NEDSI

NORTHEAST DECISION SCIENCES INSTITUTE

2020 NORTHEAST DECISION SCIENCES INSTITUTE CONFERENCE PROCEEDINGS

JUNE 3, 2020
NEDSI 2020 PROGRAM COMMITTEE

June 3, 2020

Dear colleagues:

When we began planning for the 2020 Northeast Decision Sciences Institute Conference many months ago, we could never have predicted how the COVID-19 pandemic would change our world in such a sudden and profound way. The theme of our conference at the start of this new decade was how the decision sciences could help businesses act with hindsight. Ironically, just a couple of weeks before the start of the conference we had to use our own hindsight and, with the full support and guidance from the Decision Sciences Institute and the NEDSI board, make the unprecedented decision to cancel the NEDSI conference due to the raging pandemic.

The safety and wellbeing of everyone involved guided our decision, which happened before the country entered the lock-down period. In retrospect, we know this was the right decision despite the very disappointing consequence of not being able to see all of you in person.

We are grateful for the hard work of everyone involved in creating the NEDSI programming and its proceedings, including all the track chairs and award organizers.

We hope you stay safe and well and we have no doubt that we will see you again in an upcoming conference.

With best regards,

Gang Li, Ph.D. and Euthemia (Effie) Stavrulaki, Ph.D.
Program Co-Chairs, NEDSI 2020
Associate Professors of Operations and Supply Chain Management,
Management Department

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Big Data, Business Analytics and Knowledge Management	**Matthew Liberatore**, Villanova University
Decision Making	**John Weber**, DeVry University
Information Systems and Decision Support	**Manouchehr Tabatabaei**, Georgia Southern University
Innovation and Creativity	**Carolyn Lamacchia**, Bloomsburg University
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Teaching and Innovative Education	**Handanhal Ravinder**, Montclair State University
Undergraduate Student Poster	**Jennifer Swanson**, Stonehill College **Douglas Hales**, University of Rhode Island

NEDSI 2020 Conference Best Paper Awards

David M. Levine Best Paper Award in Innovative Teaching

"Developing a Distinctive Consulting Capstone Course in Supply Chain Curriculum"

Christopher Roethlein (Bryant University),   Teresa McCarthy Byrne (Bryant University), John Visich (Bryant University),   Michael Gravier (Bryant University), and Suhong Li (Bryant University)

Richard Briotta Best Paper Award in Knowledge Management/Strategy

"Knowledge Flows in Alliances: An Antecedent to Partner Acquisition"

Simona Ileana Giura (SUNY Oneonta)

Bryant University Best Paper Award in Supply Chain Management and Logistics

"Supply Chain Resilience: An Adaptive Cycle Approach"

Henry Adobor (QUI)

NEDSI 2020 Conference Best Paper Awards (Cont.)

Best Contribution to Theory Award

"Synthetic Average Neighborhood Sampling Algorithm (SANSA): A Neighborhood Informed Synthetic Sample Placement Approach to Improve Learning from Imbalanced Data"
Murtaza Nasir (University of Massachusetts Lowell), Ali Dag (Creighton University), Serhat Simsek (Montclair State University), and Asil Oztekin (University of Massachusetts Lowell)

Best Application of Theory Award

"Improved Group Decisions for Hotel Selection in the Analytic Hierarchy Process"
Jin Fang (Drexel University) and Fariborz Partovi (Drexel University)

Best Overall Conference Paper Award

"Synthetic Average Neighborhood Sampling Algorithm (SANSA): A Neighborhood Informed Synthetic Sample Placement Approach to Improve Learning from Imbalanced Data"
Murtaza Nasir (University of Massachusetts Lowell), Ali Dag (Creighton University), Serhat Simsek (Montclair State University), and Asil Oztekin (University of Massachusetts Lowell)

Best PhD Student Paper Award

"Improved Group Decisions for Hotel Selection in the Analytic Hierarchy Process"
Jin Fang (PhD Student, Drexel University) and Fariborz Partovi (Advisor, Drexel University)

NEDSI LIFETIME SERVICE AWARD

Dr. Mark Davis

Bentley University

In recognition of a lifetime of service to NEDSI, DSI, and the Decision Sciences Community, we are delighted to announce that Dr. Mark Davis is the recipient of this year's lifetime service award. Dr. Mark Davis was the program chair of the 1992 NEDSI Conference in Boston and was subsequently elected as the NEDSI President the next year; he has been serving on the Board of Advisors since then. Dr. Davis has also served as Program Chair for the National DSI 2003 Annual Meeting and has been elected a fellow of the Institute in 2000 and President in 2005. In more than thirty years of service, Dr. Davis has helped shape the Northeast region of DSI into a thriving community of scholars and practitioners. Dr. Davis is also a world-renowned scholar in service operations research. A research paper he published in Decision Sciences was among the first to use operations management and marketing to examine how waiting for a service affects a customer's satisfaction. His research provided a framework for stores to provide better customer service. His widely cited research has been published in high-quality journals including The Journal of Operations Management, Decision Sciences, The Journal of Services Marketing, The Journal of Business Forecasting, Operations Management Review, Service Science, The International Journal of Production and Operations Management, The Euro-Asia Journal of Management, and The International Journal of Service Industry Management. He is the co-author of four books, including Operations Management: Integrating Manufacturing and Services, and Managing Services: Using Technology to Create Value.

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50th NEDSI Annual Meeting
Hershey, PA
March 25-27, 2021

MEETING ANNOUNCEMENT

The 2021 Northeast Decision Sciences Annual Meeting will be held March 25-27, in Hershey, Pennsylvania. The three-day conference will start on Thursday and continue through Saturday morning. All attendees are invited to the Welcome Reception and the President's Reception and Award Ceremony.

CALL FOR PAPERS

Full papers, abstracts, and workshops are invited for but not limited to the topic areas listed. Undergraduate students may submit proposals for Poster Sessions. Sessions involving practitioners will be given consideration. Submissions will be blind refereed and accepted papers will be published in the online Conference Proceedings. By submitting a manuscript, the author certifies that it is not copyrighted or previously published, has not been presented or accepted for presentation at another professional meeting, and is not currently under review for presentation at another professional meeting. At least one of the authors certifies that he/she intends to register for and attend the conference to present the paper if it is accepted.

All papers, abstracts, and undergraduate posters must be submitted electronically on or before December 15, 2020 via the conference website: www.nedsi.org. If you have proposals for workshops or roundtable discussions, please email to the program chair.

OUTSTANDING PAPER AWARDS

Outstanding papers are eligible for awards:
- Best Application of Theory
- Best Contribution to Theory
- Best Paper on Innovation or Sustainability
- David M. Levine Award for Innovative Education
- Best Student Papers

PROGRAM TRACKS

- Accounting, Finance, Economics
- Big Data, Analytics, and Knowledge Management
- Cyber Security, IT, and Emerging Technologies
- Decision Making: Public Administration and Policy
- DSS, Machine Learning, and Artificial Intelligence
- Education, Curriculum, and Cases
- Healthcare Analytics and Services Management
- Human-Technology Interface
- Innovation and Creativity
- Legal, Ethical, and Social Issues
- Operations Management/Operations Research
- Marketing and Consumer Behavior
- Strategy and Organizational Behavior
- Supply Chain Management and Logistics
- Sustainability Management
- Undergraduate Student Poster Competition

HOTEL ARRANGEMENTS

The host hotel is The Hershey Lodge. For reservations with the conference rate, a link will be made available on the conference website.

OFFICER NOMINATIONS

The NEDSI Nominations Committee welcomes nominations for board members and officers. Contact Douglas Hales, University of Rhode Island at dhales@uri.edu. NEDSI is the Northeast Regional Subdivision of the Decision Sciences Institute

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CONTACT INFORMATION

Dinesh R. Pai, 2021 NEDSI Program Chair, School of Business Administration, Penn State Harrisburg, Middletown, PA. drp18@psu.edu

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Accounting, Finance, Economics - Abstracts

A Lilliputian Economy in a Common Currency Area

Accounting, Finance, Economics

Dr . Theologos Homer Bonitsis [1]

1. *New Jersey Institute of Technology*

This research presents the theoretical foundations and potential empirical experience of a Lilliputian economy that enters a common currency area when its economy is divergent from the area's dominant economy. A divergent Lilliputian economy would face structural issues that would make it progressively non-competitive and prone to debt accumulation. Lilliputian policymakers would have a limited cache of pro-growth policy instruments available to implement, while short-term burdensome structural adjustments may be politically unacceptable as well as destabilizing. Such are the brass tacks for a Lilliputian economy in a common currency area, for it abdicates its policy choices for a currency commonage.

A study of the impacts of firms' financial leverage on their stock performance

Accounting, Finance, Economics

Dr . Zhixin Kang [1] *, Dr . Edwin Mensah* [1] *, Dr . Rebecca Gonzalez-Ehnes* [1]

1. *University of North Carolina at Pembroke*

In this research, we study firms' financial leverage on their stock performance. Specifically, we use the buy-and-hold stock returns as the dependent variable, and firms' financial leverage ratio as the independent variable by controlling for three other factors, namely firms' size, growth, market-to-book ratio, in a regression model to capture and test the impacts. We consider four different data time windows in this study. We find that in the four different time windows, the impacts of financial leverage on stocks' returns are quite different.

A Summary of CAM (Critical Audit Matter) Disclosed by Large Accelerated Filers for the New Expanded Auditor's Report

Accounting, Finance, Economics

Dr . Nathan Slavin [1], _Ms . Mingzhu Liu_ [2], _Dr . Jianing Fang_ [3]

1. _HOFSTRA UNIVERSITY ,_ **2.** _Hofstra ,_ **3.** _Formerly at Marist College_

On June 1, 2017, the Public Company Accounting Oversight Board (PCAOB) adopted a new auditor reporting standard, AS 3101: _The Auditor's Report on an Audit of Financial Statements When the Auditor Expresses an Unqualified Opinion._ One of the significant changes to the new standard relates to the auditor's communication of critical audit matters ("CAM"s). We will focus the first phase of the study on the accounting and audit topics disclosed by the auditors, considerations in determining the CAMs and the extent of the discussion around the audit response.

ADDITIONAL EVIDENCE ON THE INEFFECTIVENESS OF VOLUNTARY ACCOUNTING DISCLOSURE PROPOSALS: THE CASE OF THE SUSTAINABILITY ACCOUNTING STANDARDS BOARD'S PRONOUNCEMENTS

Accounting, Finance, Economics

Dr . A J Stagliano [1]

1. *Saint Joseph's University*

Sustainability concerns prompted the Securities and Exchange Commission (SEC) to issue interpretive guidance for registrants regarding disclosures related to financial risks. To complement regulatory mandates, the Sustainability Accounting Standards Board developed measurement methods and reporting guidelines for major sectors in the U.S. economy.

This study seeks to determine whether firms disclose their efforts at furthering sustainability. Data are gathered from 2008 through 2019 Form 10-K filings of every publicly traded SEC registrant in two cognate SIC Major Groups: #80—Health Services and #83—Social Services. Both quality and quantity of disclosure regarding sustainability are considered with a content analysis approach.

An Examination of Casual Relationships among the Existing House Market, Stock Market and the Mortgage Interest Rate by A Leveraged Bootstrap Causality Approach

Accounting, Finance, Economics

Dr . Kuo-Hao Lee [1]

1. _Bloomsburg University of PA_

The objective of this research is to examine the causal relationships among the behaviors of national existing-home sales price and volume, S&P 500 and the mortgage fixed interest rate. The result indicates that the change rate of the mortgage fixed interest rate causes significant movement of the S&P 500 index return and the volume of existing-home sales. Also, the stock market is driven by the performance of the price of existing-home sales. This finding provides a new vision to build an investment portfolio of real estate and stock.

An Exploratory Analysis of Wages and Employment in Business Professions

Accounting, Finance, Economics

Dr . Kelley Donalds [1]

1. Bridgewater State University

Employment and wages are important indicators of economic health. While U.S. population-level data are widely studied, less attention has been given to employment and wages within business professions. To fill this gap, this session presents a descriptive analysis of data from the Current Population Survey administered by the U.S. Census Bureau. Focusing on management and business specialist occupations, the analysis addresses how employment and wages have changed over time and how they differ across industry sectors and occupational groups. After presenting the exploratory results, a discussion will be facilitated to generate ideas for a future research agenda.

Analysts' Recommendation, Supporting Forecasts and Consistency

Accounting, Finance, Economics

Prof. Tao Li [1]
1. *SUNY New Paltz*

This study examines the consistency between individual analysts' stock recommendations and the supporting forecasts. The study introduces a probability-based consistency measure through a logit model that uses the Weight-of-Evidence of analysts' supporting forecasts as predictors. The study shows that supported recommendations are more effective than isolated recommendations and recommendations with higher consistency trigger even stronger market reactions. This recommendation consistency can be used to generate significant profit through a calendar-time portfolio strategy. Regulatory efforts that reduce analysts' conflicts of interest and over-optimism also make the consistency more informative.

Comparison Study of Portfolio Insurance Strategies: CPPI versus VTPI

Accounting, Finance, Economics

Ms . Olga Biedova [1]

1. *Bentley University*

We compare two portfolio insurance strategies: Constant Proportion Portfolio Insurance (CPPI) and Volatility Target Portfolio Insurance (VTPI), an option based portfolio insurance strategy with an embedded option linked to a Volatility Target portfolio. We rely on numerical simulations and use the main ideas of the stochastic dominance theory. The bootstrapping approach allows us to relax the assumptions on the risky asset price dynamics. We present an extended comparative quantitative analysis of strategy performances in various market scenarios and within a range of input parameter values.

Do State-Level Politics Have an Impact on Infant Health? An Empirical Investigation

Accounting, Finance, Economics

Mr . Charles Regan [1]

1. *Bentley University*

Existing evidence suggests that U.S. state-level political environments have profound impacts on the economic well-being of its residents through welfare distribution. I investigate whether governor or state legislature party affiliation has a causal impact on infant health, using births weight as a proxy and taking a random sample of 10,000 from every birth year from 1968 through 2012. My empirical strategy relies on a difference-in-differences approach and uses close gubernatorial elections to proxy a regression discontinuity design. I find no meaningful impact of party affiliation on infant health, neither from the gubernatorial nor legislative level, across all major racial groups.

DUAL-DYNAMIC RETIREMENT INCOME STRATEGY FOR BETTER RETIREMENT OUTCOMES

Accounting, Finance, Economics

Mr . Zefeng Bai [1], *Dr . Kai Wallbaum* [2]

1. *Bentley University ,* **2.** *Risklab GmbH, Allianz Global Investors*

Motivated by the persistent low expected return market environment, we propose a dual-dynamic retirement management strategy aiming at improving different retirement outcomes in a decumulation context. Utilizing a Monte Carlo simulation approach, the present study reveals that the dual-dynamic retirement strategy could significantly improve the survival rate of a retirement portfolio and provide more sustainable retirement coverage for retirees over a twenty-year hypothetical retirement span. Therefore, the dual-dynamic retirement solution that adjusts the asset allocation and the annual withdrawal rate simultaneously could be a new option for the retirement markets nowadays.

FINANCIAL REPORTING AND AUDITING REQUIREMENTS - SHOULD PRIVATE COMPANIES BE INCLUDED?

Accounting, Finance, Economics

Prof. Lynn Ruggieri [1], ***Prof. John McQuilkin*** [1]

1. *Roger Williams University*

The basic premise of IFRS (International Financial Reporting Standards) is the standardization and hence comparability of financial statements among companies domiciled in different countries. IFRS, however, is for publicly held companies. This paper examines the reporting requirements for publicly held companies and privately held companies throughout the world. This paper highlights the reasons for the substantial difference in financial and audit requirements. This paper further looks at a sample of privately held companies in terms of their impact on their host economies and makes a case for consideration of uniform reporting requirements for these companies.

Foreign Exchange Forecasting

Accounting, Finance, Economics

Dr . Augustine Arize [1], *Dr . Ioannis Kallianiotis* [2], *Dr . John Malindretos* [3], *Dr . Ike Ndu* [4], *Dr . Moschos Scoullis* [5]

1. *Texas A&M ,* **2.** *Economics and finance, university of Scranton ,* **3.** *William Paterson University ,* **4.** *Birkbeck, University of London ,* **5.** *Economics Department Kean University*

This paper evaluates various exchange rate models, considers their predictive performance effectiveness after applying parametric and nonparametric techniques to them, and chooses the exchange rate forecasting predictor with the smallest root mean square forecast error (RMSE). The autoregressive model in Equation (34) shows the most consistent evidence of being a better model, although none of the empirical evidence here gives us a wholly satisfactory forecast. The models' error correction versions will be fit so that reasonable long-run elasticities can be imposed on each model's fundamental variables.

MACROECONOMIC RISK AND HEDGE FUND RETURNS: REVISITED

Accounting, Finance, Economics

Dr . Scott Mackey [1]*, Dr . James Forest* [2]*, Dr . Michael Melton* [1]

1. *Roger Williams University ,* **2.** *University of Massachusetts, Amherst*

In this working paper we seek to improve return forecasts of directional and semi-directional hedge fund investment styles. We propose two major contributions. First, we employ modeling methods where both the model selection and factor selection are determined by both the time-varying macroeconomic/financial market environment and the hedge fund style return process. Second, we employ a unique database of macroeconomic variables representative of the actual information set available at the time fund managers made their investments. We believe that these contributions will provide better representations of the return generating process of certain hedge fund styles and lead to improved forecasts.

MNC Accounting Foreign Exchange Exposure: an Application

Accounting, Finance, Economics

Dr . Moschos Scoullis [1], Dr . Andrew Nyboga [2], Dr . John Malindretos [3], Dr . Demetri Tsanacas [4], Prof . Alfred Verrios [5]

1. Economics, School of Social Science, Kean University , 2. Accounting, taxation and Law, William Paterson University , 3. William Paterson University Wayne , 4. Economics, Finance and global business, William Paterson University , 5. economics finance and global business, William Paterson University

The first half of this paper will illustrate some background information on the translation form of foreign exchange exposure. The second half of the paper will
include a survey sent to over two hundred multinational companies who were listed in the Forbes 500 top multinational companies. This portion of the paper will include a copy of the survey itself, the cover letter that explained to the companies CFO what the purpose
of our survey was, and an explanation of my observations from the responses sent back to us.

MNC Operating Foreign Exchange exposure

Accounting, Finance, Economics

Dr . John Malindretos [1], Dr . Ikechukwu Ndu [2], Dr . Solomon Nyanga [3], Dr . alex panayides [4],
Dr . Demetri Tsanacas [5]

1. *William Paterson University Wayne ,* **2.** *Birkbeck, University of London ,* **3.** *Management and Marketing, william Paterson University ,* **4.** *economics finance and global business ,* **5.** *Economics, Finance and global business, William Paterson University*

The first half of this paper will illustrate some background information on the economic (operating) form of foreign exchange exposure. The second half of the paper will include a survey sent to over two hundred multinational companies who were listed in the Forbes 500 top multinational companies. This portion of the paper will include a copy of the survey itself, the cover letter that explained to the companies CFO what the purpose of our survey was, and an explanation of my observations from the responses sent back to us.

MNC Transactions Foreign Exchange Exposure

Accounting, Finance, Economics

Dr . Giuliana Campanelli Andreopoulos [1], Dr . John Malindretos [2], Dr . Demetri Tsanacas [3], Prof . Alfred Verrios [1], Dr . Moschos Scoullis [4]

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The first half of this paper will analyze the theory of the transactions form of foreign exchange exposure. The second half of the paper will include a survey sent to over two hundred multinational companies which were listed in the Forbes 500 top multinational companies. This portion of the paper will include a copy of the survey itself, the cover letter that explained to the companies CFO what the purpose of our survey was, and an explanation of our observations from the responses sent back to us.

MODELLING EARNINGS MANAGEMENT, CORPORATE GOVERNANCE, CAPITAL MANAGEMENT AND RISK USING DYNAMIC PANEL DATA ESTIMATION: THE CASE OF LISTED DEPOSIT BANKS IN AN EMERGING MARKET

Accounting, Finance, Economics

Dr . Ikechukwu Ndu [1] **_, Dr . Chiaku Chukwuogor_** [2] **_, Dr . Augustine Arize_** [3] **_, Dr . John Malindretos_** [4]

1. *Birkbeck, University of London ,* **2.** *Eastern Connecticut State University ,* **3.** *Texas A&M University-Commerce ,* **4.** *William Paterson University Wayne*

This study examines the relationship between earnings management, capital management, risk and corporate governance for listed Nigerian money deposit banks in the International Financial Reporting Standards (IFRS) setting. The methodology tests earnings management using Loan Loss Provisioning (LLP).

IFRS adoption and its interaction effects are not significant. The size of the board of directors and audit committee corporate governance variables are not significant in constraining earnings management. There is a significant positive association between the cost of capital adequacy violation and LLP. High risk banks appear to manage earnings to maintain lower levels of LLP relative to low risk banks.

TEACHING SUSTAINABILITY AND ENVIRONMENTAL AUDITING TO COLLEGE OF BUSINESS STUDENTS

Accounting, Finance, Economics

Dr . Carmen Quirvan [1]

1. *The University of Rhode Island*

Environmental topics have traditionally not been part of business students'college education. Climate change has required that all of us be aware of the consequences of the deterioration of the environment on the world and humanity. Because of the interaction and effect of businesses' operations on the environment, I argue that educating business students regarding sustainability, environmental auditing and companies cases will help to increase awareness of the necessity to improve financial statement disclosure of the climate change effects on companies' financial risk (in developed and developing nations).

Keywords: Sustainability, Environmental Auditing, Financial Statements, Financial Risk, Environmental Risk.

TECHNOLOGY-BASED AUDIT TOOLS IN NON-GLOBAL NETWORK FIRMS

Accounting, Finance, Economics

__Ms . Annie Witte__ [1]

__1.__ Bentley University

I investigate how in-charge auditors in non-global network firms engage in institutional work using technology-based audit tools to impact audit quality. Using semi-structured interviews through the lens of institutional theory, I identify factors that are associated with in-charge auditors' propensity to engage in institutional work, being actions that contribute to the development, continuance, and/or breach of established practices. Results reveal common motivators, resources, and outcomes of in-charges' institutional work impact audit quality at a process level. Implications for theory and practice suggest audit firm culture, engagement budgets, and training experiences are antecedents to individuals' ability to engage in institutional work.

The Effect of Perceived Risk on Smoking among High School Seniors

Accounting, Finance, Economics

Dr . Jorge Medina [1]

1. *NJCU School of Business*

This study uses regional-level panel data from 1976 to 2018 from Monitoring the Future to examine the effect of perceived risk on the consumption of cigarettes and initiation of smoking among high school seniors. It also re-examines the impact on price under this context. Results show that perceived risk is a significant determinant of consumption and initiation and that it has a stronger impact than price. These findings reinforce the need for educational and awareness programs that clearly communicate the risks of smoking.

The Impact of Cash Transfer Participation on Unhealthy Consumption in Brazil

Accounting, Finance, Economics

Mrs . Fernanda Araujo Maciel [1]

1. _Bentley University_

The objective of this paper is to assess the impact of Brazil's _Bolsa Família_ conditional cash-transfer program on unhealthy consumption. Applying Machine Learning methods to create a propensity score, I analyze the effects of participating in the program on the household purchase of ultra-processed food, alcohol, and smoking products. Preliminary results show that program participants increase the expenses on food, food away from home, and cookies. Among households that purchase unhealthy food away from home or smoking products, the amount spent on these products decreases. Program participants do not significantly change their expenditures on soda, packaged food, or alcohol.

THE RELATIONSHIP BETWEEN ECONOMIC POLICY UNCERTAINTIES AND STOCK MARKET VOLATILITY IN THE UNITED STATES AND S. KOREA

Accounting, Finance, Economics

Dr . DaeRyong Kim [1]*, Dr . Seongju Moon* [2]

1. *Delaware State University ,* **2.** *Gyeongsang National University*

The aim of this study is to find out if the EPU index generated by big data has the capability to trace the volatility of the stock market in two different countries. The main findings of the study are (1) the impacts of USEPU on VIX and of KOREPU on VKOSPI are positive in the long run and (2) the positive bidirectional relationship between USEPU and VIX and the positive unidirectional relationship between KOREPU and VKOSPI were found in the short run. The study concluded that the EPU index can provide useful information to investors in the stock/derivatives markets.

The ROIC-WACC Spread: Does Good Corporate Governance Impact Cash Distributions to Shareholders?

Accounting, Finance, Economics

Dr . Robert Goch [1]

1. *Molloy College*

This paper examines how the ROIC/WACC spread impacts cash distribution to shareholders and explores the role agency theory plays regarding such distributions. One would expect that corporations with shareholder friendly governance and compensation in place would be more apt to make cash distributions if the ROIC/WACC spread is negative.

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US Health Care Economics :Issues and Trends

Accounting, Finance, Economics

Dr . Augustine Arize [1], Dr . Giuliana Campanelli Andreopoulos [2], Dr . John Malindretos [3], Dr . alex panayides [4], Prof . Alfred Verrios [2]

1. Texas A&M University-Commerce , 2. economics finance and global business, William Paterson University , 3. William Paterson University Wayne , 4. economics finance and global business

The health care industry would benefit greatly from economic analysis. Theories and models of healthcare economics need to be modified or extended to accommodate changing institutional features. In particular health consumers are buying a product they know little about (information) with someone else's money (third-party payment) due to insurance (uncertainty). The most important current research focus should be on developing practical strategies and econometric models that would facilitate reduced cost of health care. This paper is a review of current healthcare economic trends and future forecasts (2015-2020). The areas covered this paper includes: Costs of HC, Funding of HC,

VOLATILITY SPILLOVERS BETWEEN CHINESE ENERGY, STOCK AND FOREIGN ECAHNGE MARKETS DURING THE SINO-AMERICA TRADE WAR

Accounting, Finance, Economics

Mr . Tongshuai Qiao [1] *, Mr . Lixin Huang* [2] *, Prof . Ping Li* [1]

1. *Beihang University ,* **2.** *Princeton International School of Mathematics and Science*

In this paper, we examine the static and dynamic volatility spillovers between Chinese crude oil futures, stock, and foreign exchange markets using the BEKK-GARCH model and Diebold-Yilmaz (2012, 2014)'s volatility spillover measures, including the total spillover index, directional spillover index, and net spillover index. Empirical results show that there are significant bidirectional volatility spillovers between each pair of the three markets; the crude oil futures market is the net volatility transmitter, while the stock and foreign exchange markets are the net volatility receivers. The unidirectional volatility spillovers from the crude oil futures to the stock is the strongest.

Accounting, Finance, Economics - Papers

Analysts' Recommendations and Supporting Forecasts

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Abstract

This study examines the consistency between individual analysts' stock recommendations and the supporting forecasts. The study introduces a probability-based consistency measure through a logit model that uses the Weight-of-Evidence of analysts' supporting forecasts as predictors. The study shows that supported recommendations are more effective than isolated recommendations and recommendations with higher consistency trigger even stronger market reactions. This recommendation consistency can be used to generate significant profit through a calendar-time portfolio strategy. Regulatory efforts that reduce analysts' conflicts of interest and over-optimism also make the consistency more informative.

Keywords: stock recommendations; earnings forecasts, revenue forecasts, profit forecasts; consistency; signal processing; price reactions; portfolio strategy

Analysts' Recommendations and Supporting Forecasts

In the analyst literature, analysts' earnings-per-share forecasts and stock recommendations have been widely examined to understand the role that analysts play in reducing the information asymmetry between the company management and external market participants. While many prior studies investigated earnings forecasts and recommendations in isolation, a few studies showed that earnings forecasts and recommendations are actually linked and convey distinct information (Bradshaw, 2004; Brown & Huang, 2013; Ertimur, Sunder, & Sunder, 2007; Francis & Soffer, 1997; Loh & Mian, 2006). In addition to earnings forecasts and recommendations, analysts also produce other types of forecasting outputs, such as revenue forecasts, net income forecasts, etc., to supplement their views on the company's financial and non-financial performance. The goal of this paper is to develop a probability-based consistency measure that links analysts' recommendation decisions with the way that they use forecasts to support the recommendation and assess the economic value of this consistency measure. In specific, the study considers six types of forecasts over a three-year ahead horizon that analysts most commonly issue along with their recommendation[1].

Consistent with the assumption's in existing literature that analysts' forecasts, such as the earnings forecasts, are inputs to their valuation models rather than a final product (Francis & Soffer, 1997; Schipper, 1991), this study uses analysts' pre-recommendation forecasts issued shortly before the recommendation announcement to determine the recommendation consistency (hereby denoted as *recommendation consistency*)[2]. Similar to Brown and Huang (2013), the study considers two types of recommendation: favorable and unfavorable recommendations. Individual recommendation is considered to be favorable when the recommendation rating is below the prevailing consensus[3] or when it equals the consensus and the consensus is either

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[1] This paper considers the following six forecasts based on the frequency of forecasts supporting recommendations from the IBES database: Earnings Per Share (*EPS*), Revenue/Sales (*SAL*), Net Income (*NET*), Pre-tax Profit (*PRE*), EBIT (*EBT*), Operating Profit (*OPR*).

