they pay attention to in the world around them (Chery, 2016).

This systematic bias is often due to the use of heuristics or rules of thumb by people to simplify decision making. These shortcuts can often lead to poor decision making (Lockton, 2012). A thorough list of biases may be found in RationalWiki (List of Cognitive Biases, 2016).

Once people form an opinion they "embrace information that confirms that view while ignoring, or rejecting, information that casts doubt on it … Thus, we may become prisoners of our assumptions" (Heshmat, 2015). People tend to only listen to information that supports their preconceptions. This may strengthen the beliefs of individuals and make them even more certain of their assertions.

There is a great deal of evidence that not only do facts not correct misinformation, but they make it more persistent and potent (Gorman & Gorman, 2017; Kolbert, 2017; Mercier & Sperber,

2017; Wadley, 2012). People get a rush from finding information that confirms that they are right; they would rather win an argument than discover the truth. People may have the ability to see flaws in their opponent's arguments. However, when it comes to their own opinions, that is when they are blind.

Certainty and misinformation are extremely powerful and it is difficult for facts to change people's minds. Colleen Seifert, a researcher at the University of Michigan has the following to say about misinformation.

> Misinformation stays in memory and continues to influence our thinking, even if we correctly recall that it is mistaken. Managing misinformation requires extra cognitive effort from the individual… If the topic is not very important to you, or you have other things on your mind, you are more likely to make use of misinformation. Most importantly, if the information fits with your prior beliefs, and makes a coherent story, you are more likely to use it even though you are aware that it's incorrect (Wadley, 2012).

It is very difficult to use truth to enlighten people, but it can be done. One trick is to keep repeating the truth without repeating the misinformation. The reason for this is because the more often people hear untruths, the higher the likelihood they will believe it (Hennigan, 2015):

> our preexisting beliefs, far more than any new facts, can skew our thoughts and even colour what we consider our most dispassionate and logical conclusions. This tendency toward so-called 'motivated reasoning' helps explain why we find groups so polarized over matters where the evidence is so unequivocal (Hennigan, 2015).

There is no question that it is considerably more difficult to change the opinions of people who are misinformed rather than simply uninformed. This is why it is so important to teach people to be critical thinkers. With critical thinking, the goal is to solve a problem in an honest way and not be unreceptive to new approaches and different opinions. Knowing how to resolve conflicts has become a valuable skill and it often requires the ability to help people know the truth. The following are some rules for changing opinions:

> Provide people with a narrative that replaces the gap left by false information; Focus on the facts you want to highlight, rather than the myths; Make sure that the information you want people to take away is simple and

> brief; Consider your audience and the beliefs they are likely to hold; and Strengthen your message through repetition (Wadley, 2012).

Kahneman puts forth "adversarial collaboration" as an effective way to avoid confirmation bias which arises when a researcher consciously or unconsciously designs an experiment in such a way to provide support for a particular position (Matzke *et al*., 2013). Bringing together two researchers who disagree and having them conduct an experiment jointly often results in better research (Matzke *et al*., 2013). The goal of adversarial collaboration is to discover truth, not to win arguments (Kahneman, 2012).

Kahneman talks about "willful ignorance" which is a problem that results "when we know that there are other ideas out there, but we refuse to consider them." Willful ignorance produces individuals who become so hardened in their positions that they even demonize people with differing opinions. No amount of evidence will get people suffering from "willful ignorance" to change their mind. Eventually, this refusal to listen to other points of view becomes denialism (McIntrye, 2016). For example, this seems to have happened to a large number of intelligent people who maintain that the MMR vaccine causes autism. This is why critical thinking is a vital skill (McIntrye, 2016). The hope is that individuals with critical thinking abilities will not fall into the trap of willful ignorance and will possess the capability of listening to other points of view.

Evidence-Based …

Researchers speak of evidence-based medicine, evidence-based management, evidence-based practice. How reliable is the evidence researchers use to prove their points? Munafo & Flint (2010) indicate that a "substantial proportion of scientific research may in fact be false." They attribute this to several factors including publication bias, low statistical power, "trend for effect sizes to decrease with year of publication," overestimate of true effect size, and source of funding. They conclude:

> In the meantime, readers of scientific journals should perhaps only believe large studies which report on findings in a mature literature (as opposed to early findings in a new field), place less emphasis on nominal statistical

> significance and focus instead on effect sizes and confidence intervals, and are published in journals with a low impact factor (Munafo & Flint, 2010).

According to Tractenberg, chair of the Committee on Professional Ethics of the American Statistical Association:

> A survey of more than 1,500 investigators, published in a 2016 issue of Nature, showed that more than 70 percent of researchers have tried and failed to reproduce other scientists' experiments, and more than half have failed to reproduce their own experiments (Tractenberg, 2017).

Gutting (2013) cites Ioannidis (2005) and asserts:

> John Ioannidis, in a series of highly regarded analyses, has shown that, in published medical research, 80 percent of non-randomized studies (by far the most common) are later found to be wrong. Even 25 percent of randomized studies and 15 percent of large randomized studies — the best of the best — turn out to be inadequate.

This is due to the fact that it is difficult and costly to conduct randomized controlled experiments. Therefore, most research is based on correlational data. Furthermore, "it is impossible to decipher how much data dredging by the reporting authors or other research teams has preceded a reported research finding" (Ioannidis, 2005). With data mining packages, it becomes very easy to perform hundreds of statistical tests and scour the data and come up with several statistically significant results.

Pfeffer & Sutton (2006) noted that both medicine and management are not evidence-based. Evidence-based medicine is defined as: "the conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients" (Pfeffer & Sutton, 2006). Doctors only make about 15% of decisions using scientifically valid studies.

> Recent studies show that only about 15% of their decisions are evidence based. For the most part, here's what doctors rely on instead: obsolete knowledge gained in school, long-standing but never proven traditions, patterns gleaned from experience, the methods they believe in and are most skilled in applying, and information from hordes of vendors with products and services to sell (Pfeffer & Sutton, 2006).

The same is true when it comes to management decisions. Many management beliefs are not based on hard evidence but opinions. Some examples of management myths cited by Pfeffer & Sutton (2006) include the following: (1) That the use of stock options to compensate corporate leaders will result in better financial performance for the organization; (2) Forced performance ranking of employees (this often means that the bottom 10% to 20% will be terminated) will ensure higher productivity and profits; and (3) the belief that the first company to enter an industry will have a huge advantage over competitors.

We may believe that medicine is evidence-based, but it is quite common for patients to receive treatments that are ineffective or even dangerous.

> Sometimes doctors simply haven't kept up with the science. Other times doctors know the state of play perfectly well but continue to deliver these treatments because it's profitable—or even because they're popular and patients demand them. Some procedures are implemented based on studies that did not prove whether they really worked in the first place. Others were initially supported by evidence but then were contradicted by better evidence, and yet these procedures have remained the standards of care for years, or decades (Epstein, 2017).

RightCare Alliance is an organization that consists of a partnership between community groups and health-care professionals, that is committed to "bringing medicine back into balance, where everybody gets the treatment they need, and nobody gets the treatment they don't need." Unfortunately, the current trend is "increasing medical costs without increasing patient benefits" (Epstein, 2017). Epstein (2017) cites a study published in *Mayo Clinic Proceedings* that examined 363 articles published in *The New England Journal of Medicine* that found that

> 146 studies that proved or strongly suggested that a current standard practice either had no benefit at all or was inferior to the practice it replaced; 138 articles supported the efficacy of an existing practice, and the remaining 79 were deemed inconclusive (Epstein, 2017).

Epstein (2017) cites other studies that have come to the same conclusion that many current procedures and drugs are ineffective or even dangerous. Some of the unnecessary and potentially harmful treatments described in the paper include placing stents in stable patients, using beta blockers for those with high blood pressure, and surgery for a torn meniscus. One study found that the cognitive bias known as the "availability heuristic" was a reason some cardiologists would recommend a stent despite the fact that it is quite well-known that they do not help stable patients. The availability bias is the tendency of people to overestimate the importance of information that is easily recalled – even if relatively rare -- and thus readily available to them. Thus, this bias makes us believe that the probability of being killed in a terrorist attack or airplane crash is much higher than, say, from car accident. Cardiologists remembered well-known cases of people who died suddenly – one example is Jim Fixx, the jogging expert – from a heart attack. This caused them to be afraid that they would look bad if a patient did not receive a stent and then died suddenly.

Karl Popper made scientists realize how science is supposed to work. He said: "No number of sightings of white swans can prove the theory that all swans are white. The sighting of just one black one may disprove it" (James, 2002; Popper, 1963). The way science works is that scientists are supposed to look for black swans to disprove the existing theory, not try to confirm their beliefs by looking for additional support (white swans).

Researchers have been talking about a replication crisis: It is very difficult to replicate various major studies. Approximately 60% of 100 experimental studies in psychology could not be replicated. The percentage of failed replications in experimental economics was also surprising, 40% (Bohannon, 2016). This has become a serious problem in the social sciences as well as medicine. One reason for the problem is due to the fact that "many researchers wrongly assume that achieving statistical significance in a study makes replication of its results unnecessary" (Bower, 2018). This is especially true when an alpha of .05 is used. One economist noted: "what some realize but fewer are willing to discuss: The accepted standard of a 5% significance level is not sufficient to generate results that are likely to replicate." (Bohannon, 2016).

One would think that with so many research issues, scholars would see the hazards of certainty. Unfortunately, this has not been the case. We are observing arrogant people ranging from academics to doctors to politicians who are certain of their facts. Unfortunately, not all the information available to the public is reliable. There is a great deal of bad science, junk science, fake news, and erroneous research available to the public.

Leadership and Certainty

There is evidence that the best leaders have the ability to listen to others. Spears (2004) found ten characteristics in the servant leader. One of them was "listening" which he defined as "Listening intently and receptively to what others say." Van Dierendonck (2011) affirms that "Leaders who show humility by acknowledging that they do not have all the answers, by being true to themselves, and by their interpersonal accepting attitude create a working environment where followers feel safe and trusted." Nielsen, Marrone & Slay (2010) also found that "people with humility are actively engaged in utilizing information gathered in interactions with others, not only to make sense of, but also, when necessary, to modify the self. That is, their self-views are focused on their interdependence with others rather than their independence from others."

Lynch (2017) highlights the fact that the "defining trait of the age seems to be arrogance…the arrogance of thinking that you know it all and that you don't need to improve because you are just so great already." Lynch (2017) avows that we all need intellectual humility. This means that we have to accept that we do not really know as much as we think to do given our various biases and limitations and also appreciate the importance of learning from the experience of others. This, of course, means that we have to be receptive to what others have to say, even those who have very different opinions from our own. Contrary to what many executives believe, "the humble leader is precisely the person who is best qualified to transform his firm into a profitable, successful, and respected organization." (Argandoña, 2015).