[2] It is possible that analysts choose to issue recommendations before providing supplemental forecasts. Through the data exploration, the proportion of recommendations with post-recommendation forecasts is less than 10%. In addition, including those recommendations result in a contaminated post-recommendation window in evaluating the price reactions, therefore the study doesn't treat those post-recommendation forecasts as supporting forecasts.

[3] This paper uses the original IBES 5-level rating scale, which 1-5 denotes "Strong Buy", "Buy", "Hold", "Sell", "Strong Sell" correspondingly. As the result, lower rating implies a higher optimism.

'Strong Buy' (rating 1) or 'Buy' (rating 2) or missing. Recommendation is considered to be unfavorable when the recommendation rating is above the consensus or when it equals the consensus when the consensus is either 'Sell' (rating 5), 'Underperform' (rating 4) or 'Hold' or missing.[4] A [-3,0] trading-day pre-recommendation window is adopted to determine whether each forecast under consideration is a supporting forecast or an isolated forecast. Based on the six types of annual forecasts across 3-year ahead horizon, there are potentially 18 possible supporting forecasts. In many cases, analysts only issue a subset of the 18 forecasts to support their recommendations. To account for this "incompleteness" issue, the study applies the *Weight-of-Evidence* (**WOE**)[5] transformation on the standardized forecasts value[6] and uses the forecasts *WOE* as input in a logit model to determine the prediction of recommendation. The study defines the recommendation consistency as the probability of observing the actual recommendation given the set of the supporting forecasts.

To quickly explore the types of forecasts that are most powerful in determining the recommendation consistency, the study also evaluate the *Information Value* (**IV**) of each supporting forecast across the 3-year ahead horizon. The results indicate that analysts' 2-year ahead forecasts are the most important supporting signals in determining the recommendations, followed by 1-year ahead forecasts and then 3-year ahead forecasts. Analyst' earnings forecasts is dominant in predicting the recommendation contents, then followed by net income forecasts, revenue forecasts, and profit forecasts; the least predictive forecast is analysts' EBIT forecasts.

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[4] This definition differs from (Brown & Huang, 2013) as they exclude the recommendations that have ratings equal to consensus at favorable level or unfavorable level and exclude the first recommendation, i.e. no prevailing consensus. Based on findings in previous literature, this study treats "Hold" recommendation level as unfavorable.

[5] The WOE transformation technique has been widely used in scorecard model in the application of credit rating and fraud detection (Hand & Adams, 2000; Nguyen, 2015; Thomas, 2000). For a detailed discussion of *Weight of Evidence*, see (Wod, 1985). The transformation basically discretizes numeric variables into sub-intervals and evaluates the predictive power for each sub-interval and handles missing value as a special interval, thus allowing incomplete set of forecasts to enter into traditional regression models.

[6] The standardization procedure is performed by subtracting the individual forecast value by its consensus (based on the same forecast type and same forecast end date) and then being divided by the standard deviation of the outstanding forecasts. This paper assumes that analysts' forecasts become obsolete after 180 calendar days if there is no update by the same analyst. Therefore, the outstanding forecasts are the most recent forecasts issued by each analyst on the same stock with the same forecast end date in the sample within a 180-calendar-day window.

The result of this exploratory analysis sheds light on one important question in analyst literature: "whether analysts make recommendations based on a long-term or a short-term perspective of the company's performance?" Brown and Huang (2013) used a one-year ahead annual earnings forecasts to define recommendation-forecast pairs. Evidence in this study suggest that analysts' two-year ahead forecasts may be most important input to determine analysts' recommendations.

The study then examines the value of the recommendation consistency in two aspects: the informative value and the investment value. Using the post-recommendation abnormal stock price reactions to account for the informative value, the study finds a significantly positive *buy-and-hold abnormal return* (**BHAR**)[7] over the benchmark portfolio that matches the stocks' characteristics in capital size and Book-to-Market ratio in a [0,+2] post-recommendation window. The investment value of the recommendation consistency is examined through an out-of-sample calendar-time portfolio strategy. The portfolio strategy first derives the consistency measure for each calendar year by using observations in all past years (i.e. growing in-sample) to obtain the *WOE* mapping information and then fits the logit model with the forecast *WOE* to obtain in-sample consistency quintiles. Then the in-sample logit model, in-sample forecasts *WOE* mapping and in-sample consistency quintiles are used to calculate the out-of-sample consistency measure in current year and determine the portfolio composites. Two portfolios are constructed, the 'Favorable' portfolio takes positions on stocks with favorable recommendations and the 'Unfavorable' portfolio consists stocks with unfavorable recommendations. The results show that portfolios formulated in the low rank of consistency quintile fail to achieve a desired abnormal return (*Jensen's Alpha*) from a 4-factor risk model, and portfolio constructed based on the high rank of consistency quintile achieve significant *Jensen's Alpha* in the expected direction for both 'Favorable' and 'Unfavorable' portfolios.

The study also examines the implication of Reg FD (Regulation Fair Disclosure) on the impact of consistency on recommendation effectiveness. Reg FD has been found to affect analysts' optimism in forecasts (Herrmann, Hope, & Thomas, 2008) and recommendations(Barber, Lehavy, & Trueman, 2010). Using sub-sample in pre-regulation and post-regulation to regress the BHAR on consistency measure, the study finds that market

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[7] The signs of the abnormal return for unfavorable recommendations are reversed to indicate that BHAR measures a profitability.

participants become more sensitive to recommendation consistency in the post-reg period, which indicates investor's enhanced awareness of recommendation quality.

This study makes the following contributions to existing analyst literature. First, the study provides a probability-based consistency measure to assess the value of analysts' recommendation. This consistency measure captures the how likely or unlikely that their various supporting forecasts predicts their recommendation decision. This measure differs from the analysis in most existing literature forecasts (Bradshaw, 2004; Brown & Huang, 2013; Eames, Glover, & Kennedy, 2002; Francis & Soffer, 1997; Hall & Tacon, 2010; Ke & Yu, 2009) in that it not only considers the earnings forecasts but also includes other supplemental forecasts across a three-year ahead horizon as a bundle to evaluate the likelihood of analysts' recommendation decision. As the result in this study suggests analysts' annual forecasts in a 2-year-ahead period are more important than any other forecasts in determining the recommendation contents. In addition, the study adopts the WOE transformation which avoids deleting observations with 'incomplete' set of supporting forecasts. This method and can be easily adopted to analyze any other type of probability-based connections.

Second, this study provides evidence to show that this consistency measure reflects the incremental informative value of the recommendation as well as the investment value of the recommendation. This finding is particularly appealing to practitioners when they need to explore the investment opportunities from following analysts' recommendations. This study proposes a portfolio strategy based on both the content of the recommendation and the level of the recommendation consistency and shows that the strategy yield significant abnormal return.

The remainder of this paper is organized as follows. Section 2 provides literature review. Section 3 describes data sample and methodology. Section 4 presents the empirical results and discussions. Section 5 concludes.

2. Review of Relevant Literature

2.1 Relationship between Analysts' Recommendations and Earnings Forecasts

Prior literature has extensively examined analysts' recommendations and earnings forecasts. Francis and Soffer (1997) found analysts' EPS forecasts revision, stock recommendations and recommendation revisions capture about 5% variation in the stock abnormal return over a three-trading day window around analysts' report publication dates and investors exhibit a stronger reaction to earnings forecasts revisions in buy recommendations than they do in hold and sell recommendations. Loh and Mian (2006) provided evidence that the profitability of analysts' recommendations and the quality of their earnings forecasts are connected. Sorting analysts into quintile based the accuracy of their annual earnings forecasts and creating recommendation-based portfolios for each quintile, they showed that following recommendations by analysts in the highest(lowest) accuracy quintile generate significant positive(negative) abnormal return. Hall and Tacon (2010) extended the study of Loh and Mian (2006) by constructing the recommendation-based portfolios from the history of earnings forecasts accuracy. They found that while concurrent forecasts accuracy can be translated into a statistically significant positive abnormal return in the constructed portfolios, the economic significance is limited. Portfolios that are formulated based on the forecasts accuracy in previous year cannot produce significant abnormal return. This study extends the investigation of following analysts' recommendations to extract the investment value and finds that the recommendation consistency of the individual recommendation appears to be superior signals than past accuracy as it provides timely evaluation on the recommendation and generates significant profitability.

Ertimur et al. (2007) presented results on how analysts' conflicts-of-interest distort the relationship between the recommendation profitability and the forecasts accuracy. The recommendations and forecasts have improved the internal consistence since the introduction of the Fair Disclosure regulation, which mitigated the issue of analysts' conflicts-of-interest. This study finds similar conclusions through the evaluation of stock price reactions to recommendation consistency in pre-regulation and post-regulation sub-samples. In post-regulation period, stocks responses to consistency more strongly and shows significant difference in the consistency impact for favorable recommendations and unfavorable recommendations.

In the study of intercorrelation between earnings forecasts and recommendations, Bradshaw (2004) demonstrated that stock recommendations are not consistent with the valuation estimate based on analysts' earnings forecasts. He suggested that analysts are more likely to adopt the heuristic valuation model than the present value models to provide their recommendations. Ke and Yu (2009) proposed that the deviation of analysts' recommendations from their forecasts may be explained by analysts' behavior biases such as the use of investor sentiment. Brown and Huang (2013) focused on the association between the recommendation-forecasts consistency and the earnings forecasts quality which is measured by the accuracy and timeliness of the earnings forecast. The authors defined recommendation-forecast pair as consistent if both are above or below the consensus level. Their results showed that consistent recommendations have higher market reactions and indicate a higher quality of the accompanied forecasts. This study extends the work by Brown and Huang (2013) to include the multiple supporting forecasts and produces a continuous consistency measure, which more accurately reflects the consistency impact.

2.2 Analysts' Non-Earnings Forecasts

Bradshaw (2011) indicated that very little research has been produced to examine analysts' comprehensive outputs in a multivariate setting. Different types of analysts' forecasts are associated with factors related to the companies' industry competitiveness, strategy and internal capabilities (Groysberg, Healy, Nohria, & Serafeim, 2011). Therefore, a single earnings measure may be insufficient to provide complete explanations for analysts' recommendations decisions. This section briefly reviews how analysts' non-EPS forecasts facilitate the understanding of the company's earnings and stock performance.

In the examination of analysts' forecasts related to revenue and gross sales, Ertimur, Livnat, and Martikainen (2003) found that revenue surprise plays an important role in explaining earnings surprise and can aid investors to identify the issues in earnings management. Keung (2010) found that earnings forecasts supplemented by revenue forecasts cast a stronger stock price reaction than the standalone earnings forecasts and are more accurate and timelier. Bilinski and Eames (2019) found that analysts respond to investors' demand for additional information when the quality of earnings forecasts is low and revenue quality is high. This phenomena is supported by the reputation explanation as analysts are more likely to issue sales forecasts if

these forecasts are more accurate and will not cause reputation damage (He & Lu, 2017), thus reputable analysts are more likely to issue both revenue and earnings forecasts at the same time (Ertimur, Mayew, & Stubben, 2011).

3. Data, Variables and Research Design

3.1 Sample Selection

The sample data employed in this study is obtained from two major sources. The analysts' annual forecasts and recommendations are both extracted from the IBES database. The historical stock price and rate of return data is obtained from the Center for Research in Security Prices (CRSP) database.

The sample period begins at year 1996 and ends at year 2010. Recommendations and forecasts without analysts' identification and issued on stocks that cannot be matched to CRSP database are excluded[8]. When an analyst issue intraday recommendations or forecasts with the same forecast end date, only the last record is kept. The study uses the variable FPI in IBES database to select annual records that have a forecasts horizon between 1-year and 3-year ahead period. IBES database provide up to 16 different types of forecasts, the study considers the following six measures that have the highest frequencies as being supporting forecasts in the database: Earning-Per-Share (EPS), Revenue (SAL), Net Income (NET), Pre-tax Profit (PRE), EBIT (EBT), Operating Profit (OPR). To avoid unreliable forecast records, the study deletes observations that have actuals announcement date before the forecast announcement date.

The sample for the empirical analysis requires that stocks need to be actively covered by analysts. Each stock should be covered by at least two analysts and have at least 50 forecasts and 50 recommendations. The sample also excludes infrequent analysts. Only analyst who have issued at least on favorable supported recommendation, one unfavorable supported recommendation, and at least 10 supported recommendations in the sample period will be considered. Consistent with previous studies, penny stocks that have price under $5.00 are also excluded. As the result, the final sample contains 277,224 recommendations and 6,024,975 forecasts issued by 8,227 analysts on 2,207 stocks. 627,030 forecasts are identified as supporting forecasts and are linked to 150,443 supported recommendations.

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[8] Records that have missing analyst code or analyst code being 0 are treated as unidentifiable. CRSP database only contains records for US stocks. Therefore, the study primarily focuses on US analysts, as I/B/E/S database assumes US analysts only cover US stocks and Non-US analysts cover Non-US stocks.

3.2 Variables

3.2.1 Recommendation Classification

This study classifies the analysts' recommendations into two categories: favorable (individual recommendation rating is below the consensus) and unfavorable (individual rating above the consensus), based on the original 5-level rating scale used in IBES. When analysts' individual rating equals consensus, "Buy/Strong Buy" recommendations are treated as favorable and "Sell/Underperform/Hold" recommendations are treated as unfavorable. Recommendation consensus is calculated as the average rating of all "outstanding" recommendations issued during the 180 calendar days prior to the observed recommendation announcement[9]. If an analyst revises the recommendation rating within the [-180,0) calendar day window, only the latest recommendation is considered to be "outstanding"; if an analyst doesn't issue any recommendation within the 180 calendar day period, then this analyst is considered to drop the coverage on the 180th post-recommendation calendar day. Compared with the consensus calculated by Brown and Huang (2013), this study avoids including obsolete ratings due to analysts' revision and more precisely reflects analysts' updated opinion on the stock rating.

Error! Reference source not found. presents the distribution of the data sample. Panel A and B shows the distribution of recommendations and forecasts by calendar year respectively. The results indicate that analysts are more likely to use forecasts to support favorable recommendations than to support unfavorable recommendations. One interesting finding is the ratio of supported recommendations and ratio of supporting forecasts in the last column of both panels. Several major regulatory efforts, such as the Fair Disclosure Regulation (FD-Reg), NASD Rule 2711 and NYSE Rule 472, have been made to curb analysts' over-optimism during the year 2002 and 2003. As implied by the descriptive analysis, those regulations also affected the way that analysts provide supporting materials for their recommendations. After the adoption of the regulations, analysts become more likely to issue supported recommendations (increase in % supported) and are more selective in providing the supporting forecasts (decrease in % supporting). Panel C presents the distribution of forecasts by types of estimates, which show that

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[9] This choice is consistent with the definition of stopped estimate by IBES. See https://wrds-www.wharton.upenn.edu/pages/support/support-articles/ibes/stopped-estimates/

analysts' earnings forecasts and revenue forecasts are the two most common supporting forecasts.

3.2.2 Forecasts Transformation

This study uses a two-step procedure to translate analysts' supporting forecasts into the inputs for the logit model that determines the consistency. The first step standardizes each forecast as follows:

$$F_{ijt,KH} = \frac{Forecast_{ijt,KH} - Consensus_{jt,KH}}{S_{jt,KH}}; \; K \in EPS, SAL, ..., \; H \in 1,2,...,3 \qquad 1$$

where $F_{ijt,KH}$ represents analyst i's standardized forecast (K denotes estimate type and H denotes the forecast horizon) for stock j on date t; $Forecast_{ijt,KH}$, $Consensus_{jt,KH}$ and $S_{jt,KH}$ [10]denote the original value of the forecast, the consensus and the corresponding standard deviation of the outstanding forecasts at time t. $Consensus_{jt,KH}$ is obtained in the similar way as the recommendation consensus, which uses the average of "outstanding"[11] forecasts with type K on the same forecast end date for stock j.

In the second step, the standardized forecasts are translated into forecast *Weight-of-Evidence* (**WOE**) as follows:

$$F_{ijt,KH}^{WOE} = F_{KH}^{WOE,n} = 100 \times ln\left(\frac{\%Favorable_{a_n<F_{KH}\leq b_n}}{\%Unfvorable_{a_n<F_{KH}\leq b_n}}\right), a_n < F_{ijt,KH} \leq b_n \qquad 2$$

$$\%Favorable_{F_{KH}\in(a_n,b_n]} = \frac{\# Favorable_{a_n<F_{KH}\leq b_n}}{\# Total \, Favorable} \qquad 3$$

$$\%Unfavorable_{F_{KH}\in(a_n,b_n]} = \frac{\# Unfavorable_{a_n<F_{KH}\leq b_n]}}{\# Total \, Unfavorable} \qquad 4$$

where $F_{ijt,KH}^{WOE}$ denotes the transformed *Weight-of-Evidence* value for the standardized forecast $F_{ijt,KH}$. $F_{ijt,KH}^{WOE}$ takes a constant value $F_{KH}^{WOE,n}$ as determined by the specified interval n with a lower boundary a_n and an upper boundary b_n; $\%Favorable_{a_n<F_{KH}\leq b_n}$ and

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[10] To simplify the notation, subscript H is used to denote the same forecast end date.
[11] The definition of "outstanding" is the same for both recommendations and forecasts: within a [-180, 0) calendar day window the last observation of the record will be considered as outstanding.

$\%Unfavorable_{a_n < F_{KH} \leq b_n}$ denote the distribution of the favorable/unfavorable recommendations when the standardized supporting forecasts $F_{ijt,KH}$ fall into the interval n $(a_n, b_n]$. The main analysis in the study splits the value of the standardized forecasts into 16 intervals based on the percentile of F_{KH}[12]. Missing value of the forecast signal F_{KH} is treated as a special interval. It is easy to show that forecasts with higher *WOE* value is associated with a high chance of supporting a favorable recommendation, thus WOE also provide a good approximation for consistency based each single individual forecasts.

The overall alignment of each forecast F_{KH} on the content of the supported recommendations can be evaluated by the forecasts' *Information Value* (**IV**) F_{KH}^{IV} as follows:

$$F_{KH}^{IV} = F_{KH}^{IV,missing} + F_{KH}^{IV,non\text{-}missing} =$$

$$(\%Favorable_{F_{KH}\ missing} - \%Unfavorable_{F_{KH}\ missing}) \times F_{KH}^{WOE,missing} + \qquad 5$$

$$\sum_n(\%Favorable_{a_n < F_{KH} \leq b_n} - \%Unfavorable_{a_n < F_{KH} \leq b_n}) \times F_{KH}^{WOE,n}$$

where the first item $F_{KH}^{IV,missing} = (\%Favorable_{F_{KH}\ missing} - \%Unfavorable_{F_{KH}\ missing}) \times$ $F_{KH}^{WOE,missing}$ evaluates the predictive power of a naïve prediction on the recommendation content (based on sample proportion) when there is no supporting forecast, the element of $(\%Favorable_{a_n < F_{KH} \leq b_n} - \%Unfavorable_{a_n < F_{KH} \leq b_n}) \times F_{KH}^{WOE,n}$ in the second item $F_{KH}^{IV,non-missing}$ evaluates the predictive power of prediction on recommendation content when observed standardized supporting forecasts F_{KH} is within the interval n. F_{KH}^{IV} captures the overall predictive power of the supporting forecast F_{KH}. Instead of using the original formula as specified in Eq (5), this paper proposes a modified version of the *Information Value* as follows:

$$F_{KH}^{IV^*} = \sum_n[(\%Favorable_{a_n < F_{KH} \leq b_n} - \%Unfavorable_{a_n < F_{KH} \leq b_n}) \times F_{KH}^{WOE,n} - F_{KH}^{IV,missing}] \qquad 6$$

This modified version of IV emphasizes the incremental predictive power for the observed forecast by the analyst over a naïve prediction based on the frequency.

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[12] Using the weight-of-evidence transformation by equal-size interval, which is also common in practice, doesn't show material change regarding the information value and overall conclusion of this study.

Table 2 summarizes the forecasts' *Information Value*. The results indicate that each individual forecast exhibits relatively low predictive power in determining supported recommendation, the aggregated predictive power from the 18 forecasts signals is strong. Both panel A and panel B reveal similar pattern regarding the predictive power for each individual forecast. Earnings Per Share (**EPS**) exhibits the highest predictive power and forecasts with a 2-year ahead horizon produce most alignment with the supported recommendations.

3.2.3 Consistency Measure

One central research of interest in this study is the recommendation consistency measure. The recommendation consistency is calculated as follows:

First, the following logistic regression model is employed to evaluate the probability of supported recommendation being favorable:

$$logit(Rec_{ijt} = Fav) = \beta_0 + \sum_{K \in EPS,SAL,\dots, \; H \in 1,2,3} \beta_{KH} \, F_{ijt,KH}^{WOE} \qquad 7$$

where $Rec_{ijt} = Fav$ denotes the event that the supported recommendation Rec_{ijt} is favorable, $F_{ijt,KH}^{WOE}$ are key inputs the forecasts WOE. The study also adds the year dummy and analyst dummy to control for time and analyst fixed effect.

Second, the probability of observing the actual supported recommendation conditional on the supporting forecasts is used to define the recommendation consistency as follow:

$$Con_{ijt}^{Rec} = \begin{cases} Prob(Rec_{ijt} = Fav|Forecasts\ WOEs), Rec_{ijt} = Favorable \\ 1 - Prob(Rec_{ijt} = Fav|Forecasts\ WOEs), Rec_{ijt} = Unfavorable \end{cases} \qquad 8$$

where Con_{ijt}^{Rec} denotes the recommendation consistency for recommendation Rec_{ijt}, $Prob(Rec_{ijt} = Fav|Forecasts\ WOE)$ is the probability that recommendation Rec_{ijt} is favorable from the logit model in Eq**Error! Reference source not found.**.

3.2.4 Stock Price Reaction

Adopting the common approach in analyst literature (Barber et al., 2010; Jegadeesh, Kim, Krische, & Lee, 2004; Jegadeesh & Kim, 2006; Womack, 1996), this study uses short-window stock price reactions to assess the informativeness of the supported recommendation. A Buy-and-Hold Abnormal Return ($BHAR_{ijt}$), calculated as the cumulative return of the stock minus the

cumulative return of a corresponding benchmark portfolio from day 0 to day +2, is used to measure the market reaction to recommendation Rec_{ijt}. To make sure that the $BHAR_{ijt}$ is truly attributed to Rec_{ijt} rather than the opposite causation, the study chooses the day 0 in the event window to be the first trading day that investors can trade on the recommended stocks and earn the corresponding daily rate of return. To be specific, if Rec_{ijt} is issued before 9:00AM on trading day t, then day 0 is set to be date t; for all other recommendations that are either issued during the weekend/holiday or issued after/during the financial market operation (after 9:00AM) on any trading day, then day 0 is set to be the next available trading day. The benchmark portfolio is the characteristic portfolio that share the same quintile ranking on the Book-to-Market ratio (BM ratio) and market capital value (size) as the recommended stocks. The daily rate of return for the benchmark portfolio is calculated as the value-weighted average of the individual stocks in the characteristic portfolio.

3.2.5 Other Variables

The following characteristics of recommendations, forecasts, analysts, stocks and market are included as controls in the empirical study.

Characteristics of Recommendations:

- Rec_Bold_{ijt} measures the boldness of analysts' recommendations, which is the absolute value of the difference between the rating of Rec_{ijt} and the consensus (Bagnoli, Clement, Crawley, & Watts, 2010). Prior findings suggested that recommendations issued away from consensus are more influential than recommendations issued close to consensus (Loh & Stulz, 2010).

- Rec_Rev_{jit} denotes a set of dummies that represent the recommendation revision status. If Rec_{ijt} is the first recommendation by analyst i on stock j, or if the most recent past recommendation was issued more than 180 days old, the revision status is '*New*'; if Rec_{ijt} has the same rating as the most recent previous outstanding recommendation, the revision status is '*Reiteration*'; if the rating level of Rec_{ijt} is lower (higher) than previous recommendation, the revision status is 'Upgrade' ('Downgrade'). Many studies suggested that the change of recommendation rating is more informative than the pure rating level (Barber et al., 2010; Jegadeesh et al., 2004), thus the study controls for revision status.

- $Rec\_Elasped_{jt}$ is the number of days since the most recent past recommendation announcement on stock j given by any analyst at date t. $Rec\_Elasped_{ijt}$ aims to account for impact of the frequency in affecting the recommendation effectiveness.

- $Rec\_Consensus_{jt}$ is the prevailing recommendation consensus of stock j on date t, right before observing Rec_{ijt}. The consensus rating reflects analysts' overall optimism and pessimism on the underlying stocks.

- Rec_N_{jt} is the number of outstanding recommendations on stock j at date t, which accounts for analysts' coverage and attention on the underlying stock.

- $Rec\_Dispersion_{jt}$ is the standard deviation of outstanding ratings on stock j at date t, which measures analysts' disagreement on the underlying stock.

Analyst Characteristics:

- Exp_{it} denotes the experience of analyst i, when he/she generates a recommendation or a forecast on date t. Analysts' experience is found to be an important factor for influential recommendations (Loh & Stulz, 2010) and accurate forecasts (Mikhail, Walther, & Willis, 1997). The study uses the years of record in the IBES database to proxy for analysts' experience. The study tracks the earlier date of the first observation by each analyst from both recommendation and forecast datasets to determine analysts' career start date and then uses it to calculate the years of experience.

- $Broker\_Size_{it}$ is analyst i's brokerage size, calculated as the number of analysts employed by the brokerage firm that hires analyst i at date t. Existing literature suggested that analysts from large brokerage firm have an advantage of resources and information, thus producing more effective recommendations and forecasts (Jegadeesh & Kim, 2006; Loh & Stulz, 2010; Mikhail et al., 1997)

Stock & Market Characteristics

- $Stock\_Size_{jt}$ is the nature log of the market capital value of stock j at date t. The market capital value is calculated as the number of shares outstanding multiplies the close price of the stock on date t.

- $Stock\_Ret_{jt}$ is the average daily rate of return of stock within [-2,0] window before the recommendation/forecast announcement. This study includes the stock pre-signal returns

to account for analysts' piggybacking on abnormal stock price movement in generating the recommendations and forecasts.

- Mkt_Ret_t is the average daily rate of return of a value-weight market index within [-2,0] trading day window before the recommendation/forecast announcement. The rationale to include this market pre-signal return is that analysts may also be influenced by the market abnormal performance in generating the recommendations and forecasts.

- Mkt_VIX_t is the value of the CBOE Volatility Index on the recommendation/forecast announcement date t. *VIX* is generally believed to reflect investor' fear and represents the level of uncertainty in the financial market. Inspired by prior research that examined analysts' behavior under the uncertainty (Chang & Choi, 2017; Loh & Stulz, 2018), this study controls for *VIX*.

4. Empirical Results and Analysis

4.1 The Informative Value of Supporting Forecasts and Recommendation Consistency

The study uses the following regression models to assess the impact of supporting forecasts on the market reactions to the recommendations:

$$BHAR_{ijt} = \alpha_0 + \alpha_1 Supported_{ijt} + \alpha_2 Fav_{ijt} + \alpha_3 Supported_{ijt} \times Fav_{ijt} + \Sigma\, Rec\_Char_{ijt}$$
$$+ \Sigma\, Analyst\_Char_{ijt} + \Sigma\, Stock\_Char_{jt} + \Sigma\, Mkt\_Char_t + \epsilon_{ijt}$$

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where $BHAR_{ijt}$ is the Buy-and-Hold Abnormal Return to analysts recommendation in % as specified in section 3.3.4.[13] $Supported_{ijt}$ is a dummy indicating recommendation Rec_{ijt} is supported by at least one forecast, Fav_{ijt} is a dummy indicating Rec_{ijt} is favorable, $Supported_{ijt} \times Fav_{ijt}$ denotes the interaction; $\Sigma\, Rec\_Char_{ijt}$, $\Sigma\, Analyst\_Char_{ijt}$, $\Sigma\, Stock\_Char_{jt}$ and $\Sigma\, Mkt\_Char_t$ denote the sets of controls for the characteristics of recommendations, analysts, stocks and market, as specified in previous sections, respectively. Fixed effects are controlled at analyst-year and stock-year level.

Table 3 presents the regression outputs for Eq 9. The results reveal that analysts' supported recommendations are more effective than isolated recommendations. For unfavorable recommendations, supported recommendations have an average 0.583% abnormal return over isolated recommendations; for favorable recommendations, it is a 0.583%-0.422% = 0.161% abnormal return over the isolated recommendation. Notice that the study chooses a relatively restrictive criteria to determine the post-recommendation window in calculating the *BHAR*, thus the actual magnitude of the abnormal return can get even larger if investors can take actions on recommendations observed during the market operation (between 9:30AM and 4:00PM).

The results of the coefficients for the controls also provide remarkable findings. First, consistent with previous studies, recommendations that move away from the consensus are more effective as indicated by the significant positive coefficient for *Rec_Bold.* Second, the years of experience and the brokerage size, are not significant in this study. Previous studies that solely

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[13] The signs of the unfavorable recommendations are reversed, thus a larger positive/negative *BHAR* indicates more informative/uninformative recommendation.

focuses on analysts' recommendations or forecasts claimed that analysts' ability is a strong factor for explaining the stock price change to the recommendations or forecasts. However, this study doesn't find the same conclusion after including the support dummy. Lastly, the negative coefficients *Stock_Size* reveals that small-capital stocks are affected more by analysts' recommendations than large-capital stocks; and the negative coefficients of *Mkt_Ret* and positive *Mkt_VIX* indicate that analysts' recommendations are adversely affected by the current market performance but become more informative when the market level uncertainty is high.

To assess market participants' perception on the informative value of the recommendation consistency, the study begins with an exploratory analysis of the consistency measure. ***Table 4*** shows the distribution of *BHAR* and control variables by the ranking of consistency quintile. The results of Panel A show that analysts' recommendations become more informative when they are more consistent with the supporting forecasts. At the lowest rank of consistency quintile, unfavorable recommendations generate insignificant positive abnormal return and favorable recommendations generate significantly negative abnormal return. This finding is a clear indication of analysts' over-optimism that analyst produce biased favorable recommendations in the presence of inconsistent supporting forecasts, thus making market participants to trade the stock in the opposite direction to the recommendations. Panel B shows that this consistency measure has a low correlation with many existing control variables for analysts' characteristics, stock and market characteristics in the study, therefore this measure captures new information and should not be considered as an add-on information based on the given characteristics.

The following empirical regression model is used to assess the informative value of recommendation consistency:

$$BHAR_{ijt} = \alpha_0 + \alpha_1 Con_{ijt}^{Rec} + \alpha_2 Fav_{ijt} + \alpha_3 Con_{ijt}^{Rec} \times Fav_{ijt} + \Sigma\, Rec\_Char_{ijt}$$
$$+ \Sigma\, Analyst\_Char_{ijt} + \Sigma\, Stock\_Char_{jt} + \Sigma\, Mkt\_Char_t + \epsilon_{ijt}$$

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where Con_{ijt}^{Rec} is recommendation measure for Rec_{ijt} as defined by Eq**Error! Reference source not found.** and Eq**Error! Reference source not found.**; Fav_{ijt}, $\Sigma\, Rec\_Char_{ijt}$, $\Sigma\, Analyst\_Char_{ijt}$, $\Sigma\, Stock\_Char_{jt}$ and $\Sigma\, Mkt\_Char_t$ have the same definition as Eq **Error! Reference source not found.**.

Table 5 presents the output of the regression model in Eq10 **Error! Reference source not found.**. The results show that recommendations with higher consistency also yield higher

stock price reactions. Changing the consistency level by 0.1 results in an increase of *BHAR* by 0.8637% for unfavorable recommendations and an increase of *BHAR* by 0.8637-0.1481=0.7156% for favorable recommendations. The sign and statistical significance for the control variables in Eq9 remain unchanged as in Eq10.

In summary, analysts' supported recommendations trigger stronger stock price reactions than isolated recommendations. Increasing the consistency between the supporting forecasts and supported recommendations further improve the performance of the recommendations, thus confirming the informative value of the recommendation consistency.

4.2 The Investment Value of Recommendation Consistency

The profitability on the recommendation consistency measure is examined through a calendar-time portfolio construction approach. To obtain a reliable estimation of consistency and produce an implementable portfolio strategy for practitioners, the study performs the analysis by using the out-of-sample consistency measure to form the portfolio. For each year, records from all past years in the sample are used to evaluate the forecast WOEs and fit the logit model. Then the mapping of forecast WOE and the fitted logit model are used to evaluate the recommendation consistency for records in current year. The study uses growing sample rather than rolling sample with fixed window length to reflect the fact that market participant can improve their knowledge regarding forecasts WOE when the data availability is enhanced. Once the historical recommendation consistency (in-sample prediction) and current recommendation consistency (out-of-sample prediction) are calculated, the study uses the in-sample consistency quintile to assign quintile ranks for each recommendation in the current year. Two portfolios are constructed by following recommendations within the same rank of each consistency quintile. "Favorable" portfolio takes long position for stocks with favorable recommendations and "Unfavorable" portfolio takes long positions for stocks with unfavorable recommendations. In the case of conflicting recommendations issued by different analysts on the same date, the recommendation with the highest consistency will be used to make investment decision. For both portfolios, the study considers rebalancing by equal-weight and value-weight on a daily basis. For value-weight rebalance, the weight of each stock is determined by the weight of the stock capital market value in the previous trading day. To simplify the calculation procedure, the portfolio construction approach assumes no transaction cost in rebalancing.

After calculating the daily rate of return of each portfolio, Carhart (1997)'s four-factor risk model is used to evaluate the performance of each portfolio as follow:

$$Rp_{i,t} - r_f = \beta_1 (Rm_t - r_f) + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 UMD_t + \alpha_i + \epsilon_{it} \qquad 11$$

where $Rp_{i,t} - r_f$ denotes the excess return of portfolio i on date t, $Rm_t - r_f$ denotes the excess return of market index on date t, SMB_t denotes the premium of the size factor on date t, HML_t denotes the premium of the book-to-market factor on date t and UMD_t is the premium of momentum on winner minus losers at date t. α_i is the *Jensen's alpha* for portfolio i , which reflects the portfolio abnormal return after adjusting for the given four risk factors.

Table 6 presents the performance of the portfolios that follow the investment strategy according to the rank of recommendation consistency quintile. Portfolios following recommendations with higher consistency yield higher expected abnormal return and portfolios formed at low consistency rank fail to generate the expected abnormal return. The last rows in both panels indicate a trading strategy that makes most profit from the recommendation consistency measure. To achieve the optimal profitability, investors can take long positions on both the "Favorable" portfolio in the highest consistency quintile rank and the "Unfavorable" portfolio in the lowest consistency quintile rank and simultaneously take short positions on both the "Favorable" portfolio in the lowest consistency quintile rank and the "Unfavorable" portfolio in the highest consistency quintile rank. This trading strategy produces daily risk-adjusted abnormal return at 0.165% for value-weighted portfolio and 0.113% for equal-weighted portfolio, which can be translated into an annualized abnormal return at 41.58% and 28.48% respectively. This result is a significant profitability, despite the idealized assumption of no transaction in the study.

In summary, market participants benefit from the recommendation consistency measure by selectively following and dis-following analysts' recommendation in the portfolio strategy, thus providing evidence of the investment value for the consistency measure. Therefore, the consistency measure not only contains informative value in generating significant market reactions and but also contains investment value in practice.

4.3 The Impact of Regulation on Recommendation Consistency

Existing literature finds that the regulation efforts to reduce the conflicts-of-interest issue and curb analysts' optimism (e.g. the Regulation Fair Disclosure, known as Reg FD; NYSE Rule 472 and NASD Rule 2711) have affected how analysts issue their recommendations and forecasts. The general conclusion is that with the adoption of those regulations, analysts' stock ratings became less optimistic, but analysts also strategically manipulate the announcement of recommendations with unfavorable contents to avoid penalty of giving negative stock ratings. This section explores how those regulation efforts affect the recommendation consistency developed in this study.

The three regulation rules that are relevant to the issues related to analysts' report were implemented at two different time spots. Regulation Fair Disclosure was implemented in October 2000; NASD Rule 2711, *Research Analysts and Research Reports* was adopted in May 2002 and the similar rule NYSE Rule 472 was also introduced at the same time. Therefore, the study defines the pre-regulation period as 1997-1999 and the corresponding post-regulation period as 2003-2005, where both pre-regulation and post-regulation period covers three years of records. The choice of this sub-sample period is to keep align with many early research that examined the regulation impact (Barber et al., 2010; Chen & Chen, 2009).

Table 7 presents the assessment of the regulation impact on the recommendation consistency. **Panel A** shows the distribution of the recommendation consistency in both pre- and post- regulation periods. The results indicate that favorable recommendations have higher consistency than unfavorable recommendations in both pre-regulation and post-regulation period. With the adoption of the regulation rules, the average consistency for favorable recommendation drops and the average consistency for unfavorable recommendation increases. At the aggregated level, the overall recommendation consistency level increases in the post-regulation period. **Panel B** presents the results of the regression as specified in Eq9 for both pre-regulation sample and post-regulation sample. The regression is used to identify whether the informative value of the recommendation consistency also changes due to the regulation impact. The result indicates that the information of the recommendation consistency became more valuable after the introduction of the regulation. In pre-regulation period, the consistency is insignificant for unfavorable recommendations and has only about 0.5% impact for favorable recommendations. In the post-regulation period, the coefficient of the consistency become

significantly larger and shows no difference between favorable recommendation and unfavorable recommendations. One possible explanation for this result is the reduced over-optimism and less biased estimate in analysts' report. With the improved quality of the inputs, the inter-connection among different outputs also increases its value.

5. Conclusions

This study examines the incremental value of analysts' forecasts that are issued at the same time to support their recommendations. The evidence shows that supported recommendations outperform isolated recommendations and increasing the level of consistency improves the effectiveness of the recommendations. The informative value of the recommendation consistency is reflected by the positive relationship between the consistency level and the magnitude of the market reactions to the recommendations. With the introduction of a series of regulations to reduce analysts' over-optimism, the consistency measure also improves its informative value. This recommendation consistency can also be utilized to achieve profit through the calendar-time portfolio construction approach. Taking long position on stocks with favorable recommendations at high consistency level and stocks with unfavorable recommendations at low consistency level and taking short position on stocks with favorable recommendations at low consistency level and stocks with unfavorable recommendation at high consistency level yields significant positive abnormal returns.

The study and its results should be of interest to both academics and practitioners alike. First, this study shifts the common focus in analyst literature from a narrowed scope of recommendations and earnings forecasts to a much broader coverage. Up to six types of forecasts across three-year horizon that are issued along with the recommendations are examined to identify the link between analysts' final product (recommendations) and the intermediate products (forecasts). Based on the technique of *Weight-of-Evidence* transformation, this study avoids the curse of incompleteness in the observations and reduces potential selection bias in the study. Second, this study sheds light on the value of analysts' recommendations by introducing the recommendation consistency measure, which reflects both the informative value and investment value. Investor can strategically use this consistency measure to selectively follow analysts' recommendations and enhance the profitability.

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Table 1. Distribution of Recommendations and Forecasts

Panel A: Distribution of Recommendations by Year

Year	Supported Recommendations				Isolated Recommendations				% Supported
	Favorable	Unfavorable	Total	% Favorable	Favorable	Unfavorable	Total	% Favorable	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1996	3,032	2,177	5,209	58.21%	4,309	3,235	7,544	57.12%	40.85%
1997	3,469	2,577	6,046	57.38%	3,622	2,760	6,382	56.75%	48.65%
1998	4,238	3,025	7,263	58.35%	4,536	3,642	8,178	55.47%	47.04%
1999	4,407	3,641	8,048	54.76%	5,116	4,030	9,146	55.94%	46.81%
2000	4,519	3,734	8,253	54.76%	4,684	3,733	8,417	55.65%	49.51%
2001	5,035	4,325	9,360	53.79%	5,432	4,153	9,585	56.67%	49.41%
2002	6,558	6,564	13,122	49.98%	9,773	10,722	20,495	47.68%	39.03%
2003	8,108	6,521	14,629	55.42%	4,528	4,536	9,064	49.96%	61.74%
2004	7,200	6,262	13,462	53.48%	3,547	3,445	6,992	50.73%	65.82%
2005	6,436	5,185	11,621	55.38%	3,472	2,906	6,378	54.44%	64.56%
2006	5,976	5,347	11,323	52.78%	3,515	3,812	7,327	47.97%	60.71%
2007	6,131	5,322	11,453	53.53%	3,966	4,741	8,707	45.55%	56.81%
2008	6,122	6,164	12,286	49.83%	4,103	4,036	8,139	50.41%	60.15%
2009	5,539	4,861	10,400	53.26%	2,726	2,743	5,469	49.84%	65.54%
2010	4,159	3,809	7,968	52.20%	2,405	2,553	4,958	48.51%	61.64%
Sum	80,929	69,514	150,443	53.79%	65,734	61,047	126,781	51.85%	54.27%

Panel B: Distribution of Forecasts by Year

Year	Supporting Forecasts				Isolated Forecasts #	% Supporting
	Favorable	Unfavorable	Total	% Favorable		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1996	4,545	3,049	7,594	59.85%	74,560	9.24%
1997	5,722	3,864	9,586	59.69%	78,450	10.89%
1998	6,449	4,801	11,250	57.32%	92,059	10.89%
1999	7,135	5,578	12,713	56.12%	94,304	11.88%

2000	7,666	5,793	13,459	56.96%	99,871	11.88%
2001	8,363	7,066	15,429	54.20%	139,282	9.97%
2002	13,175	12,926	26,101	50.48%	236,498	9.94%
2003	29,354	22,928	52,282	56.15%	359,155	12.71%
2004	34,974	29,809	64,783	53.99%	492,904	11.62%
2005	36,160	28,429	64,589	55.98%	539,756	10.69%
2006	35,771	30,335	66,106	54.11%	596,497	9.98%
2007	37,040	29,613	66,653	55.57%	622,028	9.68%
2008	39,017	39,030	78,047	49.99%	666,919	10.48%
2009	40,813	36,037	76,850	53.11%	624,478	10.96%
2010	32,022	29,566	61,588	51.99%	681,184	8.29%
Sum	338,206	288,824	627,030	53.94%	5,397,945	10.41%

Panel C: Distribution of Forecasts by Type

Forecast Type	Supporting Forecasts				Isolated Forecasts	% Supporting
	Favorable	*Unfavorable*	*Total*	*% Favorable*	*#*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
EPS	114,114	94,806	208,920	54.62%	1,686,951	11.02%
SAL	62,327	54,024	116,351	53.57%	1,020,486	10.23%
NET	49,854	42,846	92,700	53.78%	821,052	10.14%
PRE	46,414	39,836	86,250	53.81%	769,637	10.08%
OPR	37,888	32,430	70,318	53.88%	605,870	10.40%
EBT	27,609	24,882	52,491	52.60%	493,949	9.61%
Sum	338,206	288,824	627,030	53.94%	5,397,945	10.41%

Note: This table contains the descriptive statistics for the sample data.

Panel A shows distribution of recommendations by year. The first column denotes the year of announcement date. Column 2-5 describe the frequency distribution of recommendations with supporting forecasts and column 6-9 describe the distribution of isolated recommendations. Column 2 and column 6 are the count of favorable recommendations. Column 3 and column 7 are the count of unfavorable recommendations. Column 4 is the sum of column 2-3, and column 8 is the sum of column 6-7. Column 5(9) is the ratio

of column 2(6) and column 4(8), which measures the proportion of favorable recommendations for supported (isolated) recommendations. Column 10 represents the proportion of supported recommendations for each year.

Panel B shows the distribution of forecasts by year. The first column denotes the year of announcement date. Column 2-5 describe the frequency distribution of supporting forecasts and column 6 shows the count of isolated forecasts. Column 7 shows the proportion of supporting forecasts.

Panel C shows the distribution of forecasts by estimate type. The first column denotes the types of forecasts. Column 2-5 describe the frequency distribution of supporting forecasts and column 6 shows the count of isolated forecasts. Column 7 shows the proportion of supporting forecasts.

Table 2. Information Value of Forecasts Signals

Panel A: Information Value by Forecast Type and Forecast Horizon

Forecast Type (K)	Forecast Horizon Indicator (H)			
	1-Year	2-Year	3-Year	Sum
(1)	(2)	(3)	(4)	(5)
EPS: Earning Per Share	**0.051**	**0.113**	**0.020**	**0.184**
NET: Net Income	0.012	0.035	0.011	0.058
SAL: Revenue	0.015	0.027	0.007	0.050
PRE: Pre-tax Profit	0.010	0.030	0.009	0.049
OPR: Operating Profit	0.009	0.024	0.006	0.039
EBT: EBIT Per Share	0.005	0.012	0.005	0.022
Sum of Non-EPS	**0.024**	**0.066**	**0.020**	**0.110**
Sum of Total	0.102	0.241	0.059	0.402

Panel B: Modified Information Value (Incremental) by Forecast Type and Forecast Horizon

Forecast Type (K)	Forecast Horizon Indicator (H)			
	1-Year	2-Year	3-Year	Sum
(1)	(2)	(3)	(4)	(5)
EPS: Earning Per Share	**0.051**	**0.113**	**0.020**	**0.184**
NET: Net Income	0.012	0.035	0.011	0.058
SAL: Revenue	0.015	0.027	0.007	0.049
PRE: Pre-tax Profit	0.010	0.030	0.009	0.049
OPR: Operating Profit	0.009	0.024	0.006	0.039
EBT: EBIT Per Share	0.005	0.012	0.005	0.022
Sum of Non-EPS	0.051	0.128	0.038	0.217
Sum of Total	0.101	0.241	0.059	0.401

Note: This table contains the summary of the Information Value for the 18 forecasts signals. Panel A is based on the original definition of Information Value; panel B is based on the modified version to evaluate the incremental Information Value. Column 1 denotes the six forecasts type and column 2-6 denote the three forecast horizons. Column 7 is the sum of column 2-6.

Table 3. Regression of Market Reactions to Recommendations on Support Indicator

Target Variable: BHAR (in%)	Model A	Model B	Model C
Supported	0.568***	0.583***	0.583***
	(0.043)	(0.043)	(0.043)
Fav	-0.203***	-0.028	-0.039
	(0.040)	(0.043)	(0.043)
Supported*Fav	-0.359***	-0.421***	-0.422***
	(0.054)	(0.055)	(0.055)
Rec_Bold		0.919***	0.909***
		(0.032)	(0.032)
Rec_Rev=New		-0.270***	-0.278***
		(0.040)	(0.040)
Rec_Rev=Reiteration		-0.678***	-0.707***
		(0.063)	(0.063)
Rec_Rev=Upgrade		-0.031	-0.092*
		(0.050)	(0.050)
Rec_Elasped		-0.000***	-0.000***
		(0.000)	(0.000)
Rec_N		0.019***	0.010
		(0.007)	(0.007)
Rec_Dispersion		0.328***	0.329***
		(0.057)	(0.057)
Rec_Consensus		-0.090**	-0.143***
		(0.040)	(0.041)
Exp			0.072
			(0.055)
Broker_Size			-0.000
			(0.003)
Mkt_Ret			-3.293**
			(1.459)
Mkt_VIX			0.010***
			(0.002)
Stock_Ret			1.650***
			(0.348)
Stock_Size			-0.560***
			(0.071)
Num. obs.	277224	267634	267327
R^2	0.386	0.396	0.397
Adj. R^2	0.220	0.234	0.235

Note: ***, **, * indicates significance at 0.01, 0.05 and 0.10 levels respectively. Standard errors are reported in parenthesis.

This table presents market reactions to analysts' recommendations on the dummy indicator of being supported by forecasts. Dependent variable *BHAR* is defined as the cumulative raw return of the recommended stock minus the cumulative return of a corresponding benchmark portfolio from day 0 to day +2. The rate of return of the benchmark portfolio is calculated by first sorting all the stocks in CRSP database into quintiles based on the Book-to-Market ratio (BM ratio) and the capital market, then uses a value-weight daily rebalance to obtain the portfolio rate of return that matches the BM-quintile×Size-quintile of the recommended stock.

Independent variable *Supported* is a dummy indicating Rec_{ijt} is being supported by at least one forecast, *Fav* is a dummy indicating Rec_{ijt} is a favorable recommendation, *Supported* × *Fav* is the interaction term between *D_Supported* and *Rec_Fav*.

Detailed definitions of control variables are provided in section 3.2.

Column 1 reports the model that only controls for analyst-year and stock-year fixed-effects; column 2 reports the model that adds the control for the characteristics of recommendations; column 3 reports the model that further adds the control for the characteristics of analysts, stocks and financial market. Standard errors are reported in parenthesis.

Table 4. Exploratory Analysis of Recommendation Consistency Measure

Panel A: Market Reactions by Consistency Quintile

Consistency Quintile	BHAR (%) of Analysts' Recommendations					
	Unfavorable		Favorable		Unfavorable - Favorable	
	Mean	(S.E.)	Mean	(S.E.)	Mean	(S.E.)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.020	(0.042)	-1.215	(0.070)	1.235***	(0.087)
2	1.125***	(0.049)	0.080	(0.063)	1.045***	(0.084)
3	1.935***	(0.068)	0.535***	(0.042)	1.400***	(0.081)
4	1.759***	(0.066)	0.657***	(0.038)	1.102***	(0.078)
5	3.839***	(0.096)	1.715***	(0.040)	2.123***	(0.105)

Panel B: Distribution of Analyst, Recommendation, Stock and Market Characteristics by Consistency Quintile

Consistency Quintile	Exp	Broker Size	Forecast Count	Mkt_Ret	Mkt_VIX	Stock_Ret	Stock_Siz
	Mean (S.E.)	Mean (S.E.)	Mean (S.E.)	Mean (S.E.)	Mean (S.E.)	Mean (S.E.)	Mean (S.E
(1)	(2)	(3)	(5)	(6)	(7)	(7)	(7)
1	9.137 (0.036)	64.846 (0.364)	5.743 (0.029)	0.034 (0.006)	22.264 (0.053)	-0.657 (0.030)	11565.148 (17
2	9.475 (0.036)	61.492 (0.361)	4.496 (0.024)	0.018 (0.006)	22.812 (0.054)	-0.687 (0.026)	11237.761 (17
3	9.581 (0.037)	58.903 (0.357)	4.622 (0.025)	-0.009 (0.006)	22.834 (0.056)	-0.298 (0.025)	10366.250 (158
4	9.167 (0.035)	63.191 (0.366)	4.701 (0.026)	0.035 (0.006)	22.583 (0.050)	-0.414 (0.026)	11302.290 (17
5	9.418 (0.037)	62.108 (0.358)	6.513 (0.030)	0.027 (0.006)	22.058 (0.055)	-0.126 (0.032)	10700.480 (16

Note: ***, **, * indicates significance at 0.01, 0.05 and 0.10 levels respectively. Standard errors are reported in parenthesis.

Panel A reports the distribution of *BHAR* by the recommendation consistency quintile. The statistical tests are performed on a right-tail one-sample t-test for each consistency quintile in column 2 and column 4; and a right-tail two-sample t-test, assuming unequal variance, in column 6 *BHAR* is calculated as the cumulative raw return of the recommended stock minus the cumulative return of a corresponding benchmark portfolio from day 0 to day +2. The sign of *BHAR* of the unfavorable recommendations is reversed.

Panel B reports the distribution of the selected control variables by recommendation consistency quintile. Column 1 denotes the quintile of the recommendation consistency, column 2-8 denotes the corresponding control variables in the empirical analysis.

Table 5. Regression of Stock Price Reactions to Recommendations on Recommendation

Consistency

Target Variable: BHAR (in%)	Model A	Model B	Model C
Consistency	**8.743*****	**8.239*****	**8.637*****
	(0.275)	(0.280)	(0.287)
Fav	**-0.827*****	**-0.566****	-0.288
	(0.219)	(0.226)	(0.233)
Consistency*Fav	-0.580	**-0.835****	**8.637*****
	(0.409)	(0.425)	(0.287)
Rec_Bold		0.822***	**0.800*****
		(0.047)	(0.047)
Rec_Rev=New		-0.303***	**-0.365*****
		(0.061)	(0.061)
Rec_Rev=Reiteration		-1.027***	**-1.102*****
		(0.109)	(0.109)
Rec_Rev=Upgrade		-0.025	**-0.184****
		(0.077)	(0.078)
Rec_Elasped		-0.000***	**-0.000*****
		(0.000)	(0.000)
Rec_N		0.038***	**0.034*****
		(0.010)	(0.010)
Rec_Dispersion		0.306***	**0.308*****
		(0.084)	(0.084)
Rec_Consensus		-0.283***	**-0.239*****
		(0.060)	(0.061)
Exp			-0.096
			(0.079)
Broker_Size			0.001
			(0.004)
Mkt_Ret			**-4.444****
			(2.195)
Mkt_VIX			**0.011*****
			(0.004)
Stock_Ret			**6.548*****
			(0.535)
Stock_Size			**-0.319*****
			(0.108)
Num. obs.	150,441	145,735	145,564
R^2	0.523	0.530	0.532
Adj. R^2	0.320	0.332	0.334

Note: ***, **, * indicates significance at 0.01, 0.05 and 0.10 levels respectively. Standard errors are reported in parenthesis.

This table presents the regression results of the market reactions to analysts' recommendations on recommendation consistency. Dependent variable $BHAR$ is defined as the cumulative raw return of the recommended stock minus the cumulative return of a corresponding benchmark portfolio from day 0 to day +2. The rate of return of the benchmark portfolio is calculated by first sorting all the stocks in CRSP database into quintiles based on the Book-to-Market ratio (BM ratio) and the capital market, then uses a value-weight daily rebalance to obtain the portfolio rate of return that matches the BM-quintile×Size-quintile of the recommended stock.

Independent variable $Consistency$ is the measure of recommendation consistency as defined by Eq (7) and Eq (8). Fav is a dummy indicating whether Rec_{ijt} is a favorable recommendation, $Consistency \times Fav$ is the interaction term between $Consistency$ and Fav.

Detailed definitions of control variables are provided in section 3.2.

Model A only controls for analyst-year and stock-year fixed-effects; Model B adds the control for the characteristics of recommendations; Model C is the full model.

Table 6. Portfolio Performance by Consistency Quintile Ranks

Panel A: Performance of Value-Weighted Portfolio

Consistency Quintile	Daily Abnormal Return (Jensen's Alpha in %)					
	Favorable Portfolio		Unfavorable Portfolio		Favorable - Unfavorable	
	Mean	Standard Errors	Mean	Standard Errors	Mean	Standard Errors
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	-0.047***	(0.012)	0.000	(0.003)	-0.058***	(0.013)
2	0.002	(0.008)	-0.005	(0.003)	-0.004	(0.010)
3	0.010***	(0.003)	-0.041***	(0.007)	0.039***	(0.009)
4	0.005***	(0.002)	-0.018	(0.012)	0.012	(0.013)
5	0.021***	(0.003)	-0.097***	(0.011)	0.107***	(0.012)
High - Low	0.068***	(0.004)	-0.079***	(0.005)	0.165***	(0.008)

Panel B: Performance of Equal-Weighted Portfolio

Consistency Quintile	Daily Abnormal Return (Jensen's Alpha in %)					
	Favorable Portfolio		Unfavorable Portfolio		Favorable - Unfavorable	
	Mean	Standard Errors	Mean	Standard Errors	Mean	Standard Errors
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.020***	(0.005)	0.036***	(0.005)	-0.028***	(0.005)
2	0.039***	(0.005)	0.022***	(0.005)	0.005	(0.005)
3	0.044***	(0.004)	-0.013**	(0.006)	0.046***	(0.005)
4	0.036***	(0.004)	0.008	(0.008)	0.017**	(0.007)
5	0.056***	(0.004)	-0.041***	(0.007)	0.085***	(0.006)
High - Low	0.036***	(0.004)	-0.055***	(0.005)	0.113***	(0.004)

Note: ***, **, * indicates significance at 0.01, 0.05 and 0.10 levels respectively. Standard errors are reported in parenthesis.

This table presents the summary of the portfolio daily abnormal return (*Jensen's Alpha*) from a four-factor risk model. Each portfolio is formulated by following recommendations in its corresponding consistency quintile rank. "Favorable" portfolio holds positions for stocks with favorable recommendations, "Unfavorable" portfolio holds positions for stocks with unfavorable recommendations.

The statistical tests are performed on a two-tailed t-test for each portfolio based on the rank of consistency quintile. The first column denotes the consistency quintile rank, column 2-3 present performance of "Favorable" portfolio; column 4-5 present performance of "Unfavorable" portfolio; column 6-7 present performance of taking long position in "Favorable" portfolio and short position in "Unfavorable" portfolio.

Panel A reports the portfolio based on value-weight rebalancing. **Panel B** reports the portfolio based on equal-weight rebalancing.