Kahneman (2011: 205) states that the correlation between the quality of the CEO and the success of his or her firm is probably about .30. Several studies demonstrate that chance plays a much more important role in the performance of companies than CEOs (Fitza, 2013). Kahneman

(2011: 206-208) asserts that the halo effect together with outcome bias helps explain the popularity of various books dealing with leadership. These books focus on successful firms and then attribute it to leadership style. Actually, it most cases it is simply luck. Chance quite often explains the success of certain firms and the failures of others, not the competence of leadership. Indeed, with the passage of time, the situation often reverses itself and the successful firms become unsuccessful and vice versa. Kahneman claims that the message of *Built to Last*, a leadership book by Collins & Porras (1994), is that "good managerial practices can be identified and that good practices will be rewarded by good results." Kahneman (2011: 207) disagrees and states: "In the presence of randomness, regular patterns can only be mirages." It is interesting to note that about 8 of the 18 companies extolled in *Built to Last* have stumbled (Reingold & Underwood, 2004).

Peters & Waterman (1982), authors of *In Search of Excellence*, studied 43 of America's best run companies in order to determine what made them successful and came up with eight basic principles of management. How did these firms end up doing in the longer term? Eckel (2013) says that "two thirds of them underperformed the S&P 500 over a decade. Some faltered badly, and some even went out of business." The stock performance of these companies did not stand the test of time (Baum & Smith, 2015).

Conclusion

Donald Trump has been described as "a president who speaks loudly and confidently about things he simply doesn't understand" (Blake, 2017). He actually declared that "I know more about ISIS than the generals do, believe me." The biggest threat to the success of a society or organization is not appreciating uncertainty. People who have too much confidence in their opinions may actually have a mental flaw that can be dangerous. Lloyd (2017) avows:

> Two of the greatest achievements of Western Civilization are science and democracy. They have in common the admission of each person's own fallibility, which is psychologically a hard thing to do. In science, we must admit that our preconceived ideas about the external world might be mistaken, and that we must carry out scientific experiments to determine the truth. In democracy, we must admit that our cherished values and political convictions might be wrong, and that society should be governed

> by the majority, albeit with safeguards for the rights of minorities (Lloyd, 2017).

If Sandel (2010) is correct in his assertion that Americans are so sure of themselves that they have lost the ability to have a "democratic argument," then we are in huge trouble. Indeed, a key reason for gridlock in Congress is the rise of hyperpartisanship and absolute certainty. Members of Congress have lost the ability to work with colleagues from another political party because they are so sure that they are right; you cannot have bipartisanship in an atmosphere of absolutely certainty. Jouet (2017) believes that America is having a "meltdown" and has become extremely polarized. It is virtually impossible to compromise when one side is not only suffering from overconfidence and arrogance, but is also basing its arguments on myths and nonsense. All the more so, if both sides suffer from these issues.

> … One of the main obstacles to bridging polarization is not only that there's a major divide among Americans about their values, but also there's a major factual divide about a lot of these issues. For example, if people believe that climate change is a hoax or a myth, it's not possible to genuinely discuss solutions to the problem.
>
> If people widely believe that undocumented immigrants are massively flowing into the country, that they are responsible for illegal voting in the millions — which is completely false — there can't be a more rational discussion about issues like immigration. Unless there is more of a common nucleus of facts over which to debate, it is going to be very difficult to bridge the divide. We see that's also a big factor in the current debate over health care reform, given the magnitude of falsehoods about the oppression of Obamacare and shaping ideas about the need for eviscerating the legislation entirely (Jouet, 2017).

The best cure for the dangers of absolute certainty and overconfidence is humility and appreciating the value of doubt, constructive debate, and compromise. In fact, we should never forget that without compromise, there would not have been a United States (Leskes, 2013). Heinrich Heine wrote in his 1820-1821 play, *Almansor*, "Where they burn books, they will ultimately also burn people." He turned out to be uncannily correct; university students burnt thousands of "un-German" books on May 10,1933. It was not only Jewish authors whose works were burnt (Heine's works were also burnt): books by Hellen Keller, Jack London, Ernest

Hemingway, Erich Maria Remarque, various critics of the Nazi ideology, and many others were torched (United States Holocaust Memorial Museum, 2017).

What is the connection between book burning and murdering people? Both require an absolute certainty that one's own ideology is correct and that another individual's opinions are so wrong that these ideas must be totally eradicated. To totally eliminate an idea (if that is even possible) may then require not only burning books, but also the very authors of those books.

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PARADIGMS OF INQUIRY FOR WOMEN IN STEM AND ADVANCED TECHNOLOGY DOMAINS

Abstract

Research shows that women are significantly under-represented in Computer Science (CS), mathematics, engineering, and technology fields. Past studies show that although women make up nearly 57% of the workforce today, only 26% of engineers are females, and so also 27% of computer scientists and mathematicians, and 27% of environmental scientists are women. Continued low participation of women in CS and STEM will be detrimental as these fields will be deprived of creative energies that are available through gender diversity and balance. We believe that fresh perspectives and revised paradigms are necessary to create an improved understanding of this phenomenon and its remedial strategies. Our early stage research focuses on 1) Gaining an overview of women in STEM and advanced technology domains; and 2) Exploring paradigms conceptually, to contribute towards the development of a framework. Even though some progress has been made to increase women's presence in CS and STEM, much work still needs to be done. It is our expectation that the present study will clarify paradigmatic basis for future research in this domain.

Keywords

Computer science, women, gender bias, paradigms, research, education.

Introduction

Numerous barriers have been explored and analyzed in the past and current literature. Some researchers believe that the problem of low representation of women in CS has a defined solution, while others believe that remedying the situation is not simple and requires addressing several factors. In this study, we have chosen to focus on the effects of gender stereotypes and bias beginning from the early childhood education, mentoring and support, as well as teaching methods employed by the faculty in CS. This study will examine under-representation and low retention of women in Computer Science / STEM.

Some research has been done on gender stereotypes in the field of Computer Science. Women who are interested in pursuing a Computer Science degree realize that they are in the minority and that most of their time will be spent in a predominantly male environment. However, very few women go in to the field knowing that they will face gender stereotypes and biases. Research has shown that gender bias is deeply rooted in academic institutions even though the academia would like to renounce the fact (Mervis, J., 2012). Several studies have shown that faculty as well as department heads consistently vote higher for male candidates even though women had identical qualifications. A team at Yale University asked 127

professors at 6 U.S schools to judge the qualifications of a college graduate who wanted to become a lab manager. Each of the participants were sent an identical resume, with half of the resumes having female names and the other half having male names. The professors were significantly more likely to hire the male candidate and see him as much more qualified than his female counterpart though the resumes were similar except for the change in name. What is striking is that both male and female faculty demonstrated equally strong bias.

Literature Review

Gender bias is revealed in choosing a candidate and also in letters of recommendations. Not much research has been done on this particular topic; however, the one study that was conducted showed that letters of recommendation written for women used terms such as "student" and "teacher," while portraying men as "researchers" and "professionals" (Trix, F., Psenka, C., 2003). Letters of recommendation written for female candidates were less likely to use qualifications that would set them apart from the others and would often be mediocre in quality. A study done by professors at the Teachers College, Columbia University, showed that female applicants were most likely to receive good letters versus excellent letters written for the male candidates (Dutt, K., 2016). Excellent letters also tended to be longer by at least 10 sentences than the good letters (Dutt, K., 2016). Understanding the bias in letters of recommendation, however unintentional, is important since women tend to receive these letters at a critical point in their lives. It also appears that gender bias starts quite early, in fact, it is seen in children as young as 6 years old (Bian, L., Leslie, S., Cimpian, A., 2017). Some studies have shown that by the age of 6, girls are less likely to associate brilliance with their own gender and more likely to associate the quality with boys. Girls consistently rated boys as "really, really smart" and good at difficult games. As was predicted by the study, six -year -old girls also showed less interest in novel games that were said to be for "really, really smart children" (Bian, L., 2017). The authors of this study posit that the notions about who is more likely to be smart and / or brilliant emerge very early in one's childhood and might affect one's self-confidence in pursuing male-dominant careers. For boys, on the other hand, the notion that brilliance is equaled with their own gender might result in inflated self-esteem (Bian, L., 2017). Women across most natural or physical scientific fields leave science in greater proportions than their male counterparts (Grunspan, D., Eddy, S., Brownell, S., Wiggins, B., 2016). One contributing factor could be the environment that women experience. Gender bias is not only apparent in letters of recommendations but also in the classroom. Results have shown that male students are much more likely to be named as being more knowledgeable about the course content by their own male peers. In fact, male classmates are over-nominated by their male peers by 0.57 points on a 4 point scale which showed a strong bias. Female students, on the other hand, nominated a classmate based on his/her performance

rather than gender and therefore indicated a lack of gender bias (Grunspan, D., 2016). The authors of this study state that in the three iterations of the same Biology course, the best student was always a male in spite the fact that all three courses had numerically more female students. We believe that these scenarios associated with the phenomenon of insufficient support, representation and progress of women in STEM, CS and advanced technologies warrant a need to gain fresh paradigms for inquiry. The rest of the paper identifies potential paradigms and concludes with thoughts towards integrating future research with appropriate and clearly stated paradigms.

Paradigms Of Inquiry

There are numerous paradigms of research inquiry and science parameters discussed in the article by Joseph Ponterotto (2005). The four paradigms explored are positivism, post-positivism, constructivism-interpretivism, and critical-ideological theory. For this paper, we will review all of the theories mentioned above except for the positivism paradigm. According to Ponterotto (2005), a paradigm is a "*set of interrelated assumptions about the social world which provides a philosophical and conceptual framework for the organized study of the world*". A paradigm, or a framework, sets the context for the researcher's study. In this paper, we discuss how the research problem of under-representation and low-retention of women in Computer Science might exist within the contexts of post-positivism, constructivism and critical-ideological theories. There has been an increasing emphasis on the importance of unequivocally declaring the paradigmatic foundations of research publications by their respective authors, along with applicability and relevance (Shannon-Baker, 2016).

Positivism Paradigm

Positivists operate on the basis of an objective reality, distinct from the researcher and therefore the researcher has a responsibility to discover such knowledge, often through the use of commonly accepted scientific methods such as structured experimentation, hypothesis testing and quantitative modeling. Descarte and Galileo have been famously associated with the origins of positivist thought (Kvasz, 2012; Mills, 1981). Positivism is grounded in an objective ontological acceptance of a reality that can be discovered through scientific process and thus the reality being studied can be epistemologically represented – this serves as an important foundation for critical thinking as it lends itself to external validation, anticipation of homogeneity in repetition of conditions and a fair degree of generalizability for a given construct.