Table 7. Recommendation Consistency vs. Regulation Effort

Panel A: Distribution of Consistency Measure

	Favorable Recommendations		Unfavorable Recommendations		All Recommendations	
	Mean	Std	Mean	Std	Mean	Std
	(1)	(2)	(3)	(4)	(5)	(6)
Pre-Regulation	0.5829	(0.1025)	0.4568	(0.1075)	0.5276	(0.122)
Post-Regulation	0.5626	(0.1128)	0.4968	(0.1164)	0.5322	(0.1191)

Panel B: Regression of BHAR on Consistency in Sub-Samples

Target Variable: BHAR (in%)	Pre-Reg Sample	Post-Reg Sample
Consistency	-0.357	**11.675*****
	(0.829)	(0.503)
Fav	**-2.286*****	-0.650
	(0.646)	(0.403)
Consistency*Fav	**3.126****	-0.860
	(1.235)	(0.760)
Rec_Bold	0.145	**0.797*****
	(0.141)	(0.077)
Rec_Rev=New	**-0.366****	**-0.696*****
	(0.158)	(0.106)
Rec_Rev=Reiteration	-0.317	**-1.490*****
	(0.264)	(0.193)
Rec_Rev=Upgrade	-0.121	-0.131
	(0.206)	(0.133)
Rec_Elasped	-0.000	-0.000
	(0.000)	(0.000)
Rec_N	0.014	0.010
	(0.028)	(0.017)
Rec_Dispersion	0.154	**0.539*****
	(0.232)	(0.139)
Rec_Consensus	-0.077	**-0.279*****
	(0.171)	(0.101)
Exp	-0.169	0.216
	(0.221)	(0.162)
Broker_Size	0.004	0.002
	(0.008)	(0.008)
Mkt_Ret	2.386	3.305
	(6.851)	(6.158)
Mkt_VIX	0.017	**0.035****

	(0.012)	(0.014)
Stock_Ret	**5.367*****	**-2.376****
	(1.394)	(1.068)
Stock_Size	-0.107	0.009
	(0.245)	(0.228)
Num. obs.	20269	38552
R^2	0.533	0.530
Adj. R^2	0.250	0.364

Note: ***, **, * indicates significance at 0.01, 0.05 and 0.10 levels respectively. Standard errors are reported in parenthesis.

Panel A presents the distribution recommendation consistency in both pre-regulation (1997-2009) and post-regulation period (2003-2005). Column 1-2 shows the mean and standard deviation of recommendation consistency for favorable recommendations; column 3-4 shows the mean and standard deviation of recommendation consistency for unfavorable recommendations; column 5-6 shows the mean and standard deviation for all recommendations in the sub-sample period.

Panel B the regression results of the market reactions to analysts' recommendations on recommendation consistency. Dependent variable $BHAR$ is defined as the cumulative raw return of the recommended stock minus the cumulative return of a corresponding benchmark portfolio from day 0 to day +2. The rate of return of the benchmark portfolio is calculated by first sorting all the stocks in CRSP database into quintiles based on the Book-to-Market ratio (BM ratio) and the capital market, then uses a value-weight daily rebalance to obtain the portfolio rate of return that matches the BM-quintile×Size-quintile of the recommended stock.

Independent variable $Consistency$ is the measure of recommendation consistency as defined by Eq7 and Eq8. Fav is a dummy indicating whether Rec_{ijt} is a favorable recommendation, $Consistency \times Fav$ is the interaction term between $Consistency$ and Fav.

Detailed definitions of control variables are provided in section 3.2.

DUAL-DYNAMIC RETIREMENT INCOME STRATEGY FOR BETTER RETIREMENT OUTCOMES

[Working Paper]

ABSTRACT

Motivated by the persistent low expected return market environment, we propose a dual-dynamic retirement management strategy aiming at improving different retirement outcomes in a decumulation context. Utilizing a Monte Carlo simulation approach, the present study reveals that the dual-dynamic retirement strategy could significantly improve the survival rate of a retirement portfolio and provide more sustainable retirement coverage for retirees over a twenty-year hypothetical retirement span. Therefore, the dual-dynamic retirement solution that adjusts the asset allocation and the annual withdrawal rate simultaneously could be a new option for the retirement markets nowadays.

Keywords: retirement solution, target volatility, dynamic annual withdrawal, asset allocation.

1. INTRODUCTION

As more population enters retirement, how to optimize retirement planning has become one of the major topics in retirement markets. According to The Population 65 Years and Older in the United States: 2016 published by the United States Census Bureau in 2018, 9% of the world population (i.e., approximately 617 million people) were aged 65 or older, and foreseeably, this number will increase to 12% (i.e., about 1 billion people) by 2030 (Roberts, Ogunwole, Blakeslee, & Rabe, 2018). Recently, new challenges have raised in the retirement domain due to a passive expected return of equity markets (Horneff, Maurer, & Mitchell, 2018), and a persistent low interest rate runs across bond markets (Boubaker, Gounopoulos, Nguyen, & Paltalidis, 2017). This leads to a myriad of problems since most of the retirement portfolios rely heavily on equities and bonds to yield an adequate amount of capital such that retirees could support their life after retirement.

To date, various retirement strategies have been proposed by different retirement practitioners and scholars in response to the low expected return market environment. In the pension accumulation phase, for example, the classical target-date concept is proved to be an effective and simple pension solution (Fisch & Turner, 2018) which has been used as the default pension investment strategy in the 401(k) plans in the United States (Chan, Chen, Chiang, & Lai, 2017; Kilgour, 2019). Others have shown that a dedicated adjustment to the target-date pension

solution, such as implementing a liability-based asset allocation, could improve various pension outcomes that meet the requirements of pension investors (Crook, 2019). Studies about how to improve retirement outcomes in the decumulation phase are also well-documented. In general, during the retirement portfolio decumulation phase, different retirement outcomes could be achieved by changing the asset allocation (Liu, Qiu, Zhao, & Zhu, 2019; Louton, McCarthy, Rush, Saraoglu, & Sosa, 2015) or adjusting the annual withdrawal rate (Blanchett, 2017; Clare, Seaton, Smith, & Thomas, 2017; DeJong Jr & Robinson, 2017). Early studies have suggested that a retirement portfolio with a simple constant asset allocation could provide attractive portfolio returns (Ho, Milevsky, & Robinson, 1994; Milevsky, Ho, & Robinson, 1997) and a retirement portfolio with a risky asset allocation between 50% to 75% is preferred (Bengen, 1994). More recent works have confirmed that a fixed asset allocation of 60% equity and 40% bond is an effective retirement solution for investors to implement under different market conditions (Estrada, 2016). In terms of the annual withdrawal rate, which is another important factor that determines the sustainability of a retirement portfolio, prior studies have proposed a 4% constant annual withdrawal rate as a fruitful annual withdrawal amount in different market contexts (Bengen, 1994).

Given the volatile market conditions, however, recent research has shown that a retirement portfolio with dynamic asset management components such as the constant proportion portfolio insurance (CPPI) (Bernard & Kwak, 2016; Temocin, Korn, & Selcuk-Kestel, 2018) and the target volatility concept (Sergio Albeverio, Steblovskaya, & Wallbaum, 2018) could be more suitable in the retirement markets today. Lately, studies have indicated that the classical target-date strategy or so-called the lifecycle pension solution needs better asset diversification (Dhillon, Ilmanen, & Liew, 2016), and the implicit assumption that asset volatility is stationary is not sound (Kritzman, 2017). New evidence has suggested that the 4% annual withdrawal rule is still deemed to be a suitable retirement solution in the pension decumulation context today but only under a mean-variance driven asset allocation strategy, which adjusts the asset allocation of a retirement portfolio periodically (Dang, Forsyth, & Vetzal, 2017).

Hence, motivated by the recently low market return environment and the increasing popularity of dynamic retirement solutions worldwide, we propose a dual-dynamic retirement management strategy that adjusts the asset allocation and the annual withdrawal rate at the same time with regard to different risk-return profiles of the retirement portfolio in a decumulation

context. To do so, we combine a dynamic risk control component called the target volatility mechanism with an existing performance-based annual withdrawal framework. Using analysis based on forward-looking returns over a twenty-year hypothetical retirement span, we reveal that retirement portfolios with a combination of the dynamic annual withdrawal strategy and a target volatility mechanism (addressed as the dual-dynamic retirement strategy thereafter) could provide better retirement outcomes (i.e., the average ending value, the survival rate, and the sustainability) compared to benchmark portfolios with only the dynamic annual withdrawal strategy and a constant asset allocation (addressed as benchmark strategy thereafter).

The rest of this paper is organized as follows: section two introduces the simulation model, the benchmark retirement strategy, and the dual-dynamic retirement strategy. Section three presents the simulation results and section four concludes this paper.

2. MATERIAL AND METHODOLOGY

To evaluate the effectiveness of the dual-dynamic retirement solution (i.e., the retirement solution with the dynamic annual withdrawal rate and the target volatility mechanism) proposed in this paper, we compare the performance of two pension portfolios – an aggressive one and a conservative one – each of which runs under the dual-dynamic retirement strategy and a benchmark strategy. We conduct a Monte Carlo simulation based on the classical Geometric Brownian Motion ($i.e., \frac{dS}{S} = \mu dt + \sigma dz$) (Hull, 2012) to simulate the returns of equity and bond 10,000 over a twenty-year retirement span. Table 1 summarizes the input parameters used for the Geometric Brownian Motion model to simulate the equity and the bond returns. The rest of this section introduces the retirement portfolios with the benchmark retirement strategies and the dual-dynamic retirement strategies examined in this paper.

Table 1. Input parameters for simulation

	Annual expected return	Annual volatility
Equity market	7%	15%
Bond market	3%	6%

2.1 The Benchmark Retirement Strategies

Selecting an appropriate benchmark to evaluate the performance of a portfolio is often a challenging exercise. Prior research has shown the merit of a retirement portfolio with a static asset allocation strategy. In particular, it is evident that a balanced mandate which consists of 50% equity and 50% bond could serve as a suitable benchmark to evaluate the performance of other retirement

plans due to its reliable performance and simple management procedure over time (Bengen, 1994; Finke & Blanchett, 2016). Therefore, we first consider a retirement portfolio with a constant asset allocation of 50% equity and 50% bond as the benchmark to the aggressive retirement portfolio. Further, a retirement portfolio with a constant asset allocation of 30% equity and 70% bond is taken as the benchmark to the conservative retirement portfolio.

We follow Frank, Mitchell, and Blanchett (2011) to build the dynamic annual withdrawal strategy adopted in this paper. In general, the dynamic annual withdrawal strategy is a retirement withdrawal measure that adjusts the annual withdrawal rate based on the annual performance of the retirement portfolio. Specifically, the annual withdrawal rate gets adjusted according to the previous annual return of the retirement portfolio. For both of the aggressive retirement portfolio and the conservative retirement portfolio, the annual withdrawal rate increases (decreases) by 1% if the annual return in the present year outperforms (underperforms) the annual return in the previous year by 0.5 standard deviations of the return. For example, suppose the annual return of the retirement portfolio in 2001 was 5% with a standard deviation of 6%. In 2002, the retirement portfolio successfully generated an annual return of greater than $5\% + 0.5 \times 6\% = 8\%$. In this case, the annual withdrawal rate would increase to 6% for the coming year. In this paper, we examine the performance of the retirement portfolio under the benchmark strategy and the dual-dynamic strategy with a starting annual withdrawal rate of 4%, 5%, 6%, 7%, and 8% at the beginning of the hypothetical retirement span. We then set a minimum annual withdrawal rate of 2% as the basic coverage for the retirees.

2.2 The Dual-Dynamic Retirement Strategies

The newly proposed dual-dynamic retirement strategy follows the same annual withdrawal strategies as the ones used in the benchmark strategies (i.e., the annual withdrawal rate increases (decreases) by 1% if the annual return in the present year outperforms (underperforms) the annual return in the previous year by 0.5 standard deviations of the return). In addition, the dual-dynamic retirement strategy contains a dynamic asset allocation component (i.e., the target volatility mechanism) which adjusts the asset allocation of a retirement portfolio on a daily basis. Following S Albeverio, Steblovskaya, and Wallbaum (2013), the asset allocation of the retirement portfolios under the target volatility mechanism is determined by a ratio between a pre-determined target volatility and a realized market volatility as follows:

$$A_{risky} = min\left\{\frac{a_1}{a_2}; b\right\}$$

$$A_{risk-free} = 1 - A_{risky}$$

In the formulas above, a_1 represents the target volatility specified at the beginning of the hypothetical retirement scheme, and a_2 stands for the realized market volatility represented by the annualized volatility based on the market returns over the past twenty business days. To prevent the retirement portfolio from overexposure to risky assets, we also set up a maximum risky asset allocation represented by b. In this study, the maximum leverage is set to 200% for the aggressive retirement portfolio and 100% for the conservative retirement portfolio. To determine the target volatility, the annualized volatilities of the retirement portfolios that follow the constant asset allocations under the benchmark strategies are calculated based on the MSCI US market index and the US aggregate bond index from 1991 to 2017. According to the annualized volatilities of the retirement portfolios under the benchmark strategies (i.e., 10.77% for the 50% equity and 50% bond retirement portfolio and 8.00% for the 30% equity and 70% equity portfolio), we adopt a target volatility of 10% and 8% for the aggressive retirement portfolio and the conservative retirement portfolio respectively. Since the target volatility mechanism adjusts the asset allocation on a daily basis, the potential transaction cost could have a significant influence on the performance of a retirement portfolio. Hence, we also take into account a 20-bps transaction cost when the rebalancing between risky and risk-free assets occurs.

2.3 Hypothetical Retirement Span

In order to evaluate the performance of the two types of retirement portfolio under the dual-dynamic strategy and the benchmark strategy examined in this paper, we consider a fix twenty-year hypothetical retirement span with a 2% annual inflation rate. We then compare different risk-return profiles of the aggressive portfolio and the conservative portfolio under the dual-dynamic strategy and the benchmark strategy over the twenty-year retirement scheme.

3. RESULTS

Table 2 shows the simulation results under the twenty-year retirement span. In the aggressive portfolio case, retirement portfolio under the dual-dynamic strategy outperforms the benchmark strategy in all starting annual withdrawal rate scenarios. For instance, in contrast with the portfolio with the benchmark strategy, its counterpart with the dual-dynamic strategy can improve the portfolio survival rate by 1.02%. In the conservative portfolio case, retirement

portfolio under the dual-dynamic strategy demonstrates even higher survival rates compared to that under the benchmark strategy in all starting annual withdrawal scenarios, suggesting that the dual-dynamic strategy could improve portfolio survival rate over the twenty-year retirement span.

Table 2. Retirement portfolio survival rates (twenty-year retirement span)

Aggressive Retirement Portfolio			
Starting Annual Withdrawal Rate	Dual-dynamic Strategy	Benchmark Strategy	Difference
4%	85.63%	84.61%	1.02%
5%	72.00%	69.52%	2.48%
6%	53.97%	50.53%	3.44%
7%	35.47%	31.70%	3.77%
8%	20.28%	17.08%	3.20%
Conservative Retirement Portfolio			
Starting Annual Withdrawal Rate	Dual-dynamic Strategy	Benchmark Strategy	Difference
4%	85.81%	82.73%	3.08%
5%	71.98%	64.90%	7.08%
6%	52.83%	43.46%	9.37%
7%	32.69%	23.95%	8.74%
8%	17.70%	10.61%	7.09%

Figure 1 and Figure 2 show the portfolio value changing paths of the aggressive retirement portfolio and the conservative retirement portfolio respectively over the twenty-year retirement span.

Figure 1. Retirement Portfolio Value Changing Paths
Aggresive Retirement Portfolio
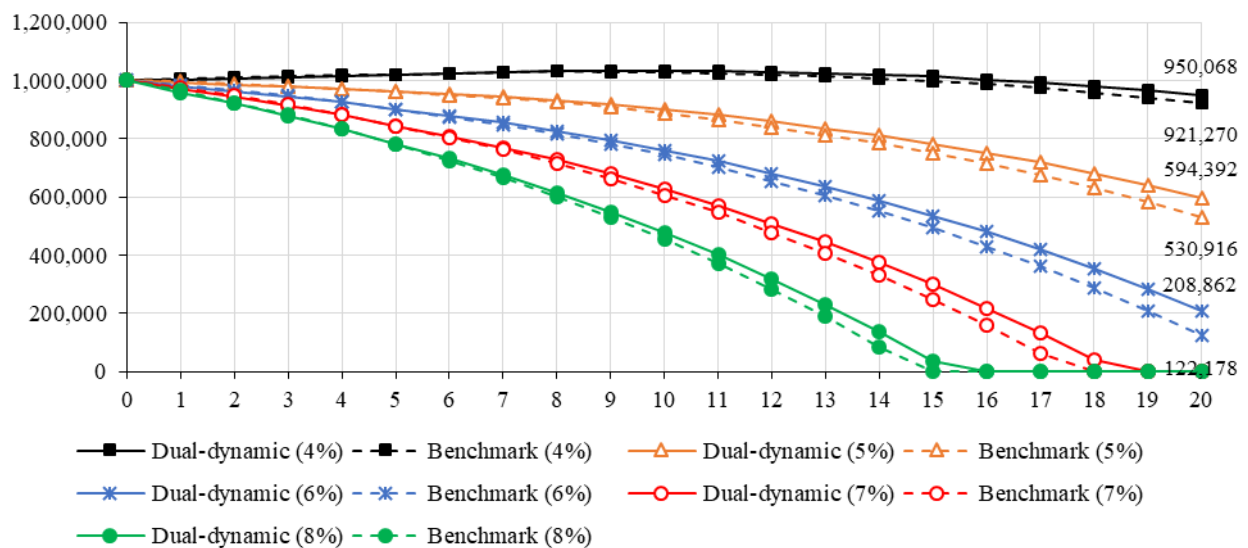
Note: Numbers in the parentheses show the starting annual withdrawal rates.

Figure 2. Retirement Portfolio Value Changing Paths
Conservative Retirement Portfolio
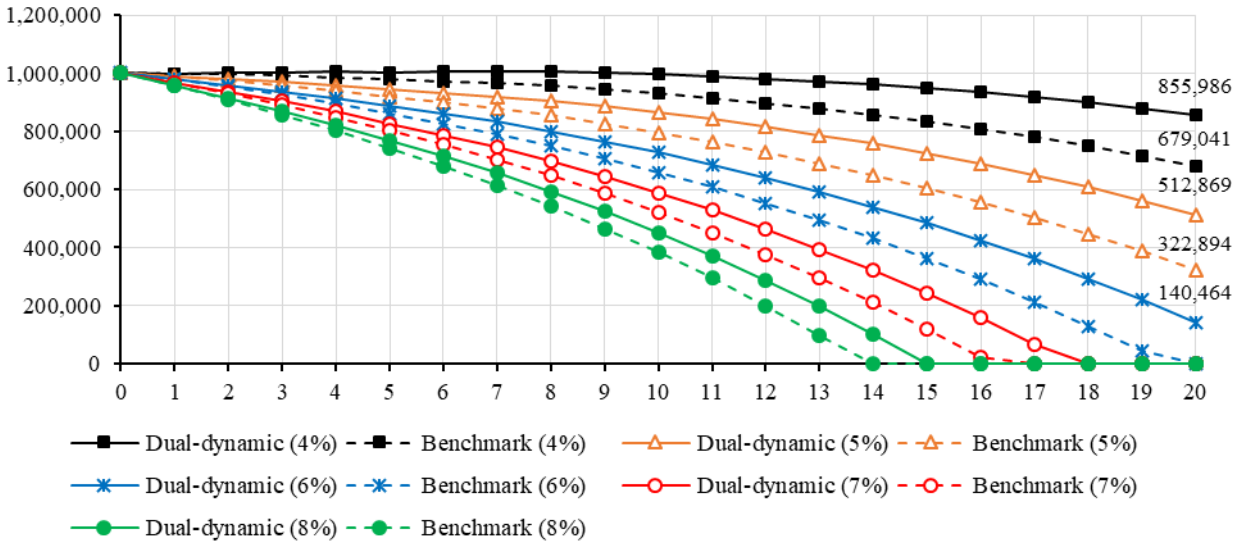
Note: Numbers in the parentheses show the starting annual withdrawal rates.

Consistent with the survival rate analysis, the retirement portfolios under the dual-dynamic strategy ends up with higher portfolio values compared to the one with the benchmark strategy. Specifically, under the dual-dynamic retirement strategy, the aggressive portfolio ends up with approximately 950,000, 590,000, 210,000 dollars with the starting annual withdrawal rate of 4%, 5%, and 6% respectively. Within the same starting annual withdrawal rate scenarios, in contrast with the dual-dynamic retirement strategy, the benchmark strategy can only generate about 920,000, 530,000, and 120,000 dollars on average at the end of the twenty-year retirement span. Moreover, although the retirement portfolio runs out of capital under both retirement strategies when the starting annual withdrawal rate is 7% or 8%, the retirement portfolio with the dual-dynamic retirement strategy could provide one additional year of coverage compared to the counterpart portfolio with the benchmark strategy.

The dual-dynamic retirement solution has shown even more prominent results in the conservative portfolio case. When the starting annual withdrawal rate is 4% or 5%, in contrast to the retirement portfolio with the benchmark strategy, which ends up with 680,000, and 320,000 dollars, the retirement portfolio with the dual-dynamic retirement strategy ends at around 860,000 and 510,000 dollars respectively. When the starting annual withdrawal rate is 6%, 7% or 8%, the retirement portfolio with the benchmarks strategy runs out of capital prior to that with the dual-

dynamic retirement solution, suggesting that the dual-dynamic retirement solution could provide more sustainable retirement coverage within the same decumulation context.

4. CONCLUSION

Given the volatile market condition and the low expected return market environment, we propose a dual-dynamic retirement strategy that rebalances the asset allocation and adjusts the annual withdrawal rate of the retirement portfolio simultaneously. Numerical results based on the forward-looking returns have suggested that the dual-dynamic retirement management strategy could improve various retirement outcomes when looking at a fixed twenty-year retirement scheme. Prior research has shown that the target volatility mechanism is an effective risk control measure (Grasselli & Marabel Romo, 2016) in the pension accumulation phase, which provides sufficient capital protection in volatile market conditions (Sergio Albeverio et al., 2018; Sergio Albeverio & Wallbaum, 2019). Extending the prior studies, the present work has suggested that the target volatility mechanism could also provide desirable retirement outcomes when combining it with other retirement management strategies in the decumulation context. This is rather important since a retirement plan often faces challenges such as sequencing risk and longevity risk which could exhaustive the capital of a portfolio when the retirees start making withdrawals after retirement. Hence, having a reliable retirement management strategy that could continue offering effective retirement portfolio protection during the decumulation phase is necessary.

Despite the findings and the contributions in this paper, it is also worth to mention that there are several limitations. First, the present study aims at proposing a feasible dynamic retirement strategy that adjusts the asset allocation and the annual withdrawal rate at the same time. Therefore, we use a simple dynamic annual withdrawal strategy that changes the annual withdrawal rate based on portfolio performance only. Second, we consider a retirement portfolio consists of equity and bond though there are more sophisticated financial derivatives available for a retirement portfolio. Finally, we use the classical Geometric Brownian Motion to simulate equity and bond returns. Therefore, we assume that no special financial events such as the financial crisis in 2008 would happen in our hypothetical retirement spans.

Based on the findings and the limitations in the present study, a future study may continue investigating the possibility of combining the target volatility mechanism, which has been proved to be an effective risk control measure in the retirement decumulation phase, with other performance-driven annual withdrawal strategies. Moreover, asset allocation and annual

withdrawal rate are two of the reasons that determine the performance of a retirement portfolio. Other social factors such as tax (Brown, Cederburg, & O'Doherty, 2017; Huang & Milevsky, 2016) and population longevity risk (Mayhew, Smith, & Wright, 2018; Simsek, Kim, Kim, & Mulvey, 2018) could also have various impacts on the performance of a retirement portfolio and could be interesting topics to investigate.

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MACROECONOMIC RISK AND HEDGE FUND RETURNS: REVISITED[1]

ABSTRACT

In this working paper we seek to improve return forecasts of directional and semi-directional hedge fund investment styles. We propose two major contributions. First, we employ modeling methods where both the model selection and factor selection are determined by both the time-varying macroeconomic/financial market environment and the hedge fund style return process. Second, we employ a unique database of macroeconomic variables representative of the actual information set available at the time fund managers made their investments. We believe that these contributions will provide better representations of the return generating process of certain hedge fund styles and lead to improved forecasts.

Keywords: Hedge funds, Return Predictability, Forecasts

I.   Introduction

Previous research has shown that changes in the macroeconomic environment lead to changes in financial markets, such as changing risk premiums and volatility, and these changes in turn lead to varying opportunities for hedge funds to advantageously adjust their strategies. The extent to which hedge funds can successfully forecast these changes in both macroeconomic and financial markets determine their success in generating consistently positive risk-adjusted returns. Indeed, the return generating process of different hedge fund strategies will reflect this forecasting, or market-timing ability. Bali, Brown, and Caglayan (2014) demonstrate that the exposure of hedge funds to macroeconomic risk is a more powerful determinant of hedge fund returns than the more common method of relating hedge fund returns to their exposure to financial market risk. Their findings link fluctuations (volatility) in the macroeconomic environment to corresponding fluctuations (volatility) in financial markets where hedge funds trade.

Bali, Brown, and Caglayan (2014) find that, consistent with market-timing ability, directional and semi-directional hedge fund managers can predict both financial and macroeconomic risk and adjust their portfolio exposures up or down in order to generate superior returns (non-directional hedge funds show a significantly weaker ability).

Our research proposes two major contributions to this line of research. First, we employ modeling methods where both the model selection and factor selection are determined by the local data generating process (both the time-varying macroeconomic/financial market environment and the hedge fund style return process) in order to assess which macroeconomic and financial factors are most important for each hedge fund strategy for maximum return predictability.

Specifically, we create a forecasting model that includes both macroeconomic conditions, macroeconomic forecasts and macroeconomic surprises, in addition to the financial market factors commonly used in the hedge fund literature. We use the model discovery methods of Oxford's David F. Hendry (Hendry and Krolzig, 2005; Hendry and Doornik, 2014) to build a model that is congruent with the local data generating process.

Second, we employ a unique database of macroeconomic variables that is representative of the actual information set that hedge funds had at their disposal at the time they made their investment decisions rather than the heavily revised historical data that comprise macroeconomic databases. We believe that this combination of improved model selection that is more consistent with the data generating process and the use of the actual macroeconomic data available when investment decisions were made will provide better representations of the return generating process of hedge funds.

At this stage of our research we have completed our initial alternative modeling, the results of which help inform our next step in modeling using the model discovery methods of Hendry – we will include factors from our macroeconomic database as well as the macroeconomic and financial factors commonly used in the hedge fund literature.

The preliminary results of our modeling are discussed in the Data and Methodology section which follows a brief Literature Review. We conclude this version of our paper with some forecast comparison techniques to evaluate the efficacy of our respective models.

II. Literature Review

We focus our literature review primarily on two recent papers on hedge fund returns and predictability using both macroeconomic and standard financial market risk factors. Avramov, Barras, and Kos (2013) systematically investigate hedge fund return predictability both in and out-of-sample using a combination of macroeconomic and financial market factors (default spread (i.e. credit spread), dividend yield, VIX levels, and a liquidity measure of aggregate fund flows). They find that combining conditional forecasts from each macroeconomic variable provides superior forecasting ability and that this is due primarily to a tradeoff between high (low) unconditional performance (mean) and low (high) conditional return predictability. Their results support the findings of previous literature about the economic rational of why and when certain factors play a dominant role for various hedge fund style strategies. For example, their results support previous findings of the negative relationship between VIX levels and performance of Event Driven funds due to the increased risk of deal failure during periods of high uncertainty.

Bali, Brown, and Caglayan (2014) examine the distinction between financial risk and economic uncertainty in relation to explaining the cross-sectional variation of hedge fund returns. They find that their measures of economic uncertainty are more effective for explaining the cross-sectional variation of hedge fund returns than standard financial market risk factors. Furthermore, they find that the predictive power of their uncertainty measures is more effective for directional and semi-directional hedge fund strategies.

Our approach draws upon these authors' research in order to investigate the predictive power of various models for hedge fund returns in a systematic manner.

III.   Data and methodology

For the preliminary research we chose to model hedge fund returns using the broadest style indices available for both directional and semi-directional investment styles. The indices we chose were the following Hedge Fund Research (HFRI) style Indices: Event Driven, Equity Hedge, Macro, and Fund of Funds. The Equity Hedge and Macro indices are directional while the Event Driven and Fund of Funds indices are considered semi-directional investment styles – as previously noted, previous research has shown that the benefits of using macroeconomic variables are most effective for directional and semi-directional investment styles. We plan to investigate more refined style indices within each of these major style indices once we have refined our forecasting models.

Data for the macroeconomic and financial factors commonly used in previous research come from the following sources: the three Fama-French (1993) equity factors and the Carhart (1997) momentum factor were downloaded from Kenneth French's website, data for the five Fung and Hsieh (2001) lookback straddles (bond, stock, interest rate, foreign exchange, and commodities) were downloaded from David Hsieh's website, and the remaining common macroeconomic factors were downloaded from the Federal Reserve Bank of St. Louis FRED database. In future updates to this research we will include forward-looking financial factors, specifically, the CBOE volatility indices which are designed to measure market expectations of future volatility implied by options prices. The CBOE volatility indices cover a range of assets including: US stock indices, Non-US stock ETFs (EFA, Emerging Markets, China, and Brazil), US interest

rates (10-year Treasuries and Swaps), Commodity ETFs (Crude Oil, Gold, Silver, Gold Miners, and Energy Sector), Currency Futures/ETFs (Euro, Yen, British Pound), and Volatility of the VIX index.

The data for our unique macroeconomic database were compiled from Briefing.com and merged with the well-known, but now defunct, proprietary survey of MMS International. The MMS survey was the standard source for announcement effect studies but the company, formerly owned by Standard & Poor's, was sold to another party during the early-to-mid 2000s. As a result, we painstakingly compiled data from the well-known Briefing.Com survey and merged it with the MMS data set. We set January 1, 2000 as the merge date where the survey shifts from MMS to Briefing.com and compared survey actuals to verify accuracy during the overlapping period (up to 2008). In rare cases where Briefing survey data observations were missing, we used the Briefing data.

The data are important for this type of study because, unlike heavily revised historical data, this data is representative of the actual information set that market participants and policymakers had at their disposal at the time. Further, having surveys of expectations for each variable, we can calculate the "surprise" component. Prior studies have shown that the underlying securities markets are responsive to only the surprise portion of the data. We standardize the surprise by dividing by the full sample standard deviation to allow better interpretation of regression results – thus a coefficient on a surprise regressor reveals the change in return associated with a one-standard-deviation shock to the information set for that particular macroeconomic variable. We believe this data represents a significant improvement over the prior studies of macroeconomic effects on hedge funds, as they tend to rely on revised historical data.

Our empirical approach is to evaluate various model specifications of different classes in hedge fund return regressions on selected predictors. We examine four core directional and semi-directional hedge fund style indices. The modelling classes include: 1) a naïve model of returns regressed on a constant, 2) a simple theoretical AR(1) model, 3) a model based on the financial factors inspired by Bali, Brown, and Caglayan's (2014) financial model – including the Fama-French (1993) factors, Carhart's (1997) momentum factor, and Fung and Hsieh's (2001) option-based market factors, and 4) a model based on the Bali, Brown, and Caglayan (2014)

macroeconomic factors – including default risk premium, dividend yield, inflation and the T-bill rate relative to its 12-month moving average.

We first run these models contemporaneously for each hedge fund index and evaluate the significance of the component regressors and evaluate the veracity of each in terms of adjusted R-squared, significance of regressors, and importantly, based on model specification tests. In all cases, as expected, the naïve mean model is clearly underspecified. The competing models have relative strengths and weaknesses. We have added additional specification tests and included a wider range for our significance levels for this version of our submission. Our presentation will include Tables of our initial results.

For example, the AR(1) models (with a constant) can explain between about 5 to 14 percent of the variation in hedge fund returns (with the exception of the Macro Index) and reduces the degree of autocorrelation in the model tremendously. Yet, the models are still highly under-specified and potentially of little practical use other than their roles here as benchmark models.

The contemporaneous financial and macroeconomic models also have relative merits and weaknesses. While still suffering from multiple forms of misspecification, these models are able to identify key variables that are important in the data generating process for hedge fund returns. Results suggest that the Fama-French market factor, the Carhart momentum factor, the Fung and Hsieh option-based factors, dividend yield and inflation offer some additional explanatory power.

We repeat regressions on one-period-ahead returns and observe reduced explanatory power for all four hedge fund strategies. This is consistent with the results of previous research. Again, our presentation will include Tables of these results.

Due to the varying success and multiple forms of misspecifications, we feel that a combined model that incorporates both macro and financial factors, in addition to autoregressive components, may be more successful in creating forecasting models. What we have so far suggests that combining the elements of the respective models in a GETs model could lead to a much improved forecasting model that parsimoniously captures the elements of the Data

Generating Process (DGP) and may reduce out of sample forecast error, which we will evaluate further as the study is expanded.[2]

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[2] We have also conducted collinearity tests and other model specification tests which are not included here. We shall include them later in an appendix.

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MODELLING EARNINGS MANAGEMENT, CORPORATE GOVERNANCE, CAPITAL MANAGEMENT AND RISK USING DYNAMIC PANEL DATA ESTIMATION: THE CASE OF LISTED DEPOSIT BANKS IN AN EMERGING MARKET

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ABSTRACT

This study examines the relationship between earnings management and corporate governance for listed Nigerian money deposit banks in the International Financial Reporting Standards (IFRS) setting and possible IFRS interaction effects. Second, it explores the relation between earnings management, capital management and risk for listed Nigerian money deposit banks in the International Financial Reporting Standards (IFRS) setting and possible IFRS interaction effects.

Although earnings management in the form of Loan Loss Provisioning (LLP) is a well-known and worldwide problem that has an adverse impact on users of the financial statements of banks in form accounting violations and bank failures, its relation to IFRS, corporate governance and capital management is neither adequately researched nor properly investigated in Nigeria. Banks are subject to powerful vested interests that frequently override corporate governance control

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mechanisms to manipulate earnings. The dearth of research in the Nigerian banking context has made it difficult for academics and practitioners to achieve a clearer understanding of this research problem. This is the first study to the authors' knowledge to date that makes interesting research contributions that significantly add to the literature of earnings management in form of LLP and its relation to corporate governance, IFRS, capital management and risk pertaining to listed Nigerian money deposit banks.

The methodology tests earnings management using LLP. A review is undertaken of the literature of earnings management, LLP, IFRS, certain corporate governance characteristics, capital management as well as the data, models, methodologies and estimation technique used in this study. Secondary financial statement, IFRS and corporate governance data are sourced from the Bloomberg database and published financial statements of listed Nigerian banks for the period 2005 to 2017.

This study has several significant interesting findings. First, IFRS adoption and its interaction effects are not statistically significant. In addition, the size of the board and audit committee corporate governance variables are not statistically significant in not constraining earnings management indicating the possible need to preserve relationships, personal connections and maintain bonded friendships among the business elite. Further, there is a statistically significant positive association between the cost of capital adequacy violation and LLP indicating that LLP is used to manage capital more as a result of erosion of the capital base of banks. Another finding of statistical significance is that high risk banks appear to manage earnings to maintain lower levels of LLP relative to low risk banks.

Overall, the results suggest the need for a more rigorous implementation of IFRS and corporate governance initiatives as well as further consolidation and re-capitalisation to limit opportunistic earnings management in listed Nigerian money deposit banks. These measures will help increase investor confidence and strengthen the financial system to maintain stability which is necessary for economic growth and development in an increasingly uncertain and challenging global business environment. It is expected the results of this study will be of interest to academics, practitioners, governments, central banks and international organisations such as the World Bank and International Monetary Fund (IMF) that are involved in policy standards setting and formulating banking regulations.

KEYWORDS: Earnings Management, Loan Loss Provisioning, IFRS, Capital Management, Corporate Governance, Emerging Market, Financial Market, Capital Adequacy Ratio, Banks

I.   INTRODUCTION

Earnings management is the alteration of the financial reports of a firm by insiders in order to mislead some stakeholders or to influence contractual outcomes that are dependent on numbers contained in the financial statements (Healy and Whalen, 1999). Banks are characteristically more susceptible to manage earnings than other industries (Greenawalt and Sinkey, 1988). Scheiner (1981) studied a sample of US commercial banks and reached the conclusion that Loan Loss Provisions (LLPs) represent an important tool that is used by bank managers to manage earnings. Other research conducted by Ma (1988) and Greenawalt and Sinkey (1988) provide support that banks raise LLPs during periods of high operating income in order to enable them lower volatility of reported earnings in the future. Most studies that focus on US banks such as Ahmed et al. (1999); Beaver and Engel (1996); Collins et al. (1995); Healy and Wahlen (1999); Liu et al. (1997); Liu and Ryan (1995); and Scholes et al. (1990) provide evidence supporting the use of LLPs by banks as a mechanism for earnings management especially for stock market purposes. Research on non-US banks arrive at similar conclusions Anandarajan et al., (2003; 2007); Pérez et al., (2008).

Previous research such as Beatty et al. (1995); Collins et al. (1995); Moyer (1990) and Scholes et al. (1990) document the use of LLPs to manage capital i.e. opportunistically alter the capital adequacy ratio. Banks have incentives to manipulate the capital adequacy ratios because violation of the ratios would result in incurring of regulatory costs which can be costly Anandarajan et al., (2003). It is important to note that the introduction of International Financial Reporting Standards (IFRS) made significant changes to loan loss provisioning and reserves IASC, (2003); Grier, (2005); PWC, (2009).

One accounting regulation mechanism that is well documented in the literature that mitigates earnings management is IFRS adoption. In July 2010, the Nigerian Federal Executive Council approved 1 January 2012 as the effective date for International Financial Reporting Standards (IFRS) adoption by listed entities in Nigeria including listed deposit banks. However, several banks had earlier adopted IFRS on a voluntary basis for financial reporting purposes.

Certain IFRS changes based on International Accounting Standard (IAS) 37: Provisions, Contingent Liabilities and Contingent Assets were adopted by the International Accounting Standards Board in 2001. IAS 39: Financial Instruments: Recognition and Measurement also outlined changes in the requirements for the recognition and measurement of financial assets, financial liabilities, and some contracts to buy or sell non-financial items. IAS 39 was released by the International Accounting Standards Board (IASB) in 2003. These were regarded as important developments in accounting as they regulated the use of provisions, minimising their abuse such as in the case of big baths. The first change IFRS introduced was the requirement for certain specific assets to be classified as investments under IFRS without loan loss provisions. The second change was the prohibition of general provisions. Prior to IFRS adoption, banks made general provisions to loan loss

reserves in the absence of specific identification of potential customers. The third change was that the determination of LLPs was to be determined using an incurred loss model backed by objective evidence supporting the existence of impairment as a result of a single loss event or a group of events. The final change was the prevention of the reflection of losses based on expected events occurring in the future which was previously allowed. The overall main objective of these changes mandated by IFRS was the replacement of subjectivity with objectivity coupled with a reduction of the ability of managers to manipulate loan loss reserves, thus mitigating the occurrence of earnings management. Another crucial factor that impacts the loan loss provisioning policy of banks is corporate governance.

Corporate governance is the system of controlling and directing a company via principles, policies, procedures and clearly defined responsibilities and accountabilities used by stakeholders to overcome the conflicts of interest in the corporate form (Cadbury, 1992). In Nigeria, weak corporate governance resulted in major corporate failures in the financial sector.

Prior to the consolidation process of banks that commenced in 2005, the financial sector witnessed significant risk evidenced by the collapse of several firms such as Forum Finance, Abacus Merchant Bank Nigeria Limited, Royal Merchant Bank Nigeria Limited, Rim Merchant Bank, Financial Merchant Bank, Progress bank and Republic Merchant Bank among others. In 2012, there was the further collapse of Oceanic Bank, Intercontinental Bank and Afribank, Uwuigbe et al., (2014). In 2015, Nigerian financial regulators, the Financial Reporting Council of Nigeria, ordered the suspension of four past and present directors of Stanbic IBTC, a division of Standard Bank, following accusations of accounting irregularities. Stanbic IBTC denied the charges, the Economist, (2015). In September 2018, Nigeria's central bank revoked the operating license of Skye Bank Plc. and established Polaris as a bridge bank to take over its assets and liabilities (Alake, 2018).

In August 2014, Carlyle Group LP, the world's third-biggest buyout firm headquartered in the United States made its first investment in Nigeria, buying $147 million of shares in Lagos-based Diamond Bank Plc. At the time, the view was that Diamond Bank was well-positioned to benefit from Nigeria's status as one of the fastest-growing economies on the African continent and planned to become one of the largest financial institutions in West Africa. However, Diamond Bank's shares plummeted as a result of the 2014 oil-price crash which adversely affected growth in Nigeria's economy and caused non-performing loans to skyrocket Wallace, (2018). In November 2018, Diamond Bank opted for a Central Bank of Nigeria (CBN) Managed acquisition by Access Bank, Proshare Research and Markets, (2018). As a result of the Central Bank of Nigeria (CBN) Managed acquisition, the Carlyle Group faces a potential impairment of $136 million with its investment in Diamond Bank.

Due to these bank failures and bank suspensions, takeovers and mergers in Nigeria have been imposed by the central bank regulator to prevent contagion and spreading of systemic risk. Consequently, it is not known whether poor corporate governance practices resulting in earnings management and capital management in

the form of loan loss provisioning were commonplace in the Nigerian banking industry early this century. Hence, there is a need to conduct further research.

As a result of these bank failures and bank suspensions, takeovers and mergers in Nigeria have been imposed by the central bank regulator to prevent contagion and spreading of systemic risk. Consequently, it is not known whether poor corporate governance practices resulting in earnings management and capital management in the form of loan loss provisioning were commonplace in the Nigerian banking industry early this century. Hence, there is a need to conduct further research.

This is the first study to the author's knowledge to date that makes important research contributions that significantly add to the literature of earnings management in form of loan loss provisioning and its relation to corporate governance, IFRS, capital management and risk pertaining to listed Nigerian banks using the Dynamic Panel Data estimation method. The study has several interesting findings. First is that although IFRS adoption provides benefits of additional extensive disclosure requirements and increased transparency through its prescriptive nature, its effect on earnings management and interaction effects are not statistically significant. Second, corporate governance characteristics comprising the size of the board and size of the audit committee do not have a statistically significant impact on earnings management. Third, there is a statistically significant positive association between the cost of capital adequacy violation and LLP indicating that LLP is used to manage capital more. Further, the study finds that high risk banks will manage earnings more to maintain lower levels of LLP relative to low risk banks.

II. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

This section discusses the theoretical framework underlying bank earnings management and reviews the literature to develop the research hypotheses regarding the use of loan loss provisioning as a tool for earnings management and examines the impact of IFRS and certain corporate governance board characteristics. The use of loan loss provisioning as a tool for capital management and how it relates to IFRS, risk and other factors are also explored.

Agency Theory
Agency Theory suggests the existence of agency costs between the principal (shareholders) and agents of the principal (managers) due to divergence in goals and appetite towards risk Berle and Means, (1932). Earnings management therefore occurs in banks when managers look to trick investors through the intentional manipulation of accounting information using methods such as loan loss provisioning.

Political Costs Theory

Political Costs Theory suggests that large profitable firms such as banks face relatively higher effective tax rates and there is a positive association between firm size and the use of earnings management practices via income-reducing accounting methods such as loan loss provisioning Watts and Zimmerman, (1978).

2.1 Loan Loss Provisioning and IFRS

There are some researchers who share the view that severely limiting the available options through IFRS adoption may lead to a reduction in quality of reported earnings Ball et al., (2003); Breeden, (1994); Burgstahler et al., (2006); Cairns, (1999); Street and Gray, (2002). Their argument is that limiting the options available to financial institutions in determining LLPs may adversely affect the quality of financial reports. This is consistent with the view of Leventis et al. et al. (2011) that IFRS reduces the amount of unallocated provisions for loan losses that banks provide in previous years to sufficiently capture subjective and judgemental aspects of credit risk which are not considered specifically on an individual basis. This reduction in general loan loss provisions may therefore act as a detriment and prevent banks from capturing credit risk accurately thus reducing the quality of financial reporting.

This assertion is shared by Barth et al. (2008) who note that constraining the discretion of managers with a view to preventing managers to act opportunistically might end up being counterproductive by eroding a firm's ability to report accounting measurements that better reflect a company's economic position and performance. Barth et al. (2008) further state that if IFRS enforcement is weak, as is the case of most emerging countries such as Nigeria with a relatively weak rule of law compared to developed countries, firms could still manage earnings.

IFRS only permits specific provisioning of loan losses. Unlike Nigerian GAAP, IFRS forbids general provisioning of loan losses. The introduction of IFRS therefore represents a significant regime change for Nigerian banks in the area of loan loss accounting regarding the recognition and measurement of credit risks. Unlike the previous Nigerian GAAP, the incurred loss approach adopted by IFRS requires banks to provide only for incurred losses, but not for future expected losses. It is therefore hypothesised for Nigerian listed money deposit banks that:

H1: There is a significant negative relationship between Loan Loss Provisioning and IFRS adoption.

2.1.1 Board Size

Xie et al. (2003) observe that the size of the board represents an important constraint on earnings management. It is therefore hypothesised for Nigerian listed money deposit banks that:

H2: There is a significant negative relationship between Loan Loss Provisioning and the size of the board.

2.1.2 Audit Committee

The larger size of the audit committee the increased likelihood of having audit committee members that possess certain levels of financial competencies that reduce the possibility of earnings management Abbott et al., (2004). It is therefore hypothesised for Nigerian listed banks that:

H3: There is a significant negative relationship between Loan Loss Provisioning and the size of the audit committee.

2.1.3 Debt

Studies such as DeFond & Jiambalvo (1994), Watts and Zimmerman (1990) and Othman and Zeghal (2006) have shown that indebted firms are motivated to manage earnings in order to avoid violating certain covenants related to debt contracts. It is therefore hypothesised for Nigerian listed money deposit banks that:

H4: There is a significant negative relationship between Loan Loss Provisioning and debt.

H5: IFRS will interact significantly positively with debt to increase Loan Loss Provisioning.

2.2 Loan Loss Provisioning, Capital Management, IFRS and Risk

Kim and Kross (1998) and Ahmed et al. (1999) using samples of consisting of US banks test whether LLPs are utilised as a tool to manage capital adequacy ratios and confirm the existence of capital management using LLPs. Anandarajan et al. (2003, 2007) and Pérez et al. (2008) find no evidence of capital management using LLPs for the Australian and Spanish banking sectors respectively. Notwithstanding, Anandarajan et al. (2003) argue there are still strong incentives for banks faced with significant costs for capital management. Such a view is analogous to the case of Nigerian banks that are struggling to meet minimum capital adequacy ratios due to a recession as a result of low oil prices. It is therefore hypothesised for Nigerian listed money deposit banks that:

H6: There will be a significant positive association between the cost of capital adequacy violation and Loan Loss Provisioning to manage capital more.

H7: IFRS will interact significantly negatively with cost of capital adequacy to manage capital less.

2.2.1 Earnings (before tax and loan loss provisions)

Consistent with Agency Theory that managers act opportunistically and manipulate earnings in order to secure personal gains, Leventis et al. et al. (2011) expect a positive coefficient with earnings (before tax and loan loss provisions) as companies will make more provisions during against higher earnings in anticipation of releasing these during loss making periods. It is therefore hypothesised for Nigerian listed money deposit banks that:

H8: Loan Loss Provisioning will be significantly positively associated with earnings (before tax and loan loss provisions).

H9: IFRS will interact significantly negatively with earnings (before tax and loan loss provisions) to manage earnings less.

2.2.2 Risk

There is the argument in the literature that troubled banks facing high levels of solvency risk will engage in earnings management to prevent costs attributed to regulatory intervention. Bhat (1996) find a strong relation between poor financial condition of banks and high earnings management. Yasuda et al. (2004) observe that Nigerian banks experiencing financial trouble engage in high window dressing of profits by making changes to provisions for bad loans. It is therefore hypothesised for Nigerian listed money deposit banks that:

H10: High risk banks will be significantly negatively associated with Loan Loss Provisioning to manage earnings more relative to low risk banks.

III. DATA AND METHODOLOGY

This section discusses the proposed data and methodology framework.

3.1 Data and Sample Selection

The dataset consisting of secondary financial statement, IFRS and corporate governance data are used in this study. The data are limited to Nigerian listed banks for the period of 2005 to 2017 and were obtained from the Bloomberg database. During the specific timeframe the commercial banks were subject to two major regulatory changes, namely, that the minimum re-capitalisation requirement to Naira 25 billion ($195 million) from the then minimum of Naira 2 billion by the end of 2005 and the adoption of IFRS by January 2012. Data were extracted from Bloomberg database and carefully reviewed for any data inconsistencies and availability. Unlisted Commercial banks, central bank, government development banks, cooperative banks and export-import banks were excluded from the sample. This procedure produced a final population sample of 15 listed commercial banks consisting of all the listed commercial banks in Nigeria. The final estimation sample size is 14 banks.

3.2 Methodology Framework

This section is organised as follows. First is the description of the estimation of the loan loss provisioning model to proxy earnings management and its relation to

certain corporate governance characteristics, IFRS adoption and control variables. Second is the description of the estimation of the loan loss provisioning model to proxy earnings management and its relation to capital management, IFRS adoption, risk and control variables. Third, the estimation technique to be used for the empirical models is discussed.

3.2.1 Loan Loss Provisioning Empirical Model, Corporate Governance and IFRS

The model that will be used for testing earnings management as it relates to corporate governance factors will be based on Eq. (1). This is consistent with Leventis et al. (2011) who recommends doing more corporate governance testing and relating to earnings management via using loan loss provisioning as a proxy for earnings management.

$$LLPR_{it} = \beta_0 + \beta_1(BOARD\_SIZ)_{it} + \beta_2(IFRS)_{it} + \beta_3(AUD\_SIZ)_{it} + \beta_4(SIZ\_FIRM)_{it}$$

$$+\beta_5(DEBT)_{it} + +\beta_6(IFRS)_{it} * (DEBT)_{it} + \beta_7(ROA)_{it} + \varepsilon_t \tag{1}$$

Where
- **LLPR:** is the ratio of loan loss provisions to total loans
- **BOARD_SIZ:** the total number of directors serving on the Board
- **AUD_SIZ:** the total number of members serving on the audit committee
- **SIZ_FIRM:** the logarithm base 10 of total assets
- **DEBT:** the ratio of total debt to total assets
- **ROA:** Return on assets (ROA) calculated as net income in year *t* divided by total assets in year *t-1*
- **IFRS:** the dummy variable. (1) if banks report under IFRSs, (0) otherwise
- **IFSR*DEBT:** The interaction of DEBT with type of accounting regime (IFRS)

3.2.2 Loan Loss Provisioning Empirical Model, Capital Management, IFRS and Risk

The model that will be used for testing earnings management as it relates to corporate governance factors will be based on the model suggested by Leventis et al. (2011) in Eq. (2) which is the modified and extended version of the cross-sectional model utilised by Ahmed et al. (1999) and Anandarajan et al. (2003, 2007).

The main premise of the model is that it is relates bank's loan loss provisions to the fundamental financial information disclosed in the financial statements and specifically earnings and Tier 1 capital. The description and specification of the model as well as the analysis of the variables are presented as follows in equation (2):

$$LLPR_{it} = \alpha_0 + \beta_1 MCAP_{it} + \beta_2 EBTPR_{it} + \beta_3 IFRS_{it} + \beta_4 Dz_{it} + \beta_5 LnTA_{it} + \beta_6 CFEER_{it}$$

$$+\beta_7 IFRS_{it} * MCAP_{it} + \beta_8 IFRS * EBTPR_{it} + \beta_9 SIZF\ IRM + e_{it} \tag{2}$$

Where

LLPR is the ratio of loan loss provisions to total loans

MCAP is the ratio of the actual regulatory capital (Tier 1 capital) before loan loss reserves to the minimum required regulatory capital

EBTPR is the ratio of earnings before taxes and LLPs to total assets

IFRS is the dummy variable. (1) if banks report under IFRSs, (0) otherwise

Dz is the dummy variable (1) for observations lying below the sample median of the Z-score (developed by Bod et al. 1993), (0) otherwise

LnTA is the natural logarithm of total assets

CFEER is the ratio of commission and fee income to total assets

IFRS*MCAP is the interaction of MCAP with type of accounting regime (IFRS)

IFRS*EBT is the interaction of EBT with type of accounting regime (IFRS)

ε is the error term

The Z score is a statistic that was developed by Boyd et al. (1993) as a metric to estimate insolvency risk as it indicates the solvency for each bank j in every year t and is calculated as follows:

$$Z = \frac{\sum_{j=1}^{12}(\pi_j / A_j) + \sum_{j=1}^{12}(E_j / A_j)}{S_r}$$

(3)

Where

π_j represents the estimated market value of total profit with the j subscript denoting the month.

π_j is calculated as follows:

$$\pi_j = c_j p_j - c_{j-1} p_{j-1}$$

(4)

Where

c_j denotes the number of outstanding shares adjusted for stock splits

p_j represents the share price of the last business day of month j.

E_j is the market value of total equity represented by the share price multiplied by the number of shares outstanding?

A_j is the market value of the total assets

$$A_j = E_j + L$$

Where

L   represents the book value of the total debt as at the end each year

S_r denotes the estimated standard deviation (SD) of π_j / A_j

The market value of total assets and total equity are averaged monthly. In addition, the Z score is inversely elated with insolvency risk as a high probability of bankruptcy is indicated by a low Z score as Z represents the number of standard deviations below the mean by which profits would fall to wipe out equity. These interpretations are consistent with Boyd et al. (1993) whose definition of risk was downside risk and being the negative values of the Z score as per Yasuda et al. (2004).

Due to the difficulty in obtaining data in to accurately estimate equations (3) and (4), the Z scores for the sample of Nigerian banks is estimated using the Altman Z Score model for emerging markets. In this paper, the calculation of the Z score is done by applying the Z-score formula revised by Altman (2000) for non-manufacturers and emerging markets which is widely used by various researchers (Aziz and Dar, 2006) and takes the form of Eq. (5) as follows:

$$3.25 + 6.56X1 + 3.26X2 + 6.72X3 + 1.05X4 \qquad (5)$$

Where

X1   represents the ratio of Working Capital to Total Assets. This variable estimates the bank's ability to cover financial obligations.

X2   represents the proportion of Retained Earnings to Total Assets. This measures the cumulative profitability of the bank over time as a proportion of total assets.

X3   represents the ratio of Operating Profit to Total Assets. It measures the managerial efficiency in terms of profitability of the business.

X4   represents the ratio of book value of equity to total liabilities of the bank. This measures the financial leverage of the banks

Consistent with Leventis et al. (2011), the model contains several control variables. As in Leventis et al. (2011) and Pérez et al. (2008), the natural logarithm of total assets will be included as a variable to control for bank size. Notwithstanding that the relation between LLP and size is non-monotonic, it is expected that higher credit portfolio diversification for big banks will lead to a negative coefficient.

In addition, consistent with Leventis et al. (2011) and Anadarajan et al. (2007), the ratio of commission and fee income to total assets (CFEER) is included. This is because a higher CFEER ratio illustrates a bank's greater interest in non-depository activities. It can be inferred that banks may increase the allocation of additional LLPs in order to convey a sense of safety, security and confidence to the market. Thus, this variable thus controls for this.

Consistent with Leventis et al. (2011), some IFRS Interactive effects are also considered and examined. The IFRS*EBTPR interactive variable captures the impact of IFRS on earnings management via LLPs. The interactive variable IFRS*MCAP measures the impact of IFRS on capital management via LLPs.

Consistent with Leventis et al. (2011), all variables extracted from financial statements in this study are deflated by lagged assets to ensure comparability across firms and to reduce the risk of heteroscedasticity.

3.3 The Specification of the Estimation Techniques

It is envisaged that the endogeneity may be an issue as the dependent variable LLPR in Eq. (1) and Eq. (2) is derived from loans that is a component of the assets variable which is an explanatory variable in the empirical models. There is therefore likely for correlation to exist between the independent variable and the error term. This will imply that regression coefficients in an Ordinary Least Squares (OLS) regression are biased. This is because the presence of endogeneity among explanatory variables makes the estimates using OLS and a static panel inconsistent in that the dependent variable can also behave like an independent variable. The Generalised Methods of Moments (GMM) panel data estimator will therefore be used to overcome the problem of endogeneity.

The dynamic panel method that will be used in this study is the Difference Generalised Method of Moments of Arellano and Bond (1991). Kang & Sivaramakrishnan (1995) note that a key benefit of GMM is that the model assumptions can be tested (Hansen, 1982). Consistent with Kang and Sivaramakrishnan (1995) and Martínez-Ferrero (2014), the Arellano-Bond GMM estimator used in this study will be lagged twice as instruments in order to avoid endogeneity issues. The Pooled Ordinary Least Squares (OLS); Fixed Effects and Random Effects Panel Data estimation techniques are not used because they do not control for endogeneity which are likely to render these model estimates invalid (Kang and Sivaramkrishnan, 1995).

IV. RESULTS AND ANALYSIS

This section discusses the descriptive as well as the empirical results, which will further aid the testing of the hypotheses.

4.1 Loan Loss Provisioning, Earnings Management and IFRS

This section tests the **Hypothesis H1** that there is a significant negative relationship between Loan Loss Provisioning and IFRS adoption; **Hypothesis H2** that there is a significant negative relationship between Loan Loss Provisioning and the size of the board; **Hypothesis H3** that there is a significant negative relationship between Loan Loss Provisioning and the size of the audit committee; **Hypothesis H4** that there is a significant negative relationship between Loan Loss Provisioning and debt; and **Hypothesis H5** that IFRS will interact significantly positively with debt to increase Loan Loss Provisioning.

The model that will be used for empirically testing Loan Loss Provisioning as it relates to corporate governance factors and IFRS adoption is Eq. (1) above. The model will be estimated using the Arellano-Bond GMM Estimation technique that controls for endogeneity and effects of panel bias.