Post-positivism Paradigm

The post-positivism paradigm is one of the primary foundations for quantitative research. The paradigm posits that there is an objective reality that is stable, uniform and can be measured and understood. Unlike the positivism, however, post-positivism implies that although we live in a coherent reality, it cannot be

measured perfectly and apprehended fully. The paradigm emphasizes the scientific method but allows for more flexibility. For example, in post-positivism researcher might also use brief interviews in addition to conducting a random study where only one variable is controlled. Where epistemology is concerned, post-positivists' position is that the researcher may have an influence on his/her research study but being independent and objective remain important guidelines. Post-positivists' view on axiology is that the researcher should keep his/her values, hopes, expectations and feelings and any kind of biases in check and detached from the research process. Even though there is no place for researcher's values in his/her study, Ponterotto (2005) acknowledges that one's values are reflected in the initial selection of the research topic. When rhetoric is present, in post-positivism rhetoric is very precise and scientific with emotions and biases detached from the description of the study and data analysis, and the report presented as objectively as possible. There has also been a significant emphasis on the use of participatory perspectives, which highlight the role of human cognition above the abstract claims of the unattainability of perfect theoretical knowledge of paradigmatic dimensions (Heron & Reason, 1997). Individual perspectives, including constructivism, have been highlighted for their limitations, leading to arguments in favor of mixed methods and participatory strategies (Guba & Lincoln, 1994).Under the post-positivism framework, our research problem might be addressed using a quantitative method. Numerical data will be collected from sufficient sample of participants using a tightly controlled study and where one variable would be manipulated. Semi-structured brief interviews might also be conducted to help identify one set of results that could be generalized to all Computer Science departments. Since post-positivism perspective emphasizes cause and effect of a phenomenon, we will be looking at what causes low-retention and under-representation of female students in CS/STEM fields. Under this framework, we will use hypotheses that would predict the results of the study before the actual study begins.

Epistemologically, our role and responsibility as researchers would be to detach ourselves from the participants and the problem studied. Our biases, emotions, and feelings should be kept in check and not allowed to influence our research. Under this theory, we might randomly choose our participants; however, if the pool of participants is already quite small, this might be a problem. For example, a research topic statement describes specific variables and the relationship between those variables and addresses relevant questions, and may look like this:

- Does participation in afterschool CS programs have a statistically significant effect on female students' skill and confidence levels?
- Is there a relationship between faculty attitudes towards their female students' abilities and student performance?

Constructivism-Interpretivism Paradigm

Constructivism-Interpretivism framework is an alternative to the positivism paradigm. Unlike positivism and post-positivism, interpretivism assumes multiple truths or realities that are subjective in nature and "constructed in the mind of the individual" (Ponterotto, 2005). The constructivism – interpretivism theory is at the foundation of the qualitative research. At the center of this position is that it is not possible to separate an objective reality from the research participant who is experiencing, processing, and labeling reality influenced by his/her situation, and contexts. The constructivist researcher will not try to find the one objective truth and will not require validation and verification from the outside. Paradigmatic approaches have also been used extensively across domains ranging from mathematics and education in mathematics (Stinson & Bullock, 2015) to religious ethics (Twiss, 2018). Concerning epistemology, the constructivism paradigm posits that the relationship between researcher and participant as subjective. Constructivist researchers spend a great deal of time with participants to better understand a phenomenon. Researcher's values, experiences, beliefs, and biases cannot be isolated from his/her research; however all biases should be acknowledged and described. According to Ponterotto (2005),

Research topics / questions using this framework might look something like this:

- What aspects of CS career do women value and appreciate the most?
- What stereotypes exist about women in CS culture? How those stereotypes are being addressed?

Although Ponterotto (2005) in his article does not discuss data analysis within the interpretivist paradigm, we assume that the data would be analyzed according to the qualitative research premises of data analysis. In studying our research topic using qualitative interpretivist paradigm, data would be transcribed and analyzed for common themes which would then be interpreted.

Critical-Ideological Paradigm

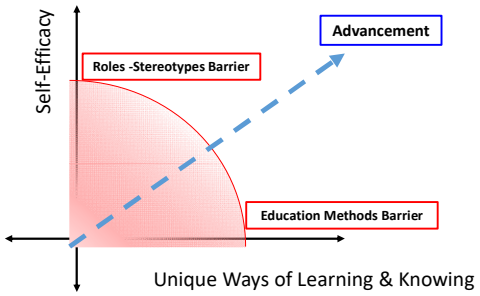
Critical-Ideological Paradigm - The critical-ideological paradigm concerns itself with emancipation and transformation. It originated in the 1920s with the idea to challenge the status quo (Ponterotto, 2005). There are several criticalist schools of thought that nevertheless share many commonalities. The paradigm posits that all educational research should be democratic and equitable. The nature of critical-ideological paradigm is idiographic and emic (Ponterotto, 2005). Power relations are at the center of this framework and it is used to emancipate the oppressed groups. Numerous qualitative methods and mixed methods strategies for research have stressed the necessity for pronounced statements and clarity on paradigms used for developing research frameworks, including widely used methods such as Grounded Theory (Annells, 1996) and naturalistic inquiry (Guba & Lincoln, 1982). The relationship between researcher and participants is dialectic and subjective where the researcher's role is to help empower the research participants to achieve transformation of the status. In reference to axiology, the critical theorists expect the researcher's values, expectations and beliefs to influence the study and data analysis (Ponterotto,

2005). The goal of this theory is to help participants emancipate themselves from whatever oppression they are facing. The reason we chose to concentrate on under-representation and low-retention of women in Computer Science/STEM is because we belief that educational opportunities should be available to all equally. Women, just as men, should have access to the same services and should be viewed just as capable as men to be successful at programming and coding. From our limited research on the subject, stereotypes about women in male-dominant fields are rampant and the more people in CS leadership and teaching positions are aware of the negative stereotypes against women, the easier it would be to deal with those assumptions that hinder womens' success in CS. Within the critical-ideological paradigm, our research problem might concentrate on implementing teaching strategies that reflect women's learning styles. we might also look at curriculum changes that might help improve female participation in Computer Science courses and encourage them to be successful.

In reference to epistemology, we would work collaboratively with the female students as well as faculty at CS conducting interviews and observation. The goal of our research within the criticalist paradigm would be to gain a deeper insight through interaction that would attempt to have a transformative result. Collecting data would happen by immersing myself in the culture of Computer Science/STEM for a longer period of time, and describing in detail our participant observations, face-to-face interviews, day-to-day experiences, and feelings. It would be interesting to be a "part" of the CS culture and perhaps gain a better understanding as to what attracts women to CS and what creates a challenge. The final report would be written in the first person and from our own experience openly detailing expectations and biases as well as the reflections on the impact of the research process.

Discussion - *Innovation to Make Sustainable Development Decisions*

Ultimately all conceptualization is optimally discussed in the context of application frameworks. We intend to adopt the AWT (Advancement of Women in Technology) framework (Samuel, et al., 2018) and adaptively discuss how innovative academic strategies could be used for sustainable development of women.



AWT Framework
Advancement of Women in Technology Framework

Figure 1 (AWT - Samuel, et al., 2018)

The paradigms of inquiry can be used to qualify and implement the AWT framework. The AWT framework is highly innovative but may not be demonstrably sustainable unless strong epistemological foundation and pedagogical methods are employed. A post-positivism framework would be most suited for early stage implementation of the AWT framework, and as discussed above, the clarity of thought provided by the paradigmatic analysis and thought development will lead to sustainable results and longevity.

Conclusion

In conclusion, it is very important to understand various paradigms that can help a researcher conduct his or her research in various ways that will increase his or her understanding about a particular phenomenon. Computer Science classroom environments may either be reinforcing or facilitating behaviors that favor male students, thus, professors need to be aware of these behaviors and consciously seek to align their behavior with best practices for fairness (Grunspan, D., et al., 2016). Additional research is required to examine if male-supportive classroom environment and pedagogical processes are inhibitive, discriminative and detrimental to female learners in those environments. It is evident that gender bias effects start in the early education and continue to the highest levels, being visible in higher education and even in recommendation and hiring stages. Based on our analysis we believe that the women in STEM and CS and advanced technologies research problems can be addressed distinctly through the three paradigms: post-positivism, constructivism-interpretivism, and critical-ideological. Understanding one's specific research problem will help identify the best paradigm to use for relevant theory selection, research process and data analysis. Additionally, for our own research, we believe that our research questions warrant a mixed-methods approach where we might use ideas from post-positivism and constructivism-interpretivist theories to guide and provide a framework for our research. It is, however, important to embrace methodological diversity in order to understand education practices (Stinson, D., Bullock, E., 2015). Therefore, understanding that each of the above mentioned paradigms has its own limitations and combining the elements of multiple paradigms, akin to taking a hybrid approach, could add significant value.

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Teaching Basic Amortization and Statistical Functions in An Introduction to Information & Technology Applications Course: May the Force be With You

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ABSTRACT

The creation of innovative challenges to interest students in learning is a viable concern for instructors that want to deviate from a publisher's online learning tools. Often times, instructors' resort to using games within their course. In an effort to challenge and engage students outside of the traditional publisher learning tools, the creation of a Star War's Games was developed for a 100-level college information and technology management application course. The Star War's game is used as end of the challenge to gauge the students gained knowledge of basic amortization and statistical functions with Microsoft Excel. Informal results revealed that that students seemed to be positively engaged and learning from the game. This presentation presents the Star War's game and instructor lessons learned.

Keywords: innovative teaching, gamification, engaging the student, information technology applications

1. INTRODUCTION

Functional hands-on knowledge of information & technology management (ITM) applications is essential for today's business students. As a result, there has been an increase in publisher's online application software tools for students to learn Microsoft Excel. However, many instructors argue that these new online learning tools only teaching students to push buttons rather then apply concepts to the application. Moreover, many also argue that the online software tools are not innovated enough to engage the student. Thus, as information and technology management application courses continue to be a permeant fixture integrated into the

business curriculum, the need for innovated learning approaches to deliver this content is essential.

In general, instructors often explore new and innovative approaches to increase student engagement within a course (Matli & Joubert, 2016; Oliveras & Crespo, 2013). Recognizing that publisher's online application software tools for students are not always the best for conducting an engaging class, many professors have turned to gamification activities within their classrooms. The goal of this study is to explain an instructor created gamification activity to teach basic amortization and statistical methods to undergraduate students. Additionally, this research will report informal student results and instructor's lesson learned. This work has practical impacts for IT and business programs and faculty wishing to engage their students. This work will also add the body of literature for gamification approaches for ITM applications. The remainder of this paper is structured as the following: brief review of literature of gamification activities, the Star Wars gamification activity, informal results, and conclusion.

2. REVIEW OF LITERATURE

There are several ways to engage students within the classroom. Over the last few years, gamification has been one of the popular methods for engaging students within the classroom (McLaren, Adams, Mayer, and Forlizzi, 2017).

Gamification

Pelling (2011) coined the term gamification. However, there are multiple definitions of the term. For the purpose of this research, we utilized the gamification definition defined by our colleague. Kapp (2012) defined gamification the integration of as the "game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solve problems".

Currently, gamification has been heavily used for an extended period within the computer science field where programing is taught (Haaranen & Kinnunen, 2015). However, gamification has been infused throughout various educational levels and subjects as well (Goshevski,D., Veljanoska, J. and Hatziapostolou, 2017)

Hwa (2018) recently utilized a digital game-based learning activity for elementary students to learn mathematics. Results revealed that for elementary students learning

mathematics "digital game-based learning is more effective than traditional class-based learning".