Table 1 below presents the descriptive statistics for the full sample estimation comprising 172 observations across 14 banks based on a balanced panel formed from the initial data. sample Table 1 shows information on the distribution of the data. The mean value of LLPR is 0.0349 and ranges from -0.0143 to a maximum of 0.6333 with a standard deviation of 0.0557. This suggests a wide variation with negative amounts in the sample relating to instances where provisions were released as credits in the income statement (i.e. reductions in provisions) to charges representing increases in provisions. Similarly, wide variations are observed in some of the corporate governance and control size variables such as ln_Assets indicating the sample characteristics to be distributed across banks from small to medium to large firms. The observed high volatility of the descriptive statistics and the occurrence of some extreme values is typical of emerging markets (Calderon-Rossell, 1990; Price, 1994; Harvey, 1995).

Table 1: Descriptive Statistics for the Banks-Loan Loss Provisioning, Corporate Governance and IFRS Testing

Table 1 shows the descriptive statistics for the sample of banks used to estimate the empirical model Eq. (1) that relates loan loss provisioning to certain corporate governance characteristics, IFRS adoption and control variables. The descriptive statistics consist of 172 observations based on a balanced panel formed from the initial data sample.

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
LLPR	Total loan loss reserve provisioning in year *t* divided by total loans in year *t*.	172	0.0349	0.0557	-0.0143	0.6333
BOARD_SIZ	Number of board directors in year *t*	172	14.1744	3.3393	6	23
IFRS	Dummy variable. (1) if banks report under IFRSs, (0) otherwise	172	0.6628	0.4741	0	1
AUD_SIZ	Number of Audit Committee members in year *t*	172	5.8372	0.9411	0	8
DEBT	Total debt (millions of USD) in year *t*	172	0.8562	0.0734	0.5948	1.3099
ln_ASSETS	Log of total assets (millions of USD) of bank in year *t*	172	8.4150	0.9219	5.5576	10.0933
ROA	Return on assets calculated as ratio of net income in year t divided by total assets in year *t-1*	172	0.0185	0.0371	-0.2889	0.1302

The mean value of LLPR is 0.0349 and ranges from -0.0143 to a maximum of 0.20 with a standard deviation of 0.0557. This suggests a wide variation with negative amounts in the sample relating to instances where provisions were released as credits in the income statement (i.e. reductions in provisions) to charges representing increases in provisions. There are also wide variations observed in some of the corporate governance and control size variables such as ln_Assets indicating the observed sample characteristics to be distributed across banks from small to medium to large firms. The observed high volatility of the descriptive statistics and the occurrence of some extreme values is typical of emerging markets (Calderon-Rossell, 1990; Price, 1994; Harvey, 1995). The optimal board size to be between seven and nine directors (Lipton and Lorsch, 1992). The mean of the Board Size is 14.17 directors ranging from a minimum of 6 to a maximum of 23. It can therefore be argued that large boards many be less effective and easier for a Chief Executive Officer (CEO) to control and opportunistically manage earnings as the cost of coordination and processing problems is higher for a large board thus making decision taking difficult.

The regression results using the Arellano-Bond GMM Estimation (One-Step) are presented in Table 2 below. The number of observations is 140 (Table 2 below),

which is different from the full sample estimation sample with 172 observations (Table 1 above). This is due to some gaps in the data as the sample was formed from an initial unbalanced panel data. This is because the first difference transformation of the Arellano-Bond GMM Estimation magnifies gaps, which further reduce the number of observations.

None of the hypothesised variables are found to be statistically significant except for **Hypothesis H3** that shows a significant negative relationship between Loan Loss Provisioning and the size of the audit committee at the 5% level of statistical significance. Regarding the control variables, only the return on assets (ROA) variable is statistically significant at the 1% level of statistical significance.

However, both the Sargan Test for over-identifying restrictions and test for no autocorrelation in Table 2 below are found to be violated and thus invalid. This implies that the moment conditions used are not valid and the results cannot be relied upon.

Table 2: Regression Results for the Loan Loss Provisioning Estimation on Corporate Governance and IFRS using the Arellano-Bond GMM Estimation (One-Step)

Table 2 shows the regression results of the full sample estimation of Loan Loss Provisioning on Corporate Governance, IFRS and control variables using the Arellano-Bond GMM Estimation (One-Step). The number of observations is 140, which is different from the full sample estimation sample with 172 observations (Table 1 above). This is due to some gaps in the data as the sample was formed from an initial unbalanced panel data. This is because the first difference transformation of the Arellano-Bond GMM Estimation magnifies gaps, which further reduce the number of observations.

VARIABLES	LLPR
BOARD_SIZ	-0.00195
	(-1.017)
IFRS	0.201
	(1.329)
AUD_SIZ	-0.00700**
	(-2.279)
DEBT	0.161
	(0.888)
IFRSDEBT	-0.275
	(-1.457)
ln_ASSETS	0.00447
	(0.552)
ROA	-1.220***
	(-5.221)
	-0.0216
Constant	(-0.140)
	-0.244
Observations	140
Number of banks	14
Sargan Test	Chi2 (63) = 107. 3577
	Prob > chi2 = 0.0068

Arellano Bond test	Order	z	Prob >z
For zero autocorrelation	1	-2.1457	0.0319
	2	-2.3101	0.0209

Robust z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Overall, the moment conditions used are not valid. This means that the results cannot be relied upon.

Due to the observed aforementioned limitations of the Arellano-Bond GMM (One-Step) Estimation, the regression is repeated using the Arellano-Bond GMM Estimation (Two-Step) based on Windmeijer (2005) that worked out a bias-corrected (WC) robust estimator for VCEs (Variance–Covariance matrix of the Estimators) of two-step GMM estimators.

The regression results of the loan loss provisioning on the variables of interest consisting of corporate governance factors and the IFRS adoption variable based on the Arellano-Bond GMM Estimation (Two-Step) are presented in Table 3 below. None of the hypothesised variables are found to be statistically significant. Both the Sargan Test for over-identifying restrictions and test for no autocorrelation in Table 3 are not found to be violated and thus valid. This implies that the moment conditions used are valid and the results can be relied upon.

Regarding the control variables and like the results obtained for the Arellano-Bond GMM Estimation (One-Step) in Table 2 above, only the return on assets (ROA) variable is statistically significant at the 1% level of statistical significance. The highly significant negative relationship between the return on assets and earnings management is consistent with the finding of Lee et al. (2005) who observe that higher return on assets results in higher earnings management. This is because lower loan loss provisioning in banks results in higher profits reported in the financial statements, consistent with the Political Costs Theory that managers will use discretionary accruals to manage earnings downwards to lower the amount of taxes paid by their firms.

Table 3: Regression Results for the Loan Loss Provisioning on Corporate Governance and IFRS using the Arellano-Bond GMM Estimation (Two-Step)

Table 3 shows the regression results of the full sample estimation of Loan Loss Provisioning on Corporate Governance, IFRS and control variables using the Arellano-Bond GMM Estimation (Two-Step). The number of observations is 140, which is different from the full sample estimation sample with 172 observations (Table 1 above). This is due to some gaps in the data as the sample was formed from an initial unbalanced panel data. This is because the first difference transformation of the Arellano-Bond GMM Estimation magnifies gaps, which further reduce the number of observations.

VARIABLES	LLPR		
BOARD_SIZ	0.000376		
	(0.258)		
IFRS	0.114		
	(0.751)		
AUD_SIZ	-0.00468		
	(-1.093)		
DEBT	0.114		
	(0.477)		
IFRSDEBT	-0.139		
	(-0.730)		
ln_ASSETS	0.00355		
	(0.411)		
ROA	-1.066***		
	(-4.102)		
Constant	-0.0535		
	(-0.269)		
Observations	140		
Number of banks	14		
Sargan Test	Chi2 (42) = 4.5900		
	Prob > chi2 = 1.0000		
Arellano Bond test	Order	z	Prob >z
for zero	1	-1.2736	0.2028
autocorrelation	2	0 .0878	0.9301

z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Overall, the moment conditions used are valid. This means the results can be relied upon. With regard to the control variables and similar to the results obtained for the Arellano-Bond GMM Estimation One-Step, only the return on assets (ROA) variable is statistically significant at the 1% level of statistical significance. The highly significant negative relationship between the return on assets and earnings management is consistent with the research findings of the non-financial firms and those of the Okougbo (2015); Lee, Li and Yue (2005) and Wu and Huang (2011) who observe that higher return on assets results in higher earnings management.

In summary, these results do not support for the **Hypothesis H1** that there is a significant negative relationship between Loan Loss Provisioning and IFRS adoption; **Hypothesis H2** that there is a significant negative relationship between Loan Loss Provisioning and the size of the board; **Hypothesis H3** that there is a significant negative relationship between Loan Loss Provisioning and the size of the audit committee; **Hypothesis H4** that there is a significant negative relationship between Loan Loss Provisioning and debt; and **Hypothesis H5** that IFRS will interact significantly positively with debt to increase Loan Loss Provisioning.

4.2 Loan Loss Provisioning, Capital Management, IFRS and Risk
This section tests the **Hypothesis H6** that there will be a significant positive association between the cost of capital adequacy violation and Loan Loss Provisioning to manage capital more; **Hypothesis H7** that IFRS will interact significantly negatively with cost of capital adequacy to manage capital less; **Hypothesis H8** that Loan Loss Provisioning will be significantly positively associated with earnings (before tax and loan loss provisions); **Hypothesis H9** that IFRS will interact significantly negatively with earnings (before tax and loan loss provisions) to manage earnings less; and **Hypothesis H10** that high risk banks will be significantly negatively associated with Loan Loss Provisioning to manage earnings more relative to low risk banks.

The model that will be used for empirically testing Loan Loss Provisioning as it relates to capital management, IFRS adoption and risk is Eq. (2) above. The model will be estimated using the Arellano-Bond GMM Estimation technique that controls for endogeneity and effects of panel bias.

Table 4 below presents the descriptive statistics for the full sample estimation comprising 158 observations across 14 banks based on a balanced panel formed from the initial data. This is different from Table 1 above that contains 172 observations due to missing data. Table 2 shows information on the distribution of the data. The mean value of LLPR is 0.0288 and ranges from -0.0143 to a maximum of 0.2089 with a standard deviation of 0.0295. This suggests a wide variation with negative amounts in the sample relating to instances where provisions were released as credits in the income statement (i.e. reductions in provisions) to charges representing increases in provisions. Similarly, there is a wide variation for MCAP as the mean value of Tier 1 capital over the minimum required capital (MCAP) is 8.7029 with a range of -1.6133 to 34.5493 with a standard deviation of 7.7139. This indicates the presence of distressed banks with high levels of solvency risk to banks of medium levels of solvency risk to banks of solid standing with low levels of solvency risk. Similar high levels of dispersion are observed in the DZ risk variable and CFEERR variable representing commission and fees income.

There are also wide variations observed in the control size ln_Assets variable indicating the sample characteristics to be distributed across banks from small to medium to large firms. The observed high volatility of the descriptive statistics and the occurrence of some extreme values is typical of emerging markets (Calderon-

Rossell, 1990; Price, 1994; Harvey, 1995).

Table 4: Descriptive Statistics for the Banks - Loan Loss Provisioning, Capital Management, IFRS and Risk

Table 4 shows the descriptive statistics for the sample of banks used to estimate the empirical model Eq. (2) that relates loan loss provisioning to capital management, IFRS adoption, risk and control variables. The descriptive statistics consist of 158 observations based on a balanced panel formed from the initial data sample. The number of observations differs from that in Table 1 above containing 172 observations due to missing data.

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
LLPR	Ratio of total loan loss reserve provisioning in year t to total loans in year t	158	0.0288	0.0295	-0.0143	0.2089
MCAP	Ratio of the actual regulatory capital (Tier 1 capital) before loan loss reserves to the minimum required regulatory capital	158	8.7029	7.7139	-1.6133	34.5493
EBTPR	Ratio of earnings before taxes and Loan Loss Provisions in year t to total assets in year t	158	0.0293	0.0308	-0.2314	0.0980
IFRS	Dummy variable. (1) if banks report under IFRSs, (0) otherwise	158	0.7594	0.4287	0	1
Dz	Dummy variable (1) for observations lying below the sample median of the Z-score, (0) otherwise	158	0.8380	1.2694	0	5.4399
CFEERR	Ratio of commission and fee income to total assets in year t	158	0.0235	0.0132	0	0.0958
ln_ASSETS	Log of total assets (millions of USD) of bank in year t	158	8.5603	0.9268	5.5576	10.0959

The mean value of LLPR is 0.0288 and ranges from -0.0143 to a maximum of 0.2089 with a standard deviation of 0.0295. This suggests a wide variation with negative amounts in the sample relating to instances where provisions were released as credits in the income statement (i.e. reductions in provisions) to charges representing increases in provisions. There is also a wide variation for MCAP as the mean value of Tier 1 capital over the minimum required capital (MCAP) is 8.7029 with a range of -1.6133 to 34.5493 with a standard deviation of 7.7139. This indicates the presence of distressed banks with high levels of solvency risk to banks of medium levels of solvency risk to banks of solid standing with low levels of solvency risk. Similar high levels of dispersion are observed in the DZ risk variable and CFEERR variable representing commission and fees income. There are also wide variations observed in the control size ln_Assets variable indicating the observed sample characteristics to be distributed across banks from small to medium to large firms. The observed high volatility of the descriptive statistics and the occurrence of some extreme values is typical of emerging markets (Calderon-Rossell, 1990; Price, 1994; Harvey, 1995).

The regression results of using the Arellano-Bond GMM Estimation (One-Step) are presented in Table 5 below. The number of observations is 129, which is different from the full sample estimation sample with 158 observations (Table 4 above). This is due to some gaps in the data as the sample was formed from an initial unbalanced

panel data. This is because the first difference transformation of the Arellano-Bond GMM Estimation magnifies gaps, which further reduce the number of observations.

Both the Sargan Test for over-identifying restrictions and test for no autocorrelation in Table 3 are not found to be violated and thus valid. This implies that the moment conditions used are valid and the results can be relied upon. None of the hypothesised variables are found to be statistically significant with the exception of **Hypothesis H6** that shows a significant positive association between the cost of capital adequacy violation and Loan Loss Provisioning to manage capital more at the 10% level of statistical significance; and **Hypothesis H10** that shows high risk banks are significantly negatively associated with Loan Loss Provisioning to manage earnings more relative to low risk banks at the 10% level of statistical significance.

The **Hypothesis H6** that there will be a significant positive association between the cost of capital adequacy violation and Loan Loss Provisioning to manage capital more is not rejected because the regression results show the MCAP variable, the ratio of the actual regulatory capital (Tier 1 capital) before loan loss reserves to the minimum required regulatory capital to be significantly positively significant with Loan Loss Provisioning at the 10% level of significance. Hence, the study accepts the null hypothesis that there will be a negative association between the cost of capital adequacy violation and LLPs. Thus, there is enough evidence to support the hypothesis that loan loss provisions will be used to manage capital adequacy ratios.

This result contrasts with Leventis et al. et al. (2011) who find a negative coefficient between LLPR and MCAP for their sample of European banks. A plausible explanation is that the observed high failure rate of Nigerian banks to date has resulted in the occurrence of under-capitalised banks relative to the risk of their operations. This is further corroborated in Figure 1 below that shows a volatile capital adequacy ratio for Nigerian banks that collapses during the period 2007 and 2010, drastically declines during the period between 2015 to 2017, and rises in 2018 due to the recovery from recession. This result is not surprising as based on Agency Theory, distressed or more risky banks with high levels of solvency risk will have greater incentives to manage capital because the costs of insolvency or bankruptcy are very costly in terms of job losses, loss of reputation, capital infusion, licence suspension and regulatory fines etc.

The **Hypothesis H10** that high risk banks will be significantly negatively associated with Loan Loss Provisioning to manage earnings more relative to low risk banks is not rejected because the regression results show the Dz variable to be significantly negatively with Loan Loss Provisioning at the 10% level of significance. Hence, the study accepts the null hypothesis that there will be a negative association between LLPs and risk. There is therefore enough evidence to support the hypothesis that high risk banks will be significantly negatively associated with Loan Loss Provisioning to manage earnings more relative to low risk banks.

This result is not surprising because the Dz variable is a dichotomous variable which captures the effect of insolvency risk. In other words, the higher the Z-score the

lower the insolvency risk. This finding corroborates the results of Leventis et al. et al. (2011). This is expected as riskier banks will have less diversified loan portfolios and hence have higher loan loss provisions especially in a highly regulated Nigerian banking environment. This is also consistent with the observed events where Nigerian banks that have collapsed to date such as the recent Skye Bank failure in 2016 have all had higher loan loss provisions than their less risky counterparts.

Nigerian banks have been relatively risky for much of the testing period as evidenced in Figure 1 below that shows Nigerian banks struggling to meet the minimum capital adequacy ratios. This is because Nigerian banks are required to maintain a minimum regulatory capital adequacy ratio (CAR) of 15% for banks with international authorisation and systemically important Banks (SIBs) while a CAR of 10% will be applicable to other banks (Central Bank of Nigeria, 2019).

Table 5: Regression Results for the Loan Loss Provisioning Empirical Model, Capital Management, IFRS and Risk using the Arellano-Bond GMM Estimation (One-Step)

Table 5 shows the regression results of the full sample estimation of Loan Loss Provisioning on Capital Management, IFRS, Risk and control variables using the Arellano-Bond GMM Estimation (One-Step). The number of observations is 129, which is different from the full sample estimation sample with 172 observations (Table 1 above). This is due to some gaps in the data as the sample was formed from an initial unbalanced panel data. This is because the first difference transformation of the Arellano-Bond GMM Estimation magnifies gaps, which further reduce the number of observations.

VARIABLES	LLPR
MCAP	0.00665*
	(1.873)
EBTPR	-0.0415
	(-0.260)
IFRS	0.00377
	(0.211)
Dz	-0.0103*
	(-1.877)
CFEERR	0.237
	(0.523)
IFRSMCAP	-0.00529
	(-1.462)
IFRSEBTPR	0.180
	(0.703)
ln_ASSETS	-0.00998
	(-0.858)
Constant	0.0925
	(0.841)
Observations	129
Number of id	14
Sargan Test	Chi2 (63) = 72.7904
	Prob > chi2 = 0.5508

Arellano Bond test	Order	z	Prob >z
For zero	1	-2.3676	0.0179
autocorrelation	2	1.6162	0.1060

Robust z-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Overall, the moment conditions used are valid. This means the results can be relied upon. None of the hypothesised variables are found to be highly statistically significant. There is a significant positive association between the cost of capital adequacy violation and Loan Loss Provisioning to manage capital more at the 10% level of statistical significance. In addition, high risk banks are significantly negatively associated with Loan Loss Provisioning to manage earnings more relative to low risk banks at the 10% level of statistical significance.

Figure 1 below displays the graph of the capital adequacy ratios for Nigerian banks for the period 2004 to 2019.

Figure 1: Nigeria Capital Adequacy Ratio [2004 - 2019]

Figure 1 shows the graph of the capital adequacy ratios for Nigerian banks for the period 2004 to 2019.
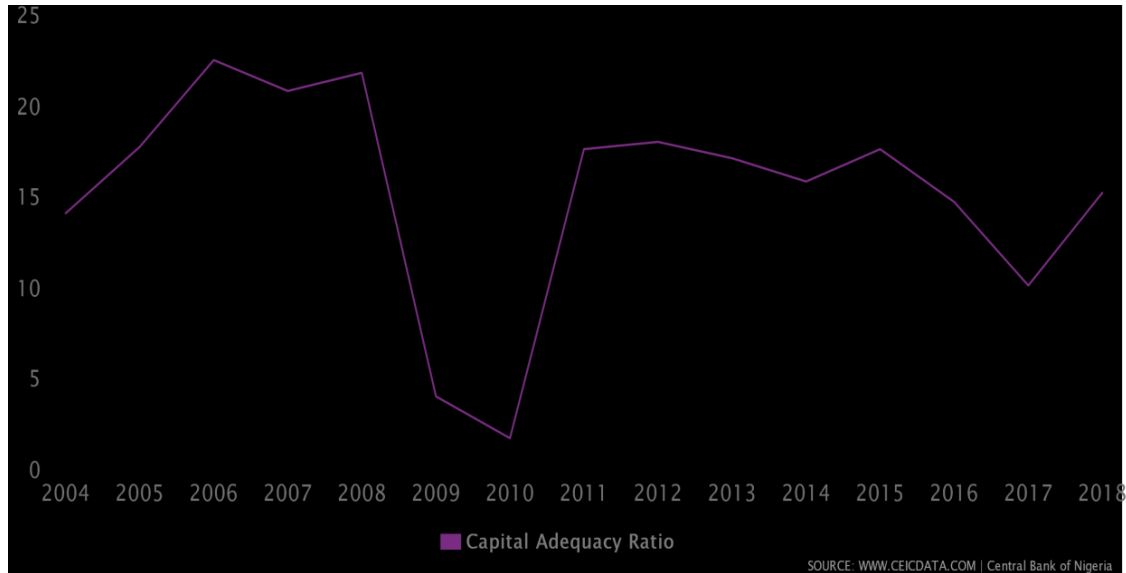
Source: CEIC Data-UK

In summary, these results do not support the **Hypothesis H7** that IFRS will interact significantly negatively with cost of capital adequacy to manage capital less; **Hypothesis H8** that Loan Loss Provisioning will be significantly positively associated with earnings (before tax and loan loss provisions); and **Hypothesis H9** that IFRS will interact significantly negatively with earnings (before tax and loan loss provisions) to manage earnings less.

Results support the **Hypothesis H6** that there will be a significant positive association between the cost of capital adequacy violation and Loan Loss Provisioning to manage capital more; and **Hypothesis H10** that high risk banks will be significantly negatively associated with Loan Loss Provisioning to manage earnings more relative to low risk banks.

V. CONCLUSIONS AND RECOMMENDATIONS

In this study, there is a focus on the influence of IFRS and certain corporate governance characteristics on earnings management in Nigerian banks using Loan Loss Provisioning as a tool. IFRS and the tested corporate governance characteristics are not found to be statistically significant. There are several plausible explanations. First, is that there is a weak enforcement of IFRS adoption by the regulatory authorities. Second, is that special relationships and close bonds of the elite board

members and audit committee members in Nigeria will likely limit the effectiveness of the board and audit committee. This is because in Nigeria, the appointment of special groups such as audit committees is based on membership and affiliation of elite groups that are based on prior personal connections and close relationships with the executive board directors. There will therefore likely be a need to preserve these relationships and bonds. In addition, consistent with organisational theory, Steiner (1972) finds that larger groups take relatively longer times to take decisions and arrive at conclusions. The optimal board size to be between seven and nine directors (Lipton and Lorsch, 1992). The mean of the Board Size is 14.17 directors ranging from a minimum of 6 to a maximum of 23. It can therefore be argued that large boards many be less effective and easier for a Chief Executive Officer (CEO) to control and opportunistically manage earnings as the cost of coordination and processing problems is higher for a large board thus making decision taking difficult.

In this study, there is also a focus on the influence of IFRS, capital management and risk on earnings management in Nigerian banks using Loan Loss Provisioning as a tool. The findings indicate that Nigerian banks manipulate capital using LLPS and that high-risk banks maintain will manage earnings more to have lower levels of LLPs relative to low risk banks. These observations may be due to the aforementioned reasons.

Overall, the results suggest the need for a more rigorous implementation of IFRS and corporate governance initiatives as well as further consolidation and re-capitalisation to limit opportunistic earnings management in listed Nigerian money deposit banks. These measures will help increase investor confidence and strengthen the financial system to maintain stability which is necessary for economic growth and development in an increasingly uncertain and challenging global business environment. It is expected the results of this study will be of interest to academics, practitioners, governments, central banks and international organisations such as the World Bank and International Monetary Fund (IMF) that are involved in policy standards setting and formulating banking regulations.

One recommendation is a strengthening of the implementation of IFRS and the increased regulation and monitoring of Nigerian banks. This can be achieved by closer supervision and tighter regulation and enforcement of banking laws, rules and regulation.

Another recommendation is to implement further consolidation and re-capitalisation to limit opportunistic earnings management in listed Nigerian money deposit banks and in view of the significant depreciation of the naira since the last consolidation exercise in 2005 by the Central Bank stipulating banks to have a minimum capital of 25 billion naira. These measures will help increase investor confidence and strengthen the financial system to maintain stability which is necessary for economic growth and development in an increasingly uncertain and challenging global business environment.

A limitation of this research is the relatively small sample size and restricted number of observations. An avenue for further research could be to investigate if earnings management by risker banks is anticipated by the Nigerian stock market. It is also noted that the loan loss provisioning earnings management testing could be extended to other corporate governance variables such as board structure and independence, audit committee characteristics, CEO duality, managerial ownership and ownership structure variables.

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INSTITUTIONAL WORK IN NON-GLOBAL NETWORK FIRMS

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INSTITUTIONAL WORK IN NON-GLOBAL NETWORK FIRMS

ABSTRACT:
I investigate how in-charge auditors in non-global network firms (NGNFs) (i.e., firms other than the "Global 7") engage in institutional work using technology-based audit tools (TBATs) to impact audit quality. Using semi-structured interviews through the lens of institutional theory, I identify factors that are associated with in-charge auditors' propensity to engage in institutional work, being actions that contribute to the development (i.e., creation), continuance (i.e., maintenance), and/or breach (i.e., disruption) of established practices. My results reveal patterns of common motivators, resources, and outcomes of in-charges' institutional work to impact audit quality at a process level. Implications for theory and practice suggest audit firm culture, engagement budgets, and training experiences are important antecedents to individuals' ability to engage in institutional work and effect organizational change.

KEYWORDS: Audit quality; institutional work; audit technology; audit tools; non-global network firms.

I. INTRODUCTION

In this qualitative study, I examine dynamic processes of institutional change prompted by technological advances in the audit workplace, through the lens of institutional theory. Although institutional theory's origins stem from the study of conformity among organizations, we continue to witness the rise of industry leaders among similar organizations. Why do some organizations, and some individuals within organizations, succeed in embracing and mastering the continuing changes associated with technological advances? The theory of "institutional work" has emerged as a stream of literature under the umbrella of institutional theory to address this question, exploring how change is experienced by institutions, institutional concepts, and the institutional fields that house these items (Seo and Creed 2002). I study how responsive behaviors of institutional agents (in this setting, in-charge auditors) amass to actions that prompt how institutions (i.e., audit firms themselves), institutional concepts (e.g., audit quality), and the institutional field of the auditing profession undergo change. In the parlance of institutional theory, technological change is an "institutional disruptor," and auditors' responses to such disruptions are the essence of institutional work. The purpose of this study is to examine auditors' reactions to technology, and to consider how the institutional concept of audit quality is impacted.

Technology is of particular importance to auditing, because of its ubiquitous impact on audit practices across firms around the globe. Although technology is often assumed to enhance audit quality, prior research suggests mixed evidence regarding its ability to improve effectiveness and efficiency in practice (Arnold 2016; Bedard Deis, Curtis, and Jenkins 2008; Dowling and Leech 2007; Downey and Bedard 2018; Earley 2015). Specifically, firms can experience unforeseen growing pains when implementing new technology, such as resistance to appropriate use of technology tools (Dowling 2009; Bedard, Ettredge, and Johnstone 2006), and the

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development of new audit risks directly related to technology (PCAOB 2013). Non-global network firms (NGNFs) (i.e., firms other than the "Global 7") engage a significant market share of audit and assurance clients, and thus audit quality for those firms has implications for investors, clients, regulators, and the public market alike (Lawrence, Minutti-Meza, and Zhang 2011). Furthermore, recent research suggests these NGNFs have continued to increase their market share over public company audits (Defond, Francis, and Hallman 2018). It follows that these NGNFs should continue to increase their investments in technology-based audit tools (TBATs)[1], and develop related TBAT processes and networks to meet the needs of their expanding client base (Lowe, Bierstaker, Janvrin, and Jenkins 2018; Bills, Hayne, and Stein 2018).

Our understanding of the modern technological landscape within auditing firms has become opaque with the evolution of TBATs, as extant literature struggles to reflect rapid changes in how auditors engage with these tools on a daily basis to impact audit quality. Janvrin, Bierstaker, and Lowe (2008, 2009) and Lowe et al. (2018) are among the few studies that explicitly consider technology use across audit firms of different sizes, and these surveys offer an initial depiction of the state of technology use in audit firms. Therefore, providing a rich description of how auditors use TBATs, as well as how related TBAT processes evolve, are significant contributions of this study. This study also contributes to the literature by bringing institutional theory to life in a professional setting. I provide data to address Hwang and Colyvas's (2011) call to identify how institutional agents' interests materialize and how they become a collective (if at all) as an important area of mapping the process of institutional work in a real-world context. More specifically, findings from this study extend theory by offering insights as to how an inconspicuous institutional agent, such as an in-charge auditor, can impart lasting institutional work to influence

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[1] Technology-based audit tools (TBATs) include computer-aided audit tool systems (CAATS), computer systems and various technology-based practice aids leveraged in the audit process.

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an institutional field by altering its concepts. Results from this study provide a challenge to the assumption that institutional work must originate from agents predisposed to high levels of organizational power. Finally, this study contributes to an outstanding theatrical debate by suggesting non-industry leaders and their members are indeed important constituents of institutional work.