Researchers Matli and Joubert (2016) utilized a non-digital gamification method, crossword puzzles, as part of an assessment to engage first year information system students in the course content. They found that students positively perceived gamification as an innovative learning and assessment tool.

Additionally, Oliveras and Crespo (2013) utilized a gamification activity within an introductory accounting course. Their results revealed that student valued gamification activities and the positive interaction it provided. Moreover, there are numerous claims about the educational benefits of learning with games versus traditional approaches (Gee, 2003; McLaren et al. 2017; Prensky, 2006; Sheldon, 2011; Squire & Jenkins, 2003).

Gamification for Basic Amortization and Statistical Functions

In a simple internet search of Excel games at a college level, it can be found that games are based in common instruction of specific functions and formulas and applies factious data. The creation of a mortgage payments or to solve a statistical problem may be useful for the student, however the games used predefined data that may not connect with the student or motivate the student to reach the end of the game. Frownfelter- Lohrke (2017), present an example of teaching students excel with the use of Swifty's T-Shirts Compensation Calculation. The question a student may ask is who is Swifty as an organization, why should I care? This example and use of data question may not be differentiated from a problem in an Excel textbook. The example problem of Swifty has a generic feel to the data and there is little motivation in correlation in of need of information since the source of the data is unknown to the user. Customizing a class lecture through gamification to suit the appropriate use of curriculum in a manner that sparks a student's interest that can allow amortization and statistical function to be seen as challenge with knowledge through use of background data. For example, will Yoda make more that Darth Vader? Will the Imperial's or the Rebel's make more money in the Star Wars Empire?

3. THE STAR WARS GAME IN EXCEL

Using a practical game, like Star Wars in Excel, allows the student to demonstrate a culmination of basic functions and formulas learned throughout the semester. The applied

process of the game connects the use of the formulas to achieve an end result that student can apply in an integrated method showing their knowledge. Given as a challenge at the end of the semester to a 100-level applications course, the game was created to test the student's knowledge of basic Excel functions using context and working data connected to fun theme. The use Star Wars provided a means of correlation to familiar names of characters to compute their salary due to their standing and allegiance in the light or dark side of the force. The use of Star Wars is twofold; the student's interest in the Star Wars franchise as movies return to theaters and the use of a multitude of legendary and general neutral characters that supply a large enough amount of data for calculation without inundation.

The challenge begins with an ammonization tables to discern the amount of interest Darth Vader will have to pay back at the end of the advance. Following the interest loan calculation, the students are then tasked to calculate benefits based upon a given table and the employees benefit code which the students would need to add the benefit calculation to base salary of each employee, thus demonstrating the use of absolute cell references when formulas are copied numerous employees. The goal of calculating the benefits allow the student to work out which side of the force is more expensive to employ. The students are tasked to calculate the employer's cost of benefits using functions such as vlookup, and basic calculations to find the expense of each employee. Once the expense is calculated, the general statistical functions such as the use of min, max, average as well as sumif is used to determine a summation of the amount the employees are costing the organization based upon the employee's allegiance.

This presentation will present the course syllabus with specific learning objectives that coordinate to the Star Wars Excel game. The Star Wars Excel file along with the student instructions for completing the game will be shared during the presentation. This presentation will also address some of the important instructor lessons learned and warnings to students throughout the deployment of this game.

4. INFORMAL RESULTS

Given time for trial and error the estimated time for a student to complete the game is one-hour or one class period. Depending on the student's depth of applied knowledge the game could take a student upwards to two hours or 2 class periods. Longer time of completion could be due in part to length of the game or the amount of formulas the student had to remember in order to ascertain successful end results. Points of interest include student's difficulty of the use in the

later instructional task of the sumif statistical functions result when differentiating members of the light or dark side to calculating the costs of the employees. Whereas other students had difficulty identifying the need to add the benefit to the salary using a nested vlookup function. As this game was built specifically to encompass the learnt fundamentals of the course the student's ability to apply all of the functions learned with only an instruction sheet and starter file lead to some student's resignation of the game partially finished or misused a function in early steps and lead to miscalculations throughout the final submission. While a small margin of students completed the game successfully.

Overall, students reacted positively to the game. Students seemed engaged and excited.

5. CONCLUSION, LIMITATIONS AND FUTURE RESEARCH

The results of this study are consistent to similar gamification studies within other disciplines such as Oliveras and Crespo (2013) and McLaren et al. (2017). This research adds to the literature regarding the positive engagement and interaction of a game that can be used within the ITM and computing disciplines.

It is important to note that this research is not without limitations. Limitations of the game can be based in preparation of the student as well as coaching to remind the student of the correct use of functions. Neither coaching nor a review where given before the game conferred. This game was used to test skills cohesively learned and applied without the aid of a book, simulation, or instructor assistance. It was found however, that when the student did make a mistake because of the context and understanding of the data the student did recognize that a mistake or miscalculation had been made. Additional limitations include the time in creation of both the instructions and the starter files. Gamification creation to spark students interest requires both an understanding of what the students deem interesting and the creator's ability to interject that interest in the game. Future research that addresses these limitations should be explored. Nevertheless, this research is important because it provided a learning resource/game for institutions and faculty to explore.

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THE IMPORTANCE OF USING REAL-WORLD EXAMPLES AND DATA TO TEACH CORRELATION

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ABSTRACT

In the age of analytics and big data, it is becoming easier to dredge the data and find significant correlations. It is important for educators to enhance their lectures dealing with correlation. The authors feel that the best way to accomplish this is by using actual, real-world correlations uncovered by researchers. This paper provides examples of correlations from many diverse disciplines including management, education, psychology, and health.

Keywords: correlation, spurious correlation, causality, regression to the mean, Google Correlate.

INTRODUCTION

A great deal of research is based on correlational data. This may be because it is difficult and often costly to conduct randomized controlled experiments. Correlational data, however, presents several problems. First, with sophisticated data mining programs, it is quite simple to dredge the data, perform thousands of statistical tests, and come up with statistically significant findings. It is therefore not surprising that most published research findings in medicine are wrong. Gutting (2013) cites Ioannidis (2005) and asserts:

> John Ioannidis, in a series of highly regarded analyses, has shown that, in published medical research, 80 percent of non-randomized studies (by far the most common) are later found to be wrong. Even 25 percent of randomized studies and 15 percent of large randomized studies — the best of the best — turn out to be inadequate.

Another problem is the confusion of statistical significance with practical results. With huge data sets, correlations as low as .15 or less may be significant but of no real value. The first thing researchers have to do is use a classification scheme such as the one offered by Cohen (1988). With this approach, correlations are classified as small effects if they are below .30; medium effects if they are between .30 and .50; and large effects if they are greater than .50.

Most educators teaching correlation stress that correlation does not mean causality. They might use these types of examples. Rich people are more likely to eat caviar than poor people, i.e., there is a correlation between how much caviar is consumed by a household and wealth. However, eating caviar will not make one rich. If there is a significant correlation between ice cream consumption and number of crimes, it is not because eating ice cream causes one to engage in criminal activity. It is probably because there are more crimes during hot weather than when it is cold outside. For many years, researchers were finding correlations between low levels of Vitamin D and arthritis. However, this does not mean that low levels of Vitamin D cause arthritis. It is quite possible that low levels of Vitamin D might correlate with another factor that affects arthritis. There is no way to isolate the effects of Vitamin D without conducting a controlled experiment (Gutting, 2013).

Many significant correlations are spurious and meaningless (e.g., salaries of teachers and amount

of alcohol consumed). Spurious correlations result when data is churned, and many statistical tests are performed. Tyler Vigen (2015) provides several examples of spurious correlations: U.S. spending on science, space and technology correlates with suicides by hanging, strangulation, and suffocation (r = .99789); the divorce rate in Maine correlates with per capita consumption of margarine (r=.99256); and the age of Miss America correlates with murders by hot steam, vapors and hot objects (r= .87013).

It is, however, much more difficult to make students understand that even if there exists a strong, significant relationship between two variables, this does not mean that there will not be exceptions. Indeed, many intelligent people feel that global warming is a myth because of a cold spell that lasts a week or two. Students fall into the trap of believing that if they know a few heavy smokers who were robust and healthy and died in their 90s, this proves that smoking is not dangerous. The spread of the dangerous belief that vaccinations cause autism may be due to a few cases of autism that happened to occur after each child was vaccinated.

The purpose of this paper is to provide educators with real-world examples of correlations for use in their lectures. Students will have a better understanding of correlation if they can see real-world examples such as the correlation between IQ and income, SAT scores and GPA, or home runs and team wins. These type of examples will also make it clear that there will be exceptions, even if correlations are relatively strong.

It will also enable instructors to demonstrate that weak correlations may indeed be significant but that does not necessarily mean that the effect size is very strong. Thus, the correlation between the quality of a CEO and the success of his/her firm is .30. Luck has much more to do with the success of an organization than the talents of its CEO. The same can be said for IQ. The correlation between IQ and income is relatively low. Factors such as “personality, looks, networking, perseverance, concern for the future, and just plain luck, to mention only a few” account for much more of the variation in income (Dickens, Schultze & Kane, 1995).The authors provide a sufficient number of examples so that instructors may select correlations that the class finds interesting.

DIFFERENT PRACTICAL EXAMPLES OF CORRELATIONS

Variables	**Correlation or Coefficient of Determination**	**Source**
Student Academic Outcomes and Teacher Effectiveness	$r^2 = .14$	Mosle (2018). Unfair to blame teachers if scores on standardized tests are low. Variables that affect student performance include family educational background, how frequently students change schools because of homelessness or other disturbances, effects of poverty, and exposure to stress resulting from such factors as gun violence or abuse.
Height and Weight of Adult American Males	r = .41	Kahneman (2011: p. 181)
Height of Parents and Height of Children	r = .50	Kahneman (2011: p. 181)
Amount Countries Spend on Health Care and Life Expectancy	r = .46	Wade (2012). The U.S. is an outlier and spends a huge amount on healthcare with a relatively low life expectancy. If the U.S. is not included, r = .72.
Income Inequality and Happiness	r = -.618	Florida (2015)
Life Expectancy and Air Pollution (based on 2,996 counties in US)	r = -.27	Allen et al. (2016)
Life Expectancy and Median Income in a County	r = .68	Allen et al. (2016)
Life Expectancy and Percent Smokers in a County	r = -.63	Allen et al. (2016)
Life Expectancy and Percent Obese in a County	r = -.77	Allen et al. (2016)
Sedentariness and Obesity (n = 3,139 counties in US)	r =.74	Levine (2011)
Birth Order and Personality	r =.02 not significant	DiSalvo (2015)
SAT Scores and First Year Undergraduate College GPA (FYGPA)	r =.53	Mattern, Patterson & Kobrin (2012)
Math Scores on SAT Exams and First Year Mathematics Course Grades Taken in College	r =.52	Mattern, Patterson & Kobrin (2012)

High School GPA and First Year Mathematics Course Grades Taken in College	r =.48	Mattern, Patterson & Kobrin (2012)
Writing Scores on SAT Exams and First-Year English Course Grades Taken in College	r =.37	Mattern, Patterson & Kobrin (2012)
Critical Reading Scores on SAT Exams and First-Year English Course Grades Taken in College	r =.33	Mattern, Patterson & Kobrin (2012)
Income and Educational Level in the U.S.	r = .40	Kahneman (2011: p. 181)
Intelligence and Income (meta-analysis)	r = .20	Strenze (2007)
Intelligence and Job Performance	r = .51	Strenze (2007)
Intelligence and Education (meta-analysis)	r = .56	Strenze (2007)
Intelligence and Occupation	r = .43	Strenze (2007)
Permanent Income (average income from about age 25 to 55) and IQ	r = .40	Jensen (1998) and Dalliard (2016)
IQ at age 11 with IQ at age 90	r = .54	Resnick (2017)
Corporate Success and Abilities of the CEO	r = .30	Kahneman (2011: p. 205) also Fitza (2013). Success is often due to luck, not talent.
Employee Engagement and Voluntary Turnover Rate	r = -.43	Kruse (2012)
Predictions About Economy Made by CFOs and actual S&P Returns	r = 0	Kahneman (2011: p. 261). Used to demonstrate "An unbiased appreciation of uncertainty is a cornerstone of rationality—but is not what people and organizations want."
Simple Algorithm Developed by Ashenfelter and Future Price of Wine	r = .90	Kahneman (2011: p. 226). Used to demonstrate the superiority of simple algorithms than predictions by experts.
Student Fitness Scores (based on FITNESSGRAM® and Scores on Academic Achievement Tests	r = .54	Welk (2009)
Student Fitness Scores and Attendance	r = .52	Welk (2009)

Attendance and Academic Performance in Nigerian Secondary Schools	$r^2 = .22$	Oghuvbu (2010)
Attendance in College and GPA	r = .41	Credé, Roch & Kieszcynka (2010)
Student Fitness Scores and Number of Disciplinary Incidents	r = -.52	Welk (2009)
Time Spent on Social Networks and Psychological Well Being (self-esteem, life satisfaction, loneliness, and depression) (Meta-Analysis of 67 different studies)	r = -.07	Huang (2017)
Voting for Trump in 2016 and Prescription Opioid Use (n = 693 counties)	r = .42	Goodwin, Kuo & Brown (2018). Used to show that "Support for the Republican candidate in the 2016 election is a marker for physical conditions, economic circumstances, and cultural forces associated with opioid use."
Home Runs and Team Winning Percentage	r = .418	Prusaczyk (2016)
Fielding Percentage and Team Winning Percentage	r = .647	Netezza (2013). It might be more important for a team to focus on defense than hiring home run hitters.
Creative Thinking and Critical Thinking	r = .24	Ulger, K. (2016). The relationship between creative thinking and critical thinking skills of students. *Hacettepe University Journal of Education*, 31(4), 695-710.

GOOGLE CORRELATE – A TOOL FOR STUDENTS AND EDUCATORS

Google Correlate (https://www.google.com/trends/correlate) is a tool that can help students better understand correlation. It can be used to find search terms that have a similar time-based or regional search patterns to the term that you provide. Google Correlate allows one to compare US states, Compare weekly time series, or compare monthly time series. The following terms correlated with "quit smoking":

***Correlated with** quit smoking*

1. 0.8492 stop smoking
2. 0.8267 nicoderm
3. 0.8089 free weight
4. 0.8081 walt disney world
5. 0.8044 free weight loss
6. 0.8037 diet tips
7. 0.8035 weight watcher recipes
8. 0.8029 nicoderm cq
9. 0.7983 health and fitness
10. 0.7968 free calorie
11. 0.7964 ball exercises
12. 0.7963 free calorie counter
13. 0.7963 low fat
14. 0.7951 bridal shows
15. 0.7945 online diet
16. 0.7942 free diet plans
17. 0.7933 smoking help
18. 0.7904 free online diet
19. 0.7882 exercise log
20. 0.7879 dieting tips

REGRESSION TO THE MEAN – A DEVICE FOR PROPERLY UNDERSTANDING CORRELATION

Many incorrect causal interpretations are due to the regression to the mean phenomenon. Sir Francis Galton first observed this when comparing the heights of children with the heights of parents. Thus, if parents were extremely tall, their children would tend to be tall, but they would not be as tall, i.e., there would be a regression towards the average height. The same is true when both parents are very short. The height of their children would move towards the mean. In the words of Galton: "The mean filial regression towards mediocrity was directly proportional to the parental deviation from it" (cited in Kahneman, 2011: p. 179). If the correlation between the heights of parents and children were perfect and there was no random factor (e.g., luck) involved, then we would not have regression to the mean. Kahneman (2011: p. 181) states this succinctly: "Whenever the correlation between the two scores is imperfect, there will be regression to the mean."

Kahneman (2011: pp. 176-183) provides several interesting examples of errors of intuitive prediction that result from not taking regression to the mean into account. The so-called

"*Sports Illustrated* jinx" — i.e., that athletes who have an unusually successful season and land on the cover of *Sports Illustrated* then tend to have a less successful season the following year — is exactly what we would expect because of regression to the mean. Luck always plays a role in success (this is why the correlation between performance from season to season is not perfect). It is highly unlikely that an athlete who has a superb year and hits, say, 73 home runs in one baseball season will then hit 73 home runs in the following baseball season.

Kahneman (2011: pp. 183-184) also demonstrates the problem of regression to the mean with the following example: "Depressed children treated with an energy drink improve significantly over a three-month period." One should expect that children who deviate greatly from the mean when it comes to mental health will improve three months later no matter what they do. They can eat three green lollipops a day, and we should see improvement because of the regression to the mean phenomenon. The improvement will come regardless of what the children do.

Thus, the fact that "Highly intelligent women tend to marry men who are less intelligent than they are" is not surprising. There is no profound explanation of this other than regression to the mean. This results because the correlation between the intelligence of spouses is less than one. As Kahneman concludes: "Then it is a mathematical inevitability that highly intelligent women will be married to husbands who are on average less intelligent than they are (and vice versa, of course)" (Kahneman, 2011: p. 182).

CONCLUSION

Karl Popper made scientists realize how science is supposed to work. He said: "No number of sightings of white swans can prove the theory that all swans are white. The sighting of just one black one may disprove it" (James, 2002; Popper, 1963). The way science works is that scientists are supposed to look for black swans to disprove the existing theory, not try to confirm their beliefs by looking for additional support (white swans). The same type of approach can be used to explain correlational studies. If a correlation coefficient is 1 or -1, this means that there is a perfect relationship between the two variables. For example, suppose the correlation between IQ and income was 1, this is equivalent to saying that all swans are white. All one has to do to refute the statement is finding one individual with a low IQ making a great deal of money. A correlation of, say, .7 between attendance and GPA in college would be equivalent to saying that

swans tend to be white. Finding a black swan would not refute the finding. Of course, we noted above that the correlation between attendance in college and GPA was only .41. This means that there will be a great number of exceptions. Students will be able to understand this since they can provide their own examples where they did well in courses which they barely attended and did poorly in courses in which they never missed a class. They will probably know students whose SAT scores were quite low and have high GPAs. The best way to truly understand correlation is to work with real data, not made-up numbers.

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WHY AMERICAN SENTIMENT BELIEVES THAT HIGHER EDUCATION IS NOT HAVING A POSITIVE IMPACT ON THE COUNTRY AND POSSIBLE SOLUTION(S)

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Abstract

Does higher education have a positive impact on the United States? According to a recent poll, most Americans feel the answer is "no." This is largely due to the fact that the perceived purpose of college education has shifted in the past century from teaching ethics, morality, and values and acquiring a philosophy of life to acquiring the skills necessary to succeed in a career. Acquiring the right skills for professional success would require completing the right courses. Courses that are more concerned with indoctrination and exacerbating the culture of victimhood are of little value to students today. This paper describes the type of courses that have little value in the knowledge economy and instead are more concerned with teaching disciplinary elitism, "victimhood" politics, and biased thinking. In order for institutions of higher education to have a positive impact on society, they must ensure that both social and technical courses provide necessary skills to succeed in a knowledge economy.

Keywords: skills gap, critical thinking, lifelong learning, disciplinary elitism, and certainty bias.

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Introduction

Does higher education have a positive impact on the United States? One would think that almost every American would answer in the affirmative to this question. However, a Pew Research Center survey conducted in Summer 2018 found that the majority of Americans believe that higher education is headed in the wrong direction (Jaschik, 2018). Both Democrats and Republicans are concerned about higher education but for different reasons. Democrats are more troubled than Republicans about the fact that tuition costs are too high (92% vs. 77%, resp.); Republicans are bothered by the fact that "professors are bringing their political and social views into the classroom." (79% of Republicans vs. 17% of Democrats). The majority of Democrats and Republicans (56% and 73%, resp.) feel that "Students are not getting the skills they need to succeed in the workplace" (Jaschik, 2018). The prevalent issue that colleges and universities are more concerned with indoctrination than teaching keeps arising.

Abrams (2018) studied "student-facing" administrators that were being hired by institutions of higher education. Student-facing administrators are those whose jobs concern the character and type extracurricular experiences (events, conferences, lectures, etc.) students have on campus. He found that the ratio of liberal to conservative college administrators was 12:1; the ratio of liberal to conservative professors is 6:1; and the ratio for incoming first-year students was less than 2:1. He concluded: "It appears that a *fairly* liberal student body is being taught by a *very* liberal professoriate – and socialized by an *incredibly* liberal group of administrators" (Abrams, 2018).

A hotly debated question by educators deals with the purpose of education. Is it for: (1) acquiring skills for a career, i.e., the commercial purpose; (2) acquiring a philosophy of life and intellectual/cognitive stimulation (the cognitive approach); or (3) acquiring values, morals, and ethics (Brooks, 2014a)? One possible answer to this question is that higher education can provide all three if it focuses on the right kind of skillset. There was a time when all educators would have agreed that the purpose of higher education was to teach morals and values. After all, many schools were founded by religious institutions and orders. By 1971, however, 75% of college freshmen felt that the key purpose of higher education was to develop a "meaningful philosophy of life". Forty years later, by 2011, there was a dramatic change and almost 80% of freshmen stated that the purpose was to become "very well off financially" (Berrett, 2015; Fischer &

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Friedman, 2015). This may explain why enrollments at liberal arts colleges are declining. One member of a liberal arts college's Board of Trustees stated: "These are tough times for liberal-arts colleges, and unless you come up with something unique you're not likely to survive" (Biemiller, 2016).