I investigate the use of TBATs employed by NGNFs across a spectrum of firm sizes using mixed methods. I collect data using a pre-interview survey to validate results of semi-structured interviews in which in-charge auditors discuss two process experiences: one in which TBAT use enhanced an engagement, and another in which TBAT use hindered an engagement. To develop my research instrument and analyze results, I consider how institutional agents impart change on an institutional core concept: audit quality. I identify what motivates in-charge auditors to engage in institutional work, and how these antecedents relate to different domains of institutional work. I also make suggestions for practice to encourage acts of institutional work that can improve audit quality.

Findings suggest audit firm culture, engagement budgets, and trainings are several of the most important antecedents of in-charges' institutional work that impact audit quality. Participants from NGNFs are more likely to engage in *creating* and *maintaining* institutional work that has a positive impact on audit quality when firms communicate cultures dedicated to TBAT innovation and actively solicit feedback related to TBATs. Interestingly, a few participants report *creating* forms of institutional work as a response to budgetary pressures. These auditors proactively seek out interactions with audit clients and third-party TBAT vendors to overcome technology issues and facilitate TBAT workflows. These interactions generally focus on ways to ensure client data are compatible with TBAT capabilities, to avoid disruptions during engagements; such encounters

offer practical implications firms may consider to support audit quality. Findings also suggest that the quality and complexity of training and available TBAT resources impact in-charges' likelihood of engaging in acts of institutional work. Some participants suggest trainings at present are rudimentary and lack real-world applicability, which can result in acts of disruptive institutional work that threaten audit quality. Firms will need to be mindful when designing training teams and content to address emerging hazards of implementing new TBATs on engagements.

The remainder of this paper is organized into five sections. Section II discusses the background literature and theoretical foundation as they relate to two research questions. Section III explains the research method, including participants and design of the instrument. Section IV provides an overview of results. Section V offers implications for practice. Finally, section IV puts forth concluding remarks.

II.   BACKGROUND LITERATURE

Literature Review

While some prior research examines technology use and its impact on the audit process and audit quality among global-network firms (GNFs) (i.e., the Big 4, BDO, Grant Thornton, and RSM) (e.g., Dowling 2009; Dowling and Leech 2007, 2014; Carson and Dowling 2012; Downey and Bedard 2018), research that explores how technology has influenced audit practices in non-global network firms (NGNFs) (i.e., firms other than the GNFs) is scarce (Defond, Francis, and Hallman 2018).[2] Scholars and professional bodies alike (e.g., the American Institute of CPAs;

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[2] The scholarly focus on the GNFs is due to several factors, including GNFs' large market share of audit clients, relationships with researchers that facilitates access to data, and ease of market stratification. But this focus leads to an incomplete understanding of the audit market, as we cannot assume findings from studies of GNFs generalize to NGNFs. Contrasting levels of resources available to invest in IT infrastructure between GNFs versus NGNFs (DeFond 2010; Bedard et al. 2008; Janvrin et al. 2008, 2009), and the disparate level of power and influence the PCAOB has over GNFs relative to NGNFs given these firms' predominately private client bases (Lennox and Pittman 2010; DeFond 2010; Janvrin et al. 2008), have likely led to differences in forms of audit technology and related processes between respective firm types.

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AICPA) have advocated for studying NGNFs (Tysiac 2015), because the lack of research examining these firms clouds our understanding of their capabilities, demands, and opportunities to engage in technological innovations, as well as their ability to correct technological missteps as a means of supporting audit quality. Additionally, the more recent transition of NGNFs to a TBAT orientation makes them a better and more relevant population to study than GNFs, as related growing pains are fresh for observation.

Janvrin et al. (2008, 2009) and Lowe et al. (2018) are the only studies of which I am aware that specifically consider the role of TBATs in NGNFs. Janvrin et al. (2008) survey auditors from a mixed sample of Big 4, national, regional, and local firms, and find that auditors of Big 4 firms place a greater emphasis on IT tools in the audit process relative to auditors of smaller firms. However, the Janvrin et al.'s (2008, 2009) studies are over a decade old, and it remains unknown how the use of technology in audit processes differ between firm types. In a follow-up to these studies, Lowe et al. (2018) find national firms report having the greatest level of use and perceived importance of IT use related to audit applications. These findings suggest NGNFs have transitioned to integrate increasing amounts of technology into the audit process to levels similar to GNFs, serving as an important motivator to this research.

Institutional Theory

Institutional theory provides a valuable theoretical lens in which to examine the responsive behaviors of auditors as a result of increasingly technologically driven audit processes.[3]

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[3] This study does not rely on the widely used unified theory of acceptance and use of technology (Davis 1989), as it is difficult to identify ex ante the ways in which this theory would be extended in the setting of NGNFs. Additionally, the methodology of semi-structured interviews does not lend to the use of the TAM. Alternatively, application of institutional theory can put theory to practice by helping us grow our understanding of how institutional work occurs at a process level – whereas literature to date has heavily theorized rather than applied institutional work in a professional context.

Historically, institutional theory has emphasized the necessity of conformity of an organization to other peer organizations as a means of survival (DiMaggio and Powell 1983; Oliver 1991). Isomorphic forces (i.e., mimetic, normative, and coercive pressures) cause organizations to become increasingly similar over time (Scott 2013). Despite institutional theory's implications about the adaptation of organizations toward a common form, real world organizations are not static. Indeed, institutions, institutional concepts, and institutional fields evolve over time. Such dynamism at first appears paradoxical within the ambit of institutional theory's core notion of assimilation; however, the concept of *institutional work* offers a theoretical explanation for such changes (Oliver 1991; Greenwood, Suddaby, and Hinings 2002; Seo and Creed 2002).

Institutional Work

Institutional change refers not only to change within organizations themselves, but also includes change across the institutional field and the field's unique institutional concepts. Importantly, institutional change does not exist in a vacuum prompted by superstructure forces, but rather is prompted by organizationally relevant and individual players who engage in what is known as institutional work. Institutional work is defined as "purposive action of individuals and organizations aimed at *creating*, *maintaining*, and *disrupting* institutions" (p 215, Lawrence and Suddaby 2006). However, identification of institutional work as purely "purposive" has more recently been revised by its founding fathers (Lawrence, Suddaby, and Leca 2009; 2011) and challenged by scholars (Smets and Jarzabkowski 2013). I therefore follow the suggestion from Lawrence et al. (2009) to adopt a definition of institutional work based on its effects when analyzing micro-processes, thus including agents' intentional and unintentional institutional works.

Institutional change likely occurs because of both macro-macro events (structure and field-level forces influencing the institution), as well as micro-macro events (individual agents influencing the institution). With attention to the latter, research suggests that individual agents can impart change on institutions as these organizations encounter exogenous shocks. Technological change as an exogenous shock likely represents a disruptive event, as organizations wrestle with the challenge of implementing new technologies in a seamless manner (Malsch and Gendron 2013; Zietsma and Lawrence 2010). During this transitional time, it seems likely that institutional agents will engage in actions (i.e., *work*) that contribute to the development of new organizational practices (i.e., *creation*), the continuance of organizational practices (i.e., *maintenance*), and/or the breach of established organizational practices (i.e., *disruption*) (Zietsma and Lawrence 2010; Hayne and Free 2014).

In an accounting setting that examines how the Committee of Sponsoring Organizations (COSO) prompted different forms of institutional work among a variety of institutional agents to impact the adoption of the enterprise risk management framework, Hayne and Free (2014) identify nine behaviors of *creation*, six behaviors of *maintenance*, and three behaviors of *disruption*. For example, *creation* as institutional work includes behaviors that educate (e.g., promulgating skills and access to vital information to educate other agents in learning a new process), *maintenance* as institutional work includes behaviors that police current practices (e.g., engaging in oversight activities performed to enforce, audit, and monitor compliance), and *disruption* as institutional work includes behaviors that undermine assumptions and beliefs (e.g., challenging perceptions associated with costs and risks of innovation and differentiation by weakening the core assumptions and beliefs of an institution) (Hayne and Free 2014). The scholarly literature around institutional work comprises mostly theoretical works, with limited application of the theory in

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practice (e.g., Zietsma and Lawrence 2010). The only example of which I am aware of a functional context of institutional work in an accounting setting comes from Hayne and Free (2014).

Public Accounting as a Context for Institutional Work

In an audit setting, the institutional field is the profession of public accounting, and it houses institutional concepts (e.g., audit quality; auditor independence). Such concepts are often complex and multifaceted. These concepts are unique to a field in that they are institutionally derived from both explicitly and implicitly agreed upon meanings by institutional players (i.e., institutions and agents of these institutions). The public accounting profession as a field is a particularly rich setting in which to apply modern institutional theory in a professional context, as the field encompasses a range of both mature and evolving participants who span generations, nationalities, and cultures (Greenwood et al 2002; Wilkinson, Arnold, and Sutton 2003; Greenwood and Suddaby 2006; Suddaby, Gendron, and Lam 2009; Griffith, Hammersley, and Kadous 2015; Westermann, Bedard, and Earley 2015).

These participants take multiple forms, including central organizations (i.e., which represent industry leaders; e.g., Big N firms), peripheral organizations (i.e., non-industry leading firms, encompassed by the term NGNFs), and boundary participants. Boundary participants represent entities that interact with central and peripheral organizations, but primarily operate on tangential institutional fields. In the context of public accounting, these boundary participants include oversight bodies (e.g., PCAOB, AICPA), audit report clients, third-party vendors (e.g., audit software developer/vendors, training firms, etc.), and financial marketplace investors (Zietsma and Lawrence 2010). To date, literature leveraging institutional theory from an accounting firm-level perspective has exclusively focused on the largest audit firms, which represent central organizations (e.g., Greenwood et al. 2002; Wilkinson et al. 2003; Greenwood

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and Suddaby 2006; Kornberger, Justesen, and Mouritsen 2011; Carter and Spence 2014; Griffith, Hammersley, and Kadous 2015). However, literature suggesting whether central or peripheral institutional members are more likely to engage in significant institutional work presents an interesting question.

The ambiguity around how central and peripheral institutional players contribute to institutional work challenges an innate assumption that marketplace leaders, such as GNFs, unanimously shape the profession. On one hand, Greenwood et al. (2002) suggest GNFs can initiate change because they are less captured by prevailing routines, more attuned to emerging global opportunities, and have political resources that enable them to resist traditional practices. Alternatively, commentaries from leading scholars (Alles 2015; Arnold 2016), extant research (Carson and Dowling 2012; Dowling and Leech 2014), and public communications from Big 4 firms (Deloitte 2016; EY 2016; KPMG 2014; PwC 2015) suggest GNFs, in spite of these resources, may ironically be more constrained than smaller firms in their ability to engage in institutional work to promote institutional change. These sources suggest that isomorphic pressures prompt GNFs to a greater level of homogeneity to keep pace with one another, relative to NGNFs. Specifically, GNFs have greater pressure from the public, clients, and regulators to aspire to a high benchmark of technology-based audit processes, relative to their NGNF peers. The isomorphic pressures that drive GNFs to converge their practices toward one another may mitigate risk and increase perceptions of legitimacy when regulation is ambiguous (Griffith et al. 2015). Additionally, these GNFs are likely entrenched in established audit practices given the significant costs of proprietary IT-infrastructure already in place, which would suggest a limited ability for agents of these GNFs to engage in institutional work relative to a more agile NGNF setting.

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Meanwhile, the role of NGNFs as peripheral organizations and their capacity to engage in institutional work is unexamined but appears a promising context. The less established nature of NGNFs' technological structures suggests these firms and their members may have greater capacity to engage in meaningful institutional work relative to GNFs. The extent to which NGNFs have responded to technological disruptions infiltrating audit practice, and how agents of these organizations engage in institutional work, are important but unstudied issues. Greenwood et al. (2002) offer that that institutional pressures influence NGNFs more heavily, because these firms are more dependent on professional associations to reproduce prevailing practices and are thus embedded deeply in institutional routines. However, despite these predictions, more recent theoretical and empirical research challenges these assumptions. Zietsma and Lawrence (2010) suggest institutional innovators are often from peripheral positions in the field (i.e., non-central organizations); which means NGNFs are likely institutional innovators within the accounting field relative to GNFs as central organizations.

Indeed, network location theory suggests peripheral organizational players are more likely to disengage from institutional practices (i.e., those behaviors which are established and accepted by institutions and their agents, such as using audit checklists) because they are: "less connected to other organizations…and thus less embedded in institutional expectations…less aware of institutional expectations because of their weak field-level connection to institutional processes…often disadvantaged by prevailing arrangements and stand to benefit from change" (p 29, Greenwood and Suddaby 2006). These ideas echo Seo and Creed's (2002) institutional contradictions[4] – as central organizations are likely to have significant commitments to costly

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[4] The four sources of institutional contractions include: 1) legitimacy that undermines functional efficiency; 2) adaption that undermines adaptability; 3) intrainstitutional conformity that creates interinstitutional incompatibilities; and 4) isomorphism that conflicts with divergent interests (Seo and Creed 2002).

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existing IT infrastructures. This may cause instances of GNFs becoming unwittingly cemented with engaging in inefficient "ceremonial" practices that are accepted as legitimate by other elite institutions (Meyers and Rowan 1977). Such ceremonial practices are behaviors that do not intrinsically enrich an institution, but rather these behaviors are perpetuated so an organization can be perceived as meeting expected institutional standards of quality that may be implicitly or explicitly established (e.g., the use of standardized templates on highly unique clients).

Notably, NGNFs have probably evolved to possess technological resources and capabilities that are different from those of GNFs, as NGNFs are more apt to employ commercially available software packages and/or join networks or outsource for IT specialists and competencies (Bills et al. 2018; DeFond 2010; Bedard et al. 2008). Interestingly, Dowling and Leech (2007) suggest there is evidence of significant variation even across five large international audit firms in audit support systems and audit decision aids deployed. Such findings suggest even greater variation in technology-based audit tool (TBAT) usage among NGNFs. NGNFs are motivated by fierce market competition to innovate, although less constrained to do so by coercive pressures; making NGNFs potentially more agile as peripheral field members. This context offers important opportunities to identify common patterns of antecedents of institutional work that promotes organizational goals among a diverse group of NGNFs using varied TBATs.

Research Questions

Research suggests most individual agents in organizations are not institutional entrepreneurs (i.e., they do not set out with the intention of pursuing institutional work), but rather engage in institutional work from a practical perspective to get the job done – indicating a wide scope of agents likely contribute to institutional change (Smets and Jarzabkowski 2013). Importantly, we can't assume auditors have a similar impetus or the same opportunities to engage

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in institutional work across different firms (Hwang and Colyvas 2011), thus it is important to study auditors from a variety of NGNFs to observe the spectrum of how different factors prompt auditors to engage in institutional work. Smets and Jarzabkowski (2013) suggest institutional work is not necessarily intentional and highly effortful by agents, but may occur naturally as agents strive to fulfill their organizational duties as a means to an end – Lawrence et al. (2011) say it likely occurs in the "everyday getting by of individuals" (p 57). This suggests it is appropriate to examine in-charge auditors' role in institutional work, because in-charges are largely responsible for daily operations to facilitate engagements.

Prior literature on institutional change has been focused on institutional entrepreneurship (i.e., interactions between and among collective institutions that produce new structures or regimes) and outcomes, rather than micro day-to-day level changes that occur between the agent and his/her institution. Extant research on institutional work has often overemphasized a focus on institutional outcomes instead of institutional processes being the core of the "institutional story" as a representation of institutions' lifecycles (Suddaby 2010; Zietsma and Lawrence 2010; Malsch and Gendron 2013). Thus, my research questions focus on institutional work related to TBAT use at the process level of audit engagements.

Proponents of a more purist perspective of institutional theory may argue in-charge auditors of NGNFs cannot possibly engage in institutional work – as their actions will only impact their individual organizations. However, I challenge this idea by suggesting these individual agents of peripheral organizations can and do impart lasting institutional change by way of shifting institutional paradigms of a construct: audit quality. Audit quality is a shared institutional concept, and when individual agents impact a field level construct, they have effected institutional change outside of their individual organizations. Among NGNFs, audit quality is generally assessed in

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terms of effectiveness and efficiency of engagements. However, it remains a question as to whether various outcomes of institutional work in this context are positive, negative, or more likely – mixed.

A natural sequence of inquiry suggests first to identify drivers that prompt in-charge auditors to engage in institutional work within their respective environments, and second to classify and catalogue forms of institutional work. This leads to my research questions:

RQ1 *What factors impact in-charge auditors' likelihood of engaging in institutional work of creation, maintenance, or disruption to impact how TBATs are used within audit engagements?*

RQ2 *In what forms of institutional work of creation, maintenance, or disruption do in-charge auditors engage at a process level within audit engagements in relation to their use of TBATs?*

III. METHOD

I used a mixed methods qualitative approach of both a pre-interview questionnaire and semi-structured interviews to examine my research questions. Collecting survey data paired with semi-structured interviews help validate interpretive findings (Malsch and Salterio 2016) of the results.[5] A pre-interview questionnaire enables the participant to become acquainted with the subject of the study to facilitate rich data collection (Kenno, McCracken, and Salterio 2017). It also allowed me to collect demographic and complementary survey data, which enriches the interpretation of the semi-structured interviews. Additionally, semi-structured interviews provide flexibility to explore a subject by leveraging a list of pre-defined interview questions – while still allowing for fluidity in the order and exact content of questions (e.g., pursing emergent lines of questioning as appropriate) (Kenno et al. 2017).

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[5] I do not provide a separate analysis of the pre-interview survey outside of demographic information because survey data is redundant with that contained in semi-structured interviews.

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Participants

I surveyed and interviewed twenty-eight in-charge auditors[6] from NGNFs. Participants with a supervisory rank are an appropriate sample to interview, because they represent the "boots-on-the-ground" practitioners who are likely utilizing TBATs to the highest degree among engagement team members. Theory predicts these institutional agents are likely to engage in instances of institutional work, and such institutional work may impact audit quality. Using auditors of NGNFs as participants further allows me to examine the theoretical tension around whether members of peripheral organizations may be significant drivers of change through their acts of institutional work – as agents of these firms are often overlooked in the accounting literature. Importantly, there is a theoretical paradox intrinsic to the idea of an individual agent imparting change on an organization – as there is a circular relationship between agents who are in part shaped by their institutions and yet also working to shape the organizations of which they are a part (Lawrence et al. 2009). However, agents of peripheral organizations are particularly well positioned to engage in acts of institutional work, because I expect they are less subject to this "embedded agent paradox." It seems likely that in-charge auditors can effect change more easily given the smaller organizational stage within an NGNF's audit environment, relative to a GNF's audit environment, which is entrenched in proprietary technology already dispersed on a global scale. The setting of a NGNF parallels the familiar idiom of *big fish, small pond*, because in-charge auditors of NGNFs are naturally positioned to exert greater influence than in-charge auditors of GNFs within their respective organizations.

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[6] Note, this number includes four audit managers and one senior manager who were recently promoted within the last year. However, I do not distinguish these participants from others because participants were selected based on their supervisory "in-charge" role over the audit, suggesting all participants filled similar roles on engagements despite differences in title.

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To address my research questions, I engaged a heterogeneous sample of auditors from a spectrum of ten different NGNFs that capture small, mid-size, and large firms. Of participants, 10.71 (17.86) percent work for a large (small) NGNF with more (less) than ninety-nine (eleven) offices. Participants represent a range of industry concentrations including manufacturing (40.74 percent), services (29.63 percent), and finance, insurance, & real estate (14.81 percent). A majority (74.07 percent) of participants hold a CPA license, and the average (median) age of participants is 28.26 (27) years old. Comprehensive demographic information is summarized in Table 1.

<div align="center">**[INSERT TABLE 1 ABOUT HERE]**</div>

Development of the research instruments

Based on prior literature and theory, I developed a pre-interview questionnaire and interview protocol in tandem. I pilot tested both instruments on three in-charge auditors from NGNFs. The pre-interview questionnaire provides participants with the study's background information and researchers' backgrounds before collecting information about participant demographics. The pre-interview questionnaire then reiterates the definition of TBATs to facilitate participant comprehension on the subject matter, and asks respondents related survey and short open-ended questions regarding TBAT opinions and usage.

Prior literature suggests it can be helpful to prime participants about discussion topics ahead of being interviewed to facilitate understanding and discussion within an efficient window during the interview (e.g., Hux, Bedard, and Noga 2018). Thus, to support rich data collection, the pre-interview questionnaire closes with prompting participants to ex ante identify two complementary experiences to be discussed during the upcoming interview: one in which a TBAT or TBAT component *facilitated* the achievement of audit effectiveness and/or efficiency (hereafter termed the "*facilitating experience*"), and one in in which a TBAT or TBAT component *hindered*

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the achievement of audit effectiveness and/or efficiency (hereafter termed the "*hindering experience*"). For each, participants are asked to rate the difficulty of identifying the experience on a ten-point Likert-scale ranging from 1 (Not Difficult) to 10 (Very Difficult), as well as the complexity of the identified *facilitating experience* and the identified *hindering experience* on a ten-point Likert-scale ranging from 1 (Not Complex) to 10 (Very Complex). These questions are important to reduce noise in the analysis, and confirm results are not being driven solely by 1) a fundamental difference in difficulty of recalling a *facilitating experience* versus a *hindering experience* example, nor 2) the complexity of the identified engagement example in the context chosen to discuss. A two-tailed t-test suggests there is no difference in the difficulty of recalling a *facilitating experience* versus a *hindering experience* example (p = 0.22). Additionally, the complexity of identified engagements (p = 0.06) participants chose to discuss is not significantly different.

In accordance with Kenno et al. (2017), I strategically ordered the interview questions to ask process questions first, followed by more general and/or opinion questions to achieve a high level of validity. Process questions rather than general questions leads to capturing variation and accuracy of the recall (Kenno et al. 2017; e.g., Downey and Bedard 2018; Hux et al. 2018). Process questions focusing on experiences in which a TBAT or TBAT component *facilitated* (*hindered*) the achievement of audit effectiveness and/or efficiency were structured to be closely parallel to enhance validity between comparability of process stories from a single participant. These process questions were also randomized between participants. Half of participants were asked to discuss the *facilitating experience* first, while the other half of participants were asked discuss the *hindering experience* first. The interview protocol is included in Appendix A.

Data collection

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Two researchers and I collected data between July 2018 through November 2018.[7] Participants received an electronic link to the pre-interview questionnaire to complete the survey through Qualtrics. The pre-interview questionnaire took a median of 30 minutes to complete. Upon each participant's successful completion of the survey, a second researcher and I conducted semi-structured interviews. The semi-structured interviews were all conducted via Zoom and took a median of 53 minutes to conduct. Another researcher and I participated in each interview, with myself leading the interview while the second researcher took detailed notes (Beasley, Carcello, Hermanson, and Neal 2009). Just before the interview began, I reminded participants of their anonymity to promote candid responses (Cassell and Symon 2004) and encouraged them to ask any questions they may have had prior to commencing the discussion. Interviews were recorded with each interviewee's permission, and then professionally transcribed by a third party to facilitate detailed analysis (Cohen, Krishnamoorthy, and Wright 2002).

Data analysis

A second researcher and I conducted multiple rounds of dual coding on twenty-five percent of the semi-structured interview transcripts to support accurate interpretation and validity of data.[8] I leveraged first-level and second-level provisional coding practices to organize the data (Miles, Huberman, and Saldaña 2014; e.g., Durocher, Gendron, and Picard 2015; Hazgui and Gendron 2015). I began by developing a start list[9] of codes that included process categories of institutional work related to *creation*, *maintenance*, and *disruption* adapted from the framework developed by

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[7] Semi-structured interviews are discussion-based interactions between the researcher and subject, in which the researcher asks the participant a series of pre-ordered questions while simultaneously allowing some flexibility for the discussion to deviate from the predefined interview questions when necessary

[8] The dual coding process requires that two researchers independently code data in accordance with an agreed coding schema.

[9] "Start lists are researcher-generated codes, based on what preparatory investigation suggests might appear in the data before they are collected and analyzed. Provision codes can be revised, modified, deleted, or expanded to include new code," (Miles, Huberman, and Saldaña 2014, 77).

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Lawrence and Suddaby (2006).[10] The complete coding scheme was developed through an iterative process, and is based on expected and likely answers from a mix of prior audit technology literature (Janvrin et al. 2008, 2009; Lowe, Bierstaker, Janvrin, and Jenkins 2018; Westermann et al. 2015; Dowling 2009; Curtis and Payne 2008; Bierstaker, Janvrin, and Lowe 2014; Hayne and Free 2014; Bedard et al. 2006), theory (Lawrence and Suddaby 2006; Lawrence Suddaby, and Leca 2011), emergent themes (Miles and Huberman 1994; Kenno et al. 2017; Power and Gendron 2015; Malsch and Salterio 2016) and discussion between a second researcher and myself.

Following Zietsma and Lawrence (2010) and recommendations from Langley (1999) in process research, coders reviewed transcripts of the interviews for instances of "practice" each auditor discussed. Practice is defined as "shared routines…that guide behavior according to the situation…practices 'belong' to social groups, rather than to individuals…" (p 192, Ziestma and Lawrence 2010). The second researcher and I identified forms of institutional work that materialized within aspects of the engagement discussed by coding for behaviors that resulted in outcomes of *creation*, *maintenance*, and *disruption* of audit practice. Interviews with the in-charge auditors suggest they primarily engage in five forms of *creating* institutional works, four forms of *maintaining* institutional works, and five forms of *disrupting* institutional works. Although certain acts of institutional work can sometimes be classified within multiple domains of institutional work categories, we code acts of institutional work so that a given act of institutional work will only be assigned to a single primary domain (i.e., *creating*, *maintaining*, or *disrupting*) to facilitate analysis. Acts of identified institutional work are classified according to one of the three domains based on characterizations form Lawrence and Suddaby (2006) and summarized in Table 2.

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[10] See Hayne and Free (2014) for an example of this approach in a different context.

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[INSERT TABLE 2 ABOUT HERE]

We coded for factors that impacted that likelihood of institutional work by vouching previously identified forms of institutional work back to express antecedents participants used to explain why they engaged in acts of institutional work. The initial list was comprised of antecedents predicted by theory, literature, and updated to include emerging antecedents. The final listing of antecedents is included in Table 3.

[INSERT TABLE 3 ABOUT HERE]

Dual coding of the three pilot interviews according to the initial coding scheme resulted in an intercoder agreement of 92.38 percent (Kappa = 0.84, indicating substantial agreement; Landis and Koch 1977). The coding scheme was then further refined through discussion between the coders and validated with another round of dual coding (Saldaña 2015). We maintained a high level of intercoder agreement after the final round of coding, and ultimately achieved intercoder agreement of 95.31 percent (Kappa = 0.88). Any disagreements were reconciled through discussion between the second coder and myself. I then coded the remaining semi-structured interviews in accordance with the final coding scheme.

Leveraging the frequency of each code within and across interview transcripts recorded in NVivo facilitated my analysis of emergent themes and patterns as done in prior literature (e.g., Hux et al. 2018). To understand how antecedents motivate different forms of auditors' institutional work, I used the coded data to create network maps by drawing associations from antecedents to acts of institutional work for each participant (Miles et al. 2014; Mertler 2018). I then sorted and compiled individual network maps into three collective network maps by domain of institutional work: *creating* works; *maintaining* works; and *disrupting* works. Each collective network map compiles and translates individual participant data into a composite summary of how antecedents

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within audit firms are associated with in-charge auditors' acts of institutional work within a given domain of institutional work. The full models of the collective network maps for each domain of institutional work are included in appendix B.

To enhance the interpretability and comprehension around the multidimensional associations, I incorporated the concept of ant-trails when developing the collective network maps as explained by Heylighen (1999).

Imagine two parallel trails, A and B, leading to the same source. At first, an individual ant is as likely to choose A as it is to choose B. So, on average there will be as many ants leaving the nest through A as through B. Let us assume that path B is a little shorter than A. In that case, the ants that followed B will come back to the nest with food a little more quickly. Thus, the pheromones on B will be reinforced more quickly than those on A, and the trail will become relatively stronger... Thus, the ants are constantly tracing and updating an intricate network of trails which indicate the most efficient ways to reach different food sources. (p 260, Heylighen 1999)

Building on the behavior underlying ant-trails, I matched the thickness of links between each antecedent and each act of institutional work to correspond to the frequency count of individual participants who "walked" that given path. Therefore, thicker links between antecedents and acts of institutional work capture associations that are more heavily trafficked among participants, and arguably stronger. Employing this method allows me to identify concentrated relationships between antecedents and acts of institutional works that are frequently traveled, while also capturing the existence of varied realities among individual participants within a single visual aid.

This method is consistent with a constructivist approach in which individuals' realities are socially constructed, and appropriate given the research questions' aim to analyze complex human behaviors in varied environments (Power and Gendron 2015). In addition to using collective network maps as a visual aid to elucidate patterns within the data (Sloan 2009), it also serves as a validation method to support the internal validity of prior coding. Drawing concept maps for each

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participant required me to trace antecedents forward to actions, thereby confirming the original coding assignments that were initially applied using a vouching direction.