A recent poll found that only 37% of people indicated that they would go to a college or university to acquire additional skill sets if they lost their job to a machine (Green, 2018). This is an ominous statistic given that an Oxford University Study predicted that about 50% of Americans would lose their jobs to computers over the next 20 years (Green, 2018). There are some, including President Trump, who feel that vocational schools should replace community colleges (Green, 2018). Another disturbing trend is that a significant number of middle-class families are sending their children to community colleges rather than four-year schools in order to save money. Indeed, students are saying that they are "getting a great education at a fraction of the cost" (Spencer, 2018).

An increasing number of students are enrolling in colleges in order to acquire additional skills to utilize in the workforce. However, many college graduates cannot find appropriate jobs (especially in local businesses) since the institutions are not providing them with sufficient necessary skills – the "skills gap" (Berrett, 2017). Berrett (2017) states:

> Though the idea may hold intuitive appeal, its very existence has been questioned, and it has been plagued by fuzzy definitions. It's not always clear which skills, specifically, are lacking. Sometimes they're technical ones, like managing a robotics operation on a factory floor or using Excel in a cubicle. Sometimes it's so-called soft skills, like critical thinking or communicating well. Other times, the skills gap refers to dispositions like work ethic, persistence, or the ability to collaborate as part of a team (Berrett, 2017).

According to Jason A. Tyszko, executive director of the Center for Education and Workforce at the U.S. Chamber of Commerce Foundation, employers are complaining primarily about deficiency when it comes to soft skills. However, employers also complain about prospective employees' lack of punctuality and even their inability to pass a drug test (Berrett, 2017). Other important skills desired by employers include adaptability and lifelong learning.

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This is particularly vital in today's society as technology and globalization are rapidly changing how businesses operate (Friedman and Kass-Shraibman, 2016). Any firm can suddenly become obsolete because of "technology, globalization, or consumer-driven expectations." Many sizeable and established corporations, such as Kodak, MySpace, A&P, Toys 'R Us, Netscape, Blockbuster, and Sears have gone bankrupt. Firms and employees cannot have a "factory mindset oriented to economies of scale" if an organization is going to thrive.

Berrett (2015) asserts that Ronald Reagan may have triggered a major swing in the public's view of higher education, a shift from intellectual to vocational. On February 28, 1967, he stated that "there are certain intellectual luxuries that perhaps we could do without"; he audaciously asserted that taxpayers should not be "subsidizing intellectual curiosity." Since then, many politicians have stated unequivocally that higher education focuses on skills for a career. Thus, in 2011, Governor Rick Scott of Florida asserted: "If I'm going to take money from a citizen to put into education, then I'm going to take that money to create jobs. Is it a vital interest of the state to have more anthropologists: I don't think so." Governor Pat McCrory of North Carolina made a similar statement in 2013 about gender studies. Even President Obama made a remark that seemed to disparage art history as a major when compared to practical majors in the trades and skilled manufacturing (Berrett, 2015). Scott Walker of Wisconsin created a furor with his Wisconsin Idea to replace the University of Wisconsin's mission from "search for truth" to "meeting the state's work-force needs" (Evans, 2015). He subsequently backed off and claimed that the Wisconsin idea was a "drafting error" (Spicuzza, 2015).

Governor Bevin of Kentucky also wants to change how colleges are compensated because he believes that there are too many liberal arts majors and not enough majors in science and technology areas. On January 26, 2016, he stated the following when delivering his proposed budget: "All the people in the world that want to study French literature can do so; they are just not going to be subsidized by the taxpayer like engineers" (Kelderman, 2016).

Major stakeholders in education, ranging from students to elected officials, view the purpose of a college degree as an important stage of acquiring the necessary skills to succeed at a career. Some majors such as engineering or accounting are viewed as satisfying that requirement; other majors such as French literature, anthropology, and art history are not. The focus of education is shifting to the set of skills a potential employee possesses (Fischer & Friedman, 2015; Weinreich, 2014). Indeed, what matters to a significant number of companies is not how

many degrees one has but how much knowledge one has acquired. For example, Google is moving away from "traditional metrics" (such as G.P.A.) in gauging the value of a potential employee, and instead seeking soft skills that are rarely taught in a college setting, including "leadership, humility, collaboration, adaptability, and loving to learn and relearn," (Friedman, 2014, Weinreich, 2014). Companies are shifting focus away from seeking employees with merely college degrees, but rather employees that possess relevant skills, expertise and knowledge.

Short-term, work-related certificates, a type of "stackable credential" are increasing in popularity since they are a simple way to demonstrate that one possesses a skill (Mangan, 2015). Large companies such as Adobe, Google, and Microsoft offer certifications that are of great value in the IT industry. Employers may find that individuals possessing certificates indicating specific computer skills may be of greater value to their organizations than "geniuses" with a computer degree from a top university (de Botton, 2015).

The focus on skills may help explain why competency-based education is the latest mantra in education. Competency-based education measures how much was actually learned, as opposed to how much time was spent in a classroom. The old equivalent of fifteen hours to one credit makes little sense when many courses are offered fully or partially online. Moreover, competency-based education focuses on the individual. People learn at their own pace and take as much time as they need to master the necessary knowledge and skills. Credentials are not time-based.

> The most important characteristic of competency-based education is that it measures learning rather than time. Students progress by demonstrating their competence, which means they prove that they have mastered the knowledge and skills (called competencies) required for a particular course, regardless of how long it takes. While more traditional models can and often do measure competency, they are time-based -- courses last about four months, and students may advance only after they have put in the seat time. This is true even if they could have completed the coursework and passed the final exam in half the time. So, while most colleges and universities hold time requirements constant and let learning vary, competency-based learning allows us to hold learning constant and let time vary (Mendenhall, 2012).

An important reason for this new approach to education is to find a more accurate way to measure what students have learned. Sitting in a classroom for 45 hours does not necessarily

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guarantee that much learning took place. In addition, there has been a great concern with the rising cost of a college degree. It is hoped that competency-based education will make college more affordable. Professional certificates are one example of competency-based education; to earn a certificate, one must demonstrate competency in an area rather than demonstrate amount of time spent in a classroom. The same kind of tests used to measure competency in traditional classes may be used with certificate programs.

Alssid (2016) indicates "It's becoming increasingly clear competencies are key to aligning education and training with actual business needs." As of September 2015, approximately 600 colleges are involved with competency-based education programs. The kind of competencies that have to be built into courses are "definable, measurable, and have the longest shelf life so that employees and employers see tremendous value from their investments" (Alssid, 2016).

There is a concern that the United States is losing its edge as a world leader in educating its citizens as students are graduating with few marketable skills (Fischer, 2013; Blow, 2011; Arum & Roksa, 2011; Lee, 2010). Anne Neal, president of ACTA (American Council of Trustees and Alumni) avers: "College tuitions have risen more than 440% over the last 25 years—and for what? The students who say that college has not prepared them for the real world are largely right" (McGurn, 2011:1).

The Programme for the International Assessment of Adult Competencies (PIAAC), of the Organisation for Economic Co-operation and Development (OECD) tests the literacy and math skills of graduates in OECD member countries throughout the world. Literacy is defined as "the ability to understand and use information from written texts in a variety of contexts to achieve goals and develop knowledge and potential." The results show how weak American college graduates are when it comes to math and problem solving skills: only 18% score at the top two levels of numeracy. American college graduates are, at best, mediocre when it comes to literacy (Carey, 2014). The OECD (2015:14) report highlights the idea that five of the ten targets to improve quality of education have the purpose: "to ensure that they [students] acquire better and more relevant knowledge and skills."

Augustana College's has been a pioneer in this area and views individual courses not as self-contained pursuits of knowledge but rather as part of an overall program to teach critical skills, referred to as learning outcomes. Each course taught at the college is required to serve at

least one of nine distinct learning outcomes. Even a golf course is taught with two learning outcomes (ethics and leadership) in mind (Berrett, 2014). New models for creating universities to provide relevant knowledge and skills are being developed. Christine Ortiz, a Dean at the Massachusetts Institute of Technology, is leaving her job to start a new kind of institution of higher learning that "will have no majors, no lectures, and no classrooms." She also adds that there will be no departments – everything will be transdisciplinary. All knowledge acquisition will be done using online materials (Young, 2016).

What Skills do Employers Seek?

What are the main skills employers seek from prospective employees? Disciplinary knowledge is essential. Each professional must be competent in the knowledge related to the profession (accountants must know accounting, attorneys need to know law, etc.). However, there are a number of general skills that are often overlooked. According to Vozza (2016), "Sought-after people have a good mix of hard and soft skills, and those skills are always changing because today's business climate is in constant flux." The American Management Association affirms that the key skills needed for success are the 4Cs: communication, collaboration, creativity, and critical thinking (AMA, 2012). The National Education Association (NEA) came up with the same four when identifying the key skills to achieve success in college as well as one's future career (NEA, n.d.). The NEA wants to ensure that K-12 education stresses these vital skills as well.

We live in the Knowledge Economy and the Internet Age; creativity and adaptability are crucial skills. The firms that will survive will be resilient, agile, nimble, flexible, and innovative (Raphan & Friedman, 2014; Friedman & Lewis, 2014). In 2009, *The Economist* surveyed 349 executives from all over the world. Ninety percent of them identified *organizational agility* as a "core differentiator in today's rapidly changing business environment" (Economist Intelligent Unit, 2009).

It is not only the organization that has to be agile; employees also have to possess the ability and willingness to adapt to changing business conditions. The correlation between creative thinking and critical thinking is weak because they are two different ways of examining a problem; it is between .25 and .30 (Harris, 2010). Clear thinking requires both critical and creative thinking skills. Harris says:

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> In the process of brainstorming a solution to a problem, it is undeniable that both critical thinking and creativity are necessary and complementary. In many ways, creative thinking can be considered divergent thinking. It is the process by which we generate new ideas, imagine possibilities, and find relationships among seemingly unrelated concepts. Therefore, Critical Thinking would be the convergent process where we narrow down which of those new ideas will work best given realistic constraints and resources (Harris, 2010).

Fischer & Friedman (2015) add two more C's that are essential in the current workforce: character (which includes integrity and having a positive attitude) and curiosity (this includes a passion for lifelong learning) and provide evidence showing the importance of each of the C's. Vozza (2016) also lists a "willingness to learn" as an important skill for job-seekers. Character includes possessing the right attitude. One survey found that 85% of employers felt that it was difficult to find employees with a positive attitude. These firms felt that it was crucial to find personnel with a "positive attitude and empathy" (Millenial Branding and Experience, Inc., 2012).

Scandinavian companies such as Ikea and Skanska have been leaders in recognizing the importance of ethics as a strategic differentiator, particularly in recruiting high quality employees (Brezinski, 2014; Bartlett, Dessain, and Sjoman 2006). Johan Karlstrom, CEO of Skanska, says about his employees: "They ask about diversity, environmental aspects and business ethics. These are the things that matter to them and the way to attract top talent" (Brezinski, 2014).

Brooks (2014b) observes that "Capitalism on its own breeds people who are vaguely aware that they are not living the spiritually richest life, who are ill-equipped to know how they might do so…" Brooks concludes that capitalism without spiritual values such as ethics, integrity and compassion results in a corrupt, cruel and unforgiving society. Several other studies have been conducted to determine the essential skills needed by graduates to succeed (Biemiller, 2016; Vozza, 2016; Adams, 2014; Berrett, 2014; Friedman, Friedman, and Hampton-Sosa, 2013; Moss, 2012). There are those that feel that leadership is an essential skill and should be taught in colleges. Agnes Scott College, a liberal arts college for women in Georgia, was experiencing difficulties with low enrollments. They surveyed female high school students and found that two concepts that resonated with prospective college-bound students were leadership and global awareness. They revised the curriculum to emphasize these areas, and enrollments consequently rose (Biemiller, 2016). Many of the above-mentioned skills will also help produce effective

leaders and can be taught in a manner that emphasizes how these skills are necessary for leadership. In fact, the faculty at Agnes Scott felt that five skills were essential for effective leadership: teamwork, critical thinking, writing, public speaking, and digital literacy (Biemiller, 2016).

This paper suggests that courses that teach the above skills are of value to students not only in the workplace, but in life. Indubitably, students should avoid courses that provide no skills or the wrong type of "skills." This paper will focus on what types of courses colleges should not be teaching.

Signs of a Course of Dubious Value

Agenda Courses Whose Purpose is to Indoctrinate

In the former Soviet Union, students took required courses in atheism. These kind of courses are not meant to teach critical thinking; students are expected to parrot what the instructor taught. At many American universities, instructors are intended to teach subjects but are in effect proselytizing. Educators mock junk science since it is not evidence-based but are not as hard on junk social science. There are ideologues on both the left and right that try to promote research without solid supporting evidence.

Some of the theories of economics, e.g., *homo economicus or* 'rational man', are taught as though they are irrefutably true, i.e., a rational man acts only in his self-interest. However, Asch & Gigliotti (1991) posit that "by equating rational behavior with free riding, economists might be proselytizing rather than educating." More than 40 years ago, Robinson (2007) complained that the pursuit of self-interest has caused much harm to society and Adam Smith should not be associated with this doctrine. What Smith actually believed was that "society, however, cannot subsist among those who are at all times ready to hurt and injure one another." Raw self-interest without a foundation of morality is not what this doctrine is all about. Robinson ended a commencement address with the following warning: "I hope … that you will find that the doctrines of Adam Smith are not to be taken in the form in which your professors are explaining them to you" (Robinson, 2007).

Numerous studies demonstrate that people are not rational; what they seem to be is predictably irrational (Ariely, 2008; Thaler & Sunstein, 2008). Nouriel Roubini, a prominent economist (better known as Dr. Doom for predicting the housing market collapse in 2006), stated

that "The rational man theory of economics has not worked" Ignatius, 2009). This is why individuals sometimes have to be encouraged to do what is in their own self-interest (Thaler & Sunstein, 2008).

After the Enron debacle, Alan Greenspan, then-Chairman of the Federal Reserve, voiced his concern of how easy it was for CEOs to "craft" financial statements in ways that could deceive the public. He declared: "There's been too much gaming of the system. Capitalism is not working! There's been a corrupting of the system of capitalism" (Suskind, 2008). Apparently, Greenspan did not truly understand Adam Smith. Smith never believed in unregulated capitalism. Several years later, Greenspan, not heeding his own words, nearly allowed the entire financial system to collapse by trusting the financial institutions would take "appropriate" levels of risk. Instead, executives risked the viability of their banks and firms, by taking on huge amounts of risk via the sale of toxic, subprime mortgages and credit default swaps.

Daniel Kahneman, Nobel laureate and behavioral economist, feels that Alan Greenspan did not foresee the housing crash because of his mistaken belief in the rational man theory. Greenspan himself admitted to Congress: "I made a mistake in presuming that the self-interests of organizations, specifically banks and others, were such that they were best capable of protecting their own shareholders" (Ignatius, 2009). Rogeberg (2004) states that the "silliness of theories such as rational addiction theory raises the question of how they can be taken seriously." McSweeney (2008) argued that the goal of maximizing shareholder value (MSV) as a way to improve economic efficiency was not evidence-based; moreover, MSV did not benefit society and only helped increase income inequality. MSV as a business philosophy "reflects and reinforces the growing power of an increasingly assertive financial elite" McSweeney (2008). Yau & Brutoco (2012) maintain:

> More shareholder value has been destroyed in the pursuit of profits in the name of shareholder value maximization than for any other reason. In fact, shareholder maximization not only failed to occur in the run-up to the Great Recession from 2008 to 2009, but shareholder value was destroyed on a massive scale while societal costs were created that will be borne by the next several generations.

Courses that Promote Disciplinary Elitism

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Déformation professionelle is a cognitive bias that comes from the tendency to view the world in a narrow way and through the eyes of one's discipline or profession (Friedman, 2017). People suffering from this see the world in a distorted way and not as it really is. The quote from Mark Twain saying that "to a man with a hammer, everything looks like a nail" is reminiscent of this bias. This is similar to what Friedman & Friedman (2009) refer to as disciplinary elitism. The organization by academic departments in institutions of higher education encourages academics to think myopically in terms of the discipline. As a result, academics often have little respect for other disciplines. There is often tension between economists and sociologists who have a differing approach to problems such as crime and poverty.

Karlgaard & Malone (2015) feel very strongly that to compete in today's global economy, it is essential for a CEO to build effective teams. As there are a limited number of jobs where people work alone, the ability to be part of a team and collaborate with others – even those from other areas – is vital. A silo mentality occurs when groups or different departments in an organization refuse to share knowledge. To succeed in today's economy, people from different departments within a firm must collaborate and share information. As Don Tapscott (2013), author and futurist, notes:

> Collaboration is important not just because it's a better way to learn. The spirit of collaboration is penetrating every institution and all of our lives. So learning to collaborate is part of equipping yourself for effectiveness, problem solving, innovation and life-long learning in an ever-changing networked economy (Tapscott, 2013).

Good corporate leaders are engaging in silo busting; it has become important in management today because silos breed tribalism (Tett, 2015). Indeed, organizations that get too large often find themselves with rigid silos and consumed with turf battles.

Academic departments have become "silos" in their promotion of disciplinary elitism. Many encourage the belief that one discipline is superior to others and can provide all the answers. Most organizations require collaboration among different areas to flourish. In academe, however, it is not unusual for faculty members in one discipline to disrespect those of another discipline. This contempt often results in a tension between disciplines such as economics vs. finance; sociology vs. economics; liberal arts vs. business; sociology vs. psychology, etc. Consistent with the "us vs. them" battles in other arenas of human endeavor, the *us* often becomes narrower and more specific and the *them* larger, and so with time, the battles trickle down to sub-disciplines: computer scientists vs. MIS faculty; theoretical mathematicians vs.

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applied mathematicians; and theoretical philosophers vs. applied philosophers (Friedman, Friedman & Frankenstein, 2013).

Cowie (2016) contends that economics has become an insular discipline and the least likely to cite researchers from other areas. Cowie cites research using the prisoner's dilemma game that demonstrates that economics majors become less cooperative when they are ready to graduate than students from other majors. He speculates that this may be due to the reliance of economic theory on the principle of self-interest. Cowie states:

> Many economists are among the smartest people on campus, and I enjoy listening to them reason. But the fetishization of mathematical modeling, wrapped around the assumption of perfect markets and rational behavior, ends up being little more than a barrier to keep out the competition rather than an opening to the intellectual cooperation and collaboration that are sorely needed (Cowie, 2016).

Friedman, Friedman & Frankenstein (2013) affirm that:

> In a world culture that values diversity, no academic would propose that only white men (mostly dead) have made a significant contribution to the vast and ever-expanding body of knowledge. Similarly, we ought not tolerate the closed disciplinist who disrespects other academic disciplines. At the same time we should welcome open intellectual competitiveness and collaboration. These are the steps we need to take to get our house in order—for ourselves and for our external publics.

Friedman, Friedman & Frankenstein (2013) illustrate this concept by asking us to imagine a hospital staffed by disciplinary elitists where, say, the cardiologists believed that all sickness was related to heart problems; nephrologists felt that only the kidneys mattered; pulmonologists thought only lungs should be examined; etc. If this was not bad enough, each specialist would ridicule what others believed. Would you want to go to such a hospital? Some academics actually still believe that only their discipline can provide the correct answers. A student should take courses in departments and from faculty who take an interdisciplinary approach to knowledge. Solutions to many problems require that people from several specialties work together.

Taylor (2009) was concerned that the modern university had ever-increasing specialization and scholarship that was too narrow. Taylor believed that the modern university had to be completely restructured. He felt that departments should be abolished and, instead, colleges should create problem-focused programs. He wanted these programs to have a sunset

clause so that they could be revisited every 7 years and a decision made whether to keep them, change them, or close them. Programs that are problem-focused might include energy, water, money, body, conflict resolution, etc. Thus, a water program would require experts from many areas including the natural sciences, business, law, medicine, and social work. In Taylor's words: "Through the intersection of multiple perspectives and approaches, new theoretical insights will develop and unexpected practical solutions will emerge."

As disciplines converge, it is becoming clearer that interdisciplinary courses and programs may be more beneficial and intellectually stimulating than uni-disciplinary ones. A time may come in the not too distant future when employers will avoid students that have been trained to believe that the solution to a problem always lies in one discipline.

This may explain why students try to maximize the number of skills they pick up in college by having multiple majors. Friedman, Friedman & Amoo (2003) discuss the increase in the number of students with more than one major, and posits that it appears to result in higher salaries over the long run. This may be due to the increase in skills if the majors are very different. At Stanford University, a new major combines computer science (CS) with any of 14 disciplines in the humanities; it is known as CS + X. Thus, students may major in, say, CS + music. This is quite reasonable given that computer music has been around for quite a while (Ruff, 2016).

Courses that Promote "Victimhood" Politics, Grievances, and Tribalism

There are educators that feel that courses in diversity are not needed and have no impact. Some feel that ethnic studies encourage tribalism and do not help society (Eggington, 2018). However, if these courses are taught correctly, they provide the necessary skills that both individuals and leaders need to succeed in a pluralistic society (Brown, 2016). There is ample evidence that a company that wants to thrive in today's multicultural, global competitive environment must be serious about diversity and do everything possible to eliminate all kinds of discrimination, obvious and subtle (Friedman, Friedman & Leverton, 2016). Duarte *et al*. (2015) maintain: "Psychologists have demonstrated the value of diversity – particularly diversity of viewpoints – for enhancing creativity, discovery, and problem solving." Unfortunately, courses in diversity offered by colleges may have a deleterious effect.

Kaylan (2010) highlights a huge problem with many courses dealing with minorities:

> As we laud and empower minority cultures for their vibrancy, when do we (or they) get to point out their shortcomings? Here's what happens: the minority culturati blame their flaws entirely on the dominant culture and get a free pass on the flaws within their own tradition. Imagine Chicanos, in the current climate of education, being taught the history of Mexico and the history of the U.S. in tandem. Which one would be taught more self-critically? Which deserves to be taught more self-critically? Which would likely contain the greater amount of truth and transparency? One might point out that the grievances of Chicanos in America stem not from the country they chose to inhabit, but the one they chose to leave. How insulting to assume that minorities must be coddled and infantilized with ethnic cheerleading as a substitute for knowledge (Kaylan, 2010).

Kaylan (2010) points out that teaching any group that they are always infallible can have serious consequences. It negates critical thinking and can result in angry people who can never fit into society or the workplace. Kaylan (2010) makes the powerful observation that "Ethnic minorities resentful of America might be less inclined to act out if they had a clearer notion of how their own cultures had failed them in the first place." Ethnic/minority courses can be valuable and teach many of the above-mentioned skills but not when the purpose is to create resentful, angry and bitter people.

Jonathan Haidt co-founded Heterodox Academy to push for "viewpoint diversity" on campus (Goldstein, 2017). Heterodox Academy released a Guide to Colleges that provides ratings so that students know which campuses have diversity of thought and free speech. Haidt has been criticized for his absolutist stance on free speech which his critics feel "is at odds with the need for a diverse and inclusive university." Haidt believes that the new moral culture that is prevalent on many college campuses "values victims, prioritizes emotional safety, silences dissent, and distorts scholarship. It is a culture that undermines the university's traditional mission to pursue truth" (Goldstein, 2017). Haidt feels that colleges are responsible for exacerbating the culture of victimhood.

Haidt also believes that the list of "Sacred Victims" continues to grow. It now includes: Blacks, women, LGBT, Latinos, Native Americans, the disabled, and religious Muslims (Goldstein, 2017). He is predicting that the political dysfunction we are seeing together with the use of social media to portray the other side at its worst will ultimately lead to violence and hundreds will die (Goldstein, 2017). According to Haidt, about 70% to 75% of America is now in a protected group. It is difficult to be a candid, truthful social scientist when "you have to try

to explain social problems without saying anything that casts any blame on any member of a protected group. None of these groups can have done anything that led to their victimization or marginalization" (Leo, 2016). One group that is not on the Sacred List is the poor working class.

A hoax inflicted on several identity-oriented journals caused a big stir. Apparently, three authors were able to submit 20 papers in less than one year to several journals. Seven of the papers were accepted and four were published. These papers, written in two weeks, were pejoratively referred to as part of "grievance studies" (Schuessler, 2018). One paper had the title of "Human reactions to rape culture and queer performativity at urban dog parks in Portland, Oregon." This paper was published (and retracted after the hoax was revealed) in *Gender, Place & Culture*. Steven Pinker, renowned Harvard psychologist, remarked: "Is there any idea so outlandish that it won't be published in a Critical/PoMo/Identity/ 'Theory journal?" (Eggington, 2018). Eggington (2018) claims that the hoax demonstrates "how the drive to hyper-specialization that has become the rule in universities undermines the work the humanities should be doing for the healthy functioning of a pluralistic society." The authors themselves asserted that "scholarship based less upon finding truth and more upon attending to social grievances has become firmly established, if not fully dominant, within these fields" (Schuessler, 2018).

Courses that Create Angry, Unforgiving People

Compassion is a trait that can help a company succeed. Courses should stress the importance of compassion, empathy and caring rather than creating angry, unforgiving people. There is evidence that "compassion is good for the bottom line, it's great for your relationships and it inspires lasting loyalty. In addition, compassion significantly boosts your health." Moreover, "the more compassionate the workplace, the higher the performance in profitability, productivity, customer satisfaction and employee engagement" (Global Focus, 2016).

Held (2006) believed that justice is not enough, and society needs the value of caring. Based on this, she developed the philosophy of care ethics. This philosophy is less concerned about the ethics of justice and more about dependencies, relationships, and caring for those who are weak, helpless, vulnerable, and/or dependent. Moreover, a society cannot function properly if all that matters is economic gain. Held (1993: 228-229) stated: "Many enterprises would gain if they resembled families more and groups of hostile strangers less." Held believed that "the

markets are unable to reflect and actively advance values beyond the economic, such as mutually shared care and concern" (Hawk, 2011). Scholars have been applying care ethics to business (Ottino & Morson, 2016; Hamington & Sander-Staudt, 2011).

Grant's (2013) research on productivity and success demonstrates that the most successful people are "givers," caring people who enjoy helping others without requiring or expecting reciprocity. They help others without expecting anything in return; they have compassion for people and achieve happiness by helping them.

Vozza (2016) lists "effective conflict resolution" as a crucial skill for job-seekers in 2016. This skill may be seen as part of the ability to collaborate and be part of a team. Not everyone has the ability to disagree in a constructive manner. This is why courses must stress the importance of empathy, getting along with others, and listening to what they have to say.

Courses that Encourage Overconfidence and Biased or Passive Thinking

Critical thinking skills are vital to organizations. Critical thinkers are people who know how to solve problems because of the way they examine different points of view and have the ability to recognize underlying assumptions. Dyer (2011: 2) avows that "critical thinking is an approach to reading, thinking, and learning that involves asking questions, examining our assumptions, and weighing the validity of arguments." She adds that critical thinkers are "self-aware, curious, and independent. They introspect on their own thinking processes; they work at knowing their own biases and can name the strategies they are using when they make judgments (self-aware)." Critical thinkers develop virtues such as inquisitiveness, open mindedness, flexibility in considering alternatives and understanding others' opinions, fair mindedness, prudence in making or altering judgments, and a willingness to consider and revise views (Facione 2015). Individuals who are not critical thinkers suffer from passive thinking, group think, or biased thinking. They have no interest in considering other ideas, and some are even overconfident and arrogant.

Daniel Kahneman talks about "willful ignorance" which is a problem that results "when we know that there are other ideas out there, but we refuse to consider them" (McIntrye, 2016). Willful ignorance produces individuals who become so hardened in their positions that they even demonize people with other opinions. No amount of evidence will get people suffering from "willful ignorance" to change their mind. Eventually, this refusal to listen to other points of view

becomes denialism, and thus critical thinking is a vital skill (McIntrye, 2016). The hope is that individuals with critical thinking abilities will not fall into the trap of willful ignorance and will possess the capability of listening to other points of view.

Kahneman speaks of "adversarial collaboration" as an effective way to avoid confirmation bias which interferes with critical thinking. This occurs when researchers consciously or unconsciously design an experiment in such a way so as to provide support for a particular position (Matzke *et al*., 2013). Bringing together two researchers who disagree and having them conduct an experiment jointly often results in better and more accurate research (Matzke *et al*., 2013). The goal of adversarial collaboration is to discover the truth, not to win arguments (Kahneman, 2012). With critical thinking, the goal is to solve a problem in an honest way and not be unreceptive to new approaches and different opinions.

Bertrand Russell once said: "The whole problem with the world is that fools and fanatics are always so certain of themselves, but wiser people so full of doubts" (Chastain, 2017). Certainty together with overconfidence reduces one's ability to be a critical thinker. Kolbert (2017) highlights the fact that "People believe that they know way more than they actually do." This overestimation of the knowledge we possess is known as the overconfidence effect. Sloman & Fernbach (2017) also speak of the "knowledge illusion"; we simply do not understand how little we actually know. With certain kinds of questions, answers that people feel that their response is "99% certain to be correct" turn out to be incorrect 40% of the time (Kasanoff, 2017).

Lloyd (2017) also feels that moral certainty is dangerous. He posits, "History overflows with misery inflicted by well-intentioned people who were convinced that they had seen the only true moral values, and who sought to convert or destroy those who would not agree." His examples include the Inquisition which was based on the moral certainty of the Roman Church which was certain that only its interpretation of Christian scriptures was correct. Similarly, Stalin's Russia, Mao's China, and Hitler's Germany were totalitarian societies built on the belief that they knew the truth and anyone who disagreed had to be exterminated.

Lloyd (2017) avows:

> Two of the greatest achievements of Western Civilization are science and democracy. They have in common the admission of each person's own fallibility, which is psychologically a hard thing to do. In science, we must admit that our preconceived ideas about the external world might be

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> mistaken, and that we must carry out scientific experiments to determine the truth. In democracy, we must admit that our cherished values and political convictions might be wrong, and that society should be governed by the majority, albeit with safeguards for the rights of minorities (Lloyd, 2017).

If Sandel (2010) is correct in his assertion that Americans are so sure of themselves that they have lost the ability to have a "democratic argument," then we are in huge trouble. Indeed, a key reason for gridlock in Congress is the rise of hyperpartisanship and absolute certainty. Members of Congress have lost the ability to work with colleagues from another political party because they are so sure that they are right; bipartisanship can not exist in an atmosphere of absolutely certainty. Jouet (2017) believes that America is having a "meltdown" and has become extremely polarized. It is virtually impossible to compromise when one side is not only suffering from overconfidence and arrogance, but is also basing its arguments on myths and untruths. This is compounded if both sides suffer from these issues.

Industry also suffers from the problems of overconfidence and certainty. The relationship between predictions about the economy made by chief financial officers (CFOs) and Standard & Poor stock market returns is approximately 0 (Kahneman, 2011: p. 261). Kahneman uses this to demonstrate the dangers of overconfidence. He concludes that the so-called financial experts should have said: "There is an 80% chance that the S&P returns next years will be between -10% and +30%" (Kahneman, 2011: p. 262). Furthermore, Kahneman (2011: p. 263) notes that "An unbiased appreciation of uncertainty is a cornerstone of rationality — but is not what people and organizations want." Experts who want to keep their jobs have to act in a confident manner.

Lynch (2017) underscores the fact that the "defining trait of the age seems to be arrogance…the arrogance of thinking that you know it all and that you don't need to improve because you are just so great already." Lynch (2017) asserts that we all need intellectual humility. This is what colleges and universities should be teaching.

Conclusion

If institutions of higher education want to have a positive impact on society, they must ensure that courses provide necessary skills to succeed in a knowledge economy. These skills are both social and technical. Institutions of higher learning that want to improve the country will

have to transform themselves so that they will distance themselves away from courses that provide all the wrong skills. These include courses that stress disciplinary elitism, exacerbate a culture of victimhood, teach overconfidence and arrogance, and try to indoctrinate rather than teach critical thinking. Moreover, classes should not be politically lopsided and should encourage healthy, respectful debate. Students should be exposed to a diverse set of ideas, opinions and perspectives. Diversity actually makes us smarter and one should seek out people with different ideas (Phillips, 2014).

Most academics scoff at the words of Sir Roger Scruton because he is conservative. However, more and more people will agree with him if college and university courses ignore skills and focus instead mainly on indoctrination.

> The culture which has been entrusted to the universities to pass on is no longer passed on, because those charged with doing so no longer believe in it. The new curriculum is a curriculum of foregone conclusions… Nonsense is extremely useful, as I'm sure you've all realized, if you want to affect a major change in the culture. If you're speaking nonsense, nobody can correct you (Johnson, 2018).

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