To consider implications for audit quality, I analyzed the data for common patterns while considering how TBATs and related TBAT practices impact audit quality for the participating firms. I do not retain a formal definition of audit quality. Instead I analyze audit quality from an efficiency and effectiveness standpoint, because participating auditors generally assess the implications of their actions using these qualifiers.

IV. RESULTS

Results from the semi-structured interviews are presented as ordered discussions relating antecedents of specific instances of institutional work by domain of institutional work – first antecedents of *creating* institutional works, second antecedents of *maintaining* institutional works, and third antecedents of *disrupting* institutional works. I do not provide a separate analysis of the pre-interview survey, because survey data was used as a validation method and is redundant with participant-matched interviews. I also choose not to separate results according to *facilitating* versus *hindering* engagements, because many participants discussed facilitating and hindering aspects of process experiences within a single engagement. As such, the data does not lend itself toward bifurcating between these qualifiers. Following prior literature, I use the subsequent terms to signal percentage response frequencies of participants when discussing trends: "most," "many," or a "majority" with responses that are 60 percent or more; "about half" with responses that are between 41 and 60 percent; "some" with responses between 21 and 40 percent; and "few" for responses that are 20 percent or less (Westermann et al. 2015; Hux et al. 2018).

Antecedents of Creating Institutional Works

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The most positive implications for audit quality come from auditors' actions that improve both assurance effectiveness and efficiency, while also impacting audit processes beyond a single engagement. These actions arise from individuals who strive to alter and innovate current practice as a manifestation of their belief that such a change will promote future benefits. Lawrence and Suddaby (2006) suggest institutional work that is associated with *creating* behaviors take form when actors reconstruct rules, and when belief systems are reconfigured. Most research to date has focused on *creating* acts of institutional work (Lawrence et al. 2009); perhaps because they may be easier to identify given actors' more overt intentionality around *creating* behaviors. I choose to adopt an implicit connotation of positive outcomes attached to the categorization, which also aided the initial assignment of acts of work according to domain of institutional work. Figure 1 illustrates a collective network map linking antecedents to behaviors of *creating* forms of institutional work.

[INSERT FIGURE 1 ABOUT HERE]

Among eleven antecedents I identify from participant responses, I focus my discussion on the three most strongly associated with *creating* acts of institutional works: engagement budget, audit firm TBAT culture, and auditor belief in TBATs as a conduit to success.

Engagement budget

Interestingly, 75 percent of participants report the engagement budget as an important motivator for engaging in *creating* forms of institutional work. Most participants share instances in which they internalized the engagement budget by responding with actions of developing or improving a TBAT process. Participants believe doing so is ultimately conducive toward improving the efficiency on the engagement, despite potential short-term implementation costs. The following quotes illustrate these experiences:

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…do it for a year or two and get comfortable with it, to see how much it helps and save time ... but part of it is spending the time the first year through all of these engagements is to try and figure out how to use it and how it helps. (TG2)

I came in, kind of revamped things a little bit and set up the workpapers to have the currency numbers in there and have those linked to other workpapers… In the past, I think that because engagement didn't really have that ability, it was always manual calculations that had to be done on every balance, every workpaper, so multiply that across the whole engagement, it adds up. I think it hindered us in the past. I think I set up the workpaper efficiently for the next years. (TD4)

…for first year clients, it's been pretty tough to save on time, but going forward, knowing that all that information you rolled will be there next year has been a huge help. (TG3)

However, improvements to efficiency are not the only benefits participants mention as a result of

their actions. Improvements to assurance effectiveness are often tied into new TBAT processes,

as participants report multiple instances of leveraging sophisticated TBAT tools such as IDEA

and ACL to improve audit quality. For example:

When I did this audit and this engagement for this year, what I changed is I said, "Okay, let's put this into IDEA." We can search all those same things instantly and we can add to that. Well we know our client only works Monday to Friday. Let's look for any entries that were posted on Saturday or Sunday. We know that certain people are able to post it. Let's look at the time stamps and look for certain people. We can add all these criteria into it, and IDEA can search it all faster, instantly at one click in time. So, in that test alone, we shaved hours off the test, and at the same time we expanded the scope of test by searching more things. (TI5)

Interview data also sheds light on unforeseen, but important ways improved TBATs processes

support audit quality. As the participant in the example below explains, a newly applied TBAT

process can enable him to test 100 percent of a sample. The following quote recounts this

experience:

From testing a sample that may not be representative to testing the entire thing; not only quicker, but obviously more effective… It's good, it's fun anytime you can increase efficiencies. I think it's exciting especially when you can show the client. That's the other thing, it makes the conversation with the client so much easier when you say, "Well we looked at these 20 of the 2,000 accounts, and 5 were bad…" Well they don't agree with that. But if you can sit there and look at 100 percent

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[of accounts] and say, "Well here's the 300 accounts that haven't been paid. What are you going to do about it?" Then they can agree. They don't have a choice but to agree. (TC2)

Of course, audit effectiveness will be improved in these instances, but perhaps more remarkable is how implications of this use of a TBAT ripples out to influence subsequent interactions with the client. As TBAT processes become more sophisticated and able to mine, capture, and analyze a broader scope of data, they increase auditors' relative bargaining power during auditor-client negotiations. This is because subjectivity around disputed items is less obscured from prior constraints around testing.

Another benefit is that efficient and effective TBATs also free up resources within an engagement team. Auditors can focus their time on complex areas and interact with clients on a meaningful level. One audit reiterates this point below:

And I think I mentioned this earlier, not spending so much time massaging the data, but spending more time interacting with the client and talking about the data. So, I'm all for speeding up that side of things so I can get in and spend more time with the client. (TI4)

Although a few participants report getting positive feedback from superiors related to efficiencies gained, a couple of participants felt their efforts to improve efficiencies were overlooked. There is also a notable lack of participants who suggest they are positively acknowledged for how new TBAT processes have enhanced effectiveness on the audit. The following quotes from in-charge auditors illustrate perceptions around their superiors' disconnect with how TBATs are used on engagements:

It was just me on the job though, and the manager ... I think she was probably one of the examples I was using, where she didn't really use IDEA that much herself, so she didn't really understand how much time it did save. (TF5)

...if we installed this software 2 or 3 years ago and they've been a manager or partner for 4 or 5 years, then they might not even know that we have access to it. (TD5)

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I've had comments from my partner before. When he looks at my charged time on how long I spent on journal entry testing, he's made jokes about how the senior manager before me took eight hours to do it, and I'll only charge two hours. There's a huge gap of what we used to charge when everyone was doing it manually, and what people are doing now. (TC1)

Audit firm TBAT culture

A majority of participants suggest that their firm's culture and tone at the top around TBATs impacts how they engage with TBATs on assurance engagements. Respondents report that when firms directly communicate a consistent and strong firm commitment to TBAT innovation, they are more likely to perform TBAT-related actions that improve both assurance effectiveness and efficiency. The following quotes suggest in-charges are acutely aware of their audit firms integrating TBATs into the fabric of the firm's culture:

We have a culture at the firm where we're quite open about discussing issues that we have. So, you could walk down the hallway and you'll hear someone complaining about something and that isn't necessarily seen as negative. (TK4)

Our firm has a push for using automated technology and gaining efficiencies in our audit. So, they're encouraging us to do that, and I'm a big fan of the technology. (TI4)

Participants who believe their firm cultivates a strong culture of support around TBATs are most likely to engage in firm innovation efforts. Subjects who describe participating in firm innovation efforts also report that their audit firms expressly solicit feedback from employees related to TBATs, either through hosting firm innovation teams/events, running TBAT focus groups, or developing formalized TBAT feedback outlets. The following quotes offer examples of different innovation outlets firms are establishing:

…as a result of the topic that was being worked on, it got me invited to our firm's first ever innovation tournament that was held. There were 30 people from across the firm and including the CEO and all the other big dogs. So, I got to spend two and half days with them in an innovation tournament. (TC2)

We have like this online idea portal where people can you know, give ideas to the firm and other employees can vote yes or no to whether it's a good idea, and so we're trying to stay in line with our peers as far as technology and innovation goes. (TG2)

These constructive communication channels can translate into palpable benefits. Facilitating and encouraging employees to participate in TBAT innovation can be a windfall of ideas for audit firms to better existing TBATs by integrating helpful feedback and observations collected. As one participant recounts:

There was one specific year where the cash reconciliation template came out, I want to say two-and-half years ago, and it got rolled out and I believe that one was sent out via e-mail. So, when we went to use it, I realized there wasn't a section to summarize anything that has FDIC coverage over $250,000. So, I took it upon myself to kind of add a little table there in the template, and then I sent it back to the person in charge who rolled it out like, "Hey, I noticed this wasn't on there. I feel like it would be useful and here is the attachment with my example." And he said thank you and all that, and then a few weeks later when they rolled out a newer version, that same exact box that I had was there. So that was kind of nice to see that. (TD5)

In addition to potentially improving TBAT processes that support audit quality, these outlets can foster positive affect among participating employees. One respondent explains below:

It makes me feel appreciated. To be able to be heard, and to have, whether it be partners or the head of HR listen to the comments you have or the comments other people have and really take in to account, and a lot has come from these focus groups. I mean, obviously they're not going be able to make the improvements or suggestions that everyone has, but they do take what people say and usually try and put them into action. (TJ5)

A few participants imply disappointment about the ultimate utility of their contributions (i.e., feeling their ideas were ignored), as well as reservations about future participation given time constraints:

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Occasionally sometimes I think ideas tend to get stuck in there, because the whole thought process is you want them to vet it before it goes to national. So not all ideas go to national; which makes sense. But it does mean the process slows down a little bit. (TH6)

We have focus groups for things like our engagement software for people to explain what the issues they're having or the difficulties or errors that they think can be improved, so I have been part of those focus groups in the past. I don't know if necessarily right now it's a goal to get more involved with that, again, given time constraints with training, other areas, and just client work. (TJ5)

Apart from promoting involvement in firm innovation channels, audit firm culture is also associated with auditors' willingness to improve their self-efficacy on TBATs. A third of participants who pointed to audit firm culture as an antecedent to engaging in *creating* acts of institutional work, specifically suggest culture motivates them to pursue self-learning opportunities related to TBATs. One auditor below recounts leveraging internal and external resources to improve her TBAT skillset:

I would spend time outside of work poking around in IDEA, but there's also using IDEA's website. They have some tutorial and help videos. There are people who have posted videos on YouTube, and so you can kind of go out and see how they're doing some sort of analysis in IDEA. Then, my friends also got a handful of steps or suggestions or ideas, and so I've gone through those and tried to use them. But for the most part, I'd say it's a lot of the self-taught trial by error...my firm is encouraging and pushing for that use. (TI4)

Notably, firm culture and tone at the top related to TBATs are not without areas needing improvement. Several participants express frustration from experiencing a mismatched value system, noting disinterest and avoidance of TBAT use among higher-level personnel despite explicit messages of support for TBATs from the firms. The following quotes illustrate these sentiments:

A lot of times I see senior level people in firms, because they've been around longer they know a lot about their job, they tend to be weaker on software… (TH6)

I think the partners and directors aren't really familiar with the technologies and what they can do in that kind of unfamiliarity and it makes them a little bit uncomfortable with getting rid of their

old, traditional procedures that they fully understand everything that's happening there, and trusting this new technology that they're not too familiar with, essentially. (TI6)

...he's a senior manager... I came from my other firm and I started using pivot tables, and his question to me was "How do you audit a pivot table?" And I was like "If you don't audit an Excel summation, you don't need to audit a pivot table." So, there's some people that I think are averse to using more and more technology. They're the ones that started off using paper and pen for audits. (TG2)

These sentiments echo findings from prior research around technology use in firms. Bedard et al. (2006) suggest higher echelons of audit personnel are likely to experience more difficulties using new technologies, and Bedard et al. (2008) find evidence of quality-threatening behaviors that may detract from audit quality as audit partners fail to abide by firm policies related to TBATs. However, the future looks bright from the eyes of in-charge auditors. A few participants feel hopeful that as younger and more technologically savvy personnel move up the ranks of audit firms, it may help address this issue. The following quotes illustrate these experiences:

As millennials come into the workplace, and they have this idea of change, we're starting to be in positions where we have a little more sway than we used to… And now we're like the in-charges and the managers. We're pushing that idea of change and efficiency, and the helpfulness of what technology can do for us... it's not so much if it's not broke don't fix it, it's that we know that the world is changing so much and that audit could be changing so much that if there's a way that you can use the tools that we have and improve it, they want that. I'm saying that a lot in my firm that it's much more of a spirit of change and trying to see what we can do to improve. (TD6)

I think the younger generation is very optimistic and we're more adaptive to technology. (TG2)

Auditor belief in TBATs as a conduit to success

About half of participants report a belief that positive actions associated with TBATs are a conduit to professional success within their audit firms. These participants explicitly identify this belief as a motivator for engaging in proactive behaviors related to TBATs. Several auditors share their perspectives below:

I think the use of data analytic software is going to be huge in the future, so I'm trying to learn it now so that I can move up quicker. (TH4)

… seeing where everything's going in public accounting. If I can have a one-step advantage on the next person, that was also something that motivated me… technology's becoming so overwhelmingly popular as far as block chain and mind bridge… just getting this small step ahead of someone else that's working in the same industry I think was an opportunity that I really couldn't pass up and which drove me to pursue it and do it as best I can and put as much time in it as I possibly can to be effective in my normal job. (TG3)

I'm looking to move up in the firm and it looked like this was one way I could distinguish myself. I just try to be proactive about that. I guess that's what motivated me. (TH6)

I want to get moved up, right? So, I have to train someone who's able to do my job, and part of my job is knowing how to do journal entry testing in IDEA. So, I think it helps everyone. It helps the firm with the knowledge, it helps them in their career, and in the future, it helps me in my career. So, I think it's a win, win, win. (TI5)

These participants share the belief that mastering TBATs, integrating TBATs into engagements in new ways, and promoting new TBAT practices to others will ultimately further their career. Interestingly, a few participants also use the interview discussion as an opportunity to seemingly confess that they use TBATs to take over less interesting aspects of the engagement that can be automated. These experiences suggest some auditors perceive creating a more automated workflow process using TBATs as somehow conflicted with fulfilling the totality of their responsibilities. One auditor shares:

Another motivation is pretty selfish reason is I want to try to spend as little of time doing the manual stuff that nobody enjoys like formatting files and getting things ready for the analytics. I want to dive in and do the actual analytics. Basically, what I want to do in my career is always be value added as much as possible so every hour or minute I'm spending just formatting, which is not necessarily value added, instead of doing analytics or giving something that could be a little bit more valuable to clients, I think is a big motivator for me as well. (TD4)

Perhaps more striking is that roughly half of participants do not mention TBATs as a potential conduit to professional success as a motivator for their behaviors. This is surprising given

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the overwhelming number of participants describing their firm cultures as strongly supportive of TBATs. Indeed, not a single participant could come up with a specific example of how TBATs are a component of their formal performance reviews. This disconnect between audit firm public support related to TBATs versus performance reviews that do not incorporate metrics to reward proactive TBAT behaviors may be a missed opportunity for firms.

Antecedents of Maintaining Institutional Works

To date, *maintaining* actions are the most understudied domain of institutional work (Lawrence et al. 2009). *Maintaining* behaviors "primarily address the maintenance of institutions through ensuring adherence to rules systems," (p 230, Lawrence and Suddaby 2006) and comprise actions that perpetuate the status quo while remaining compliant with institutional expectations. Figure 2 illustrates a collective network map linking antecedents to behaviors of *maintaining* forms of institutional work related to TBATs.

[INSERT FIGURE 2 ABOUT HERE]

Among nine antecedents, I focus my discussion on the two most strongly associated with *maintaining* acts of institutional works: training and on-the-job learning, and audit firm TBAT culture.

Training and on-the-job learning

Nearly all participants discussed on-the-job learning (OTJL) in tandem with formal training on TBATs. Auditors suggest that both are important determinants of engaging in *maintaining* institutional works associated with TBAT use. This is particularly true for behaviors that reinforce established uses of TBAT protocols within firm guidelines. As one participant puts it:

I find them both useful and I think you need both in really anything within auditing to effectively learn something. I think the formal training, if you've never had any experience with it is important;

because at least it kind of gives you a sense of what's going on. You're never going to remember the specifics, which is where the on-the-job training piece comes in. Like, someone actually sits down with you and applying it to a real situation. This is how you go through the processes. So that first initial training gives you the big, general overview of what it looks like and then the on-the-job, the specifics of this is actually step by step of how you run things. (TB6)

Auditors report a preference for trainings that are conducted by experienced *audit* personnel relative to trainings conducted by third-party vendors or trainers who may lack audit experience. These auditors suggest trainings taught by auditors have more practical utility and trainers are better able to anticipate which advanced tools can be applicable on engagements. The quotes below explain further:

It was taught by one of our auditors at the firm, so they're able to relate it to specific instances on their jobs and how they use it, so that was helpful to see. (TJ5)

I would say being taught by somebody, an auditor in our firm maybe has more perspective on where we are actually going to use it and implement it, where outside it's, "You can click on this and this'll happen, you can try this and you'll get this result," and less of how exactly we are going to be using it within our engagements. (TG1)

Many participants report effective trainings improve their ability to educate others on using firm-established TBAT practices. This includes perceptions that trainings are generally foundational, while deeper knowledge acquisition occurs via on-the-job learning and collective educating. The following quotes illustrate these ideas:

Coming back to the office, I'm always trying to help my staff and show them, hey, here's how we do this in ACL. It's really important that you learn how to do this, and that way, we can continue to do it not only on this client, but any clients you have in the future. So, I definitely try to be as proactive as I can helping the people I work with, whether they be a level below or above me, learn how to use this software. (TC3)

I prefer to just sit down and walk through audit functions within it whereas our formal trainings will focus on this is what it is, this is what it is capable of doing, this is how you import. The training that I find most helpful is just sitting down with someone and running through an actual audit procedure. That way I think is the easiest way to learn it moving forward. (TH4)

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Interview data suggest one of the most common frustrations around trainings on TBATs stems from assumptions that auditors receive perfect or "clean" client data. Indeed, many participants report receiving messy or "dirty" client files that are initially (and sometimes irreparably) incompatible with firm TBAT protocols. Ultimately the lack of discussion in training about how to strategically cope with receiving dirty client files leaves auditors feeling frustrated. Several auditors recount their experiences below:

I think during the trainings some of the information that you're receiving is cleaner. So again, a PDF might be readable, whereas when you get a PDF from a client, it might not be. (TF4)

It was frustrating. Especially because IDEA, I know, has probably a lot of other functions that I'm still learning, that maybe could help. I think that there could be more training on it, but like I said, at this point, just from my experience with it, it seems like such a great audit tool, that it's almost like you wouldn't expect to have these kinds of hiccups where you have to go in and format all the data in a certain way anyway. You would think that there would be something in IDEA that could easily take care of that. (TF5)

That first training is just going to be very basic. Like great clean files. They have some files in there that you don't even get from the client, they're so clean… I know some people put feedback on there like, "You're having us import files that are so clean, and that's not realistic." (TC1)

A few participants also touch on other issues pertaining to trainings; noting firms offer limited trainings and resources to explore advanced toolbox features of TBATs. One participant also mused on why trainers failed to address a significant software error but wondered if:

They did not go over if you try to use the tax column. I think either, a) they weren't aware that that was an issue, or b) they just expected that everyone would not be using or applying that column and that they would be applying the general book balance column. (TB2)

To supplement gaps in their knowledge, several participants report collaborating with colleagues is needed to successfully employ firm-established TBAT practices. Manifestation of this behavioral response has interesting theoretical implications. In such cases, an inadequate firm

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resource evokes *maintaining* behaviors as auditors strive to protect and reestablish adherence to rules that are imperfectly administered from an institution. When individual participants view training and OTJL as inadequate, their baseline self-efficacy related to the TBATs propels them toward maintenance behaviors manifested by forming a collective among peers. This suggests in-charge auditors are indeed an important maintenance mechanism for firms when internal institutional resources falter. Several in-charges recount acts of collaboration to leverage firm-established TBATs below:

Many of the seniors feel that our technology training is inadequate when it comes to new systems. Because of that, we all try to work together to learn what we probably should've learned in training. An example that I'll get into, on the positive effects of Teammate is the Benford's analysis test. That's something that we were never taught in training but one of the other seniors figured it out and has spread it through the firm from there. That's the approach that we take, is when somebody figures out a new functionality, we try to pass it along to the other seniors we all know it. (TH4)

We do have classes. There's a couple of us that use it a lot, and so, we do ask each other questions about it. (TA1)

The best way that we've found is to share successes and talk with each other about what we're seeing works well with the use of the tool, what doesn't work well… (TA3)

Taken together, interview data suggest that firm training on TBATs are susceptible to common pitfalls including inappropriate trainer backgrounds, oversimplified training contexts, and a void of advance TBAT trainings.

Audit firm TBAT culture

Audit firm culture and norms around TBATs not only promote *creating* institutional works, but also seem to be associated with *maintaining* institutional works. Half of in-charge auditors report their respective firm cultures as a significant factor as to why they decided to use a firm TBAT to engage in *maintaining* normative firm practices related to technology. As two participants explain:

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It's heavily suggested. Of course, there are always situations where it's not intuitive or it's not helpful to use IDEA. In those unique engagements, we don't use IDEA, but those are specific cases. It is highly recommended that we use IDEA in every engagement in things that we have to do in every engagement, like journal entry testing like we talked about in FC we need to do. So that way, at a minimum, we incorporate that into certain tests like journal entry testing, for example. (TI5)

It was a firm-wide initiative to use that as a sort of an unpredictability procedure. It spits out a nice graph, which is great during exit meetings to show. It's very digestible, and it's a good general, first look at where we should be focusing prod testing, if any. (TI6)

Participants suggest firm culture and sentiment around accepted TBAT practices are imparted via communication channels such as e-mails and meetings. However, firms should be careful to reconsider rigid TBAT protocols to avoid instances of auditors being required to apply TBATs to poorly matched client data. Multiple participants recall instances in which they felt constrained by inflexible firm expectations and rules around TBATs, but ultimately upheld these practices to conform to institutional norms. These *maintaining* practices can have detrimental effects on audit quality in the long run if efficiency and effectiveness are subverted to ceremonial practices (i.e., actions that are meant to reproduce existing norms simply to achieve perceived legitimacy). The following quotes demonstrate how firm culture influences auditors' propensity to use firm-established TBATs:

We get so many e-mails… and it's just where we see the firm and the industry going, and it's mostly just letting us know that, hey there's going to be this training and this is why we think it's a benefit to roll out… (TG2)

There is rigidity with change, but it's definitely becoming more accepted and embraced almost that we should be using these types of software… (TF6)

We've had the client for a while but it was a new engagement team this year. It was kind of a trial and error with that and they had new entities so there was multiple GLs, so it kind of got all jumbled up… It's just something that I guess you still try because it's like our firm practice to always go through IDEA with it… (TB6)

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In addition to the aforementioned *maintaining* behaviors, several participants suggest their audit firm culture also prompts them to engage in educating newer staff auditors with how to use established TBATs.

I think you just help out where you can. We just have a culture where when you know something, and somebody else needs to learn, you just pass down that knowledge. I don't mind getting involved in training with the new hires. I do a client service training as well (TK5)

Everybody who hops on my team and I ask them to do a task, I'm always trying to make sure that they understand why they're doing it and I always say, "Once you understand why, try to think of a more efficient way." I'd say, "Hey, here's how I would use this. I would use Active Data, or I would try to use this tool." If they don't understand what I'm talking about, I'll walk them through it and then hopefully they keep understanding it from there on and if not, I hope that they come to me for questions. (TD4)

Many of these participants share experiences in which former superiors taught them how to use firm-established TBATs. This OTJL as a common practice works to instill firm values around the importance of educating others on adhering to standard TBAT practices. Two participants recall their experiences below:

There are two managers who just started within the last two years… they had a lot deeper of an understanding than I did. And I just kind of leveraged that… and I just knew that they were my go to people and they're always willing to help me… [I've helped] especially new staff. I try to teach as much as possible because they're going to be in my shoes eventually; so it's always good to get as much experience and practice as possible. Especially when it's actually application. (TK4)

It's pretty similar to how I am with my staff, the idea is that they're trying to help you learn how to do the job in the best way possible. It that's teaching you how to do Active Data, and I actually had one senior that was really good and he was very good with technology, and he would actually take extra time to show me interesting things that he had learned with Active Data. I learned a lot from him. (TD6)

Taken together, auditors generally perceive educating firm norms to others as a fabric of firm culture. This suggests audit firms culture as a vital mechanism to police and reaffirm expectations surrounding established TBAT uses when on-boarding and developing younger staff.

Antecedents of Disrupting Institutional Works

Finally, the most alarming set of behaviors is *disrupting* acts of institutional works. *Disrupting* actions are behaviors that "attempt to undermine institutional arrangements" (p 9, Lawrence et al. 2009). These behaviors comprise actions that cause individuals to disassociate or publicly scrutinize embedded organizational values; for example, adopting and voicing a cynical opinion on the utility of a firm practice. Similar to *maintaining* works, *disrupting* works have also received relatively little scholarly attention compared to *creating* acts of institutional work (Lawrence et al. 2009). This may be because *disrupting* acts encompass a negative connotation, and institutional workers are thereby less likely to acknowledge them publicly. Nevertheless, in-charge auditors were forthcoming in sharing several distinct *disrupting* behaviors, suggesting data obtained from the interviews are candid accounts. It is also important to note that although disruptive behaviors themselves have negative connotations; these acts of institutional work do not necessarily negatively impact audit quality. Figure 3 illustrates a collective network map linking antecedents to behaviors of *disrupting* forms of institutional work.

[INSERT FIGURE 3 ABOUT HERE]

Among nine antecedents, I focus my discussion on the three most strongly associated with *disrupting* acts of institutional works: client data quality, prior engagement issues, and engagement budget.

Client data quality

Most participants suggest client data quality as an important determinant of engaging in *disrupting acts* of institutional work. Over a third of participants report dirty data from clients as a common antecedent that provokes them to engage in a workaround behavior. Two in-charges recount their experiences:

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I would say the root of the issue is the client data. And again also, not only were it various files, but the various files were being pulled from a couple different accounting systems. It was definitely more related to the data from the client than it was ACL, or you know. (TC3)

It has been a struggle getting information from the client that works in it. So it's great if we can get things in Excel, and be able to get it to line up great in columns, but when we get information in a PDF or the way that a lot of the entries I wanted to test were pulled out of the system in Notepad, and getting that into a format that we can then run within Teammate has been the biggest challenge. (TG1)

Without exception, these behaviors translate to a loss of efficiency, which has negative implications for both audit firms and clients. This is true even in cases where a workaround ultimately leads to successful use of a TBAT, because it is preceded by sunk time in making ad hoc revisions to clean up client data. Workaround behaviors also have significant implications for audit quality from an effectiveness perspective. Of participants who report engaging in workaround behaviors prompted by low quality or incompatible client reports, many recall instances of working outside of established TBAT systems, performing normally automated processes as manual procedures, or reducing the scope of testing procedures. The following quotes offer examples:

We ran the tests we could and then it was, honestly, we had to manually go through the GL to identify those same tests that we ran within Smart Analyzer for some of them. It couldn't return what we needed it to return. (TB6)

So we've addressed it by kind of narrowing the amount for this year, the data that we're going to review. (TG1)

Sometimes IDEA's unable to get a PDF to extract properly. So instead of going through and try to mess around with it, we just go through and manually foot everything and go through it haphazardly select items when we go through testing. (TK4)

Several participants suggest either an unwillingness to circle back to clients for better data, or indicate they perceive TBATs and associated processes are lacking malleability to make pursuing such interactions worthwhile. Two auditors share their reservations in the quotes that following:

It's just one of those things where it's frustrating when it doesn't work the right way, because you do have to spend that extra time, but ... yeah, we're not going to go back to the client. (TK5)

It's difficult to change something once it becomes big. It would take a lot of effort for them to make certain tweaks. They are doing somethings. It's not like they're doing nothing. They have a general use software package that's not always customized and it's just seems to me to be outdated. (TH6)

Audit firms may consider teaching engagement team members proactive alternatives to address incompatibility issues. Indeed, a third of participants report engaging with "boundary participants," either clients or third-party TBAT vendors, to address compatibility issues between client data and TBAT capabilities. Examples of such interactions follow below:

We had the client and our team meet and just discuss, explain what we're looking for, what exactly the issue was... We just had a big meeting and talked it through and worked pretty well. (TA1)

You have to almost train your clients to export stuff, and sit down with the IT team. Which, we speak two totally different languages, accounting and IT. Which I think is getting better. We're bridging that gap a little more. (TC1

...our firm is paying for the service, we do have not a say, but we have a voice for using the service. They want know how they can get better and I just wanted to make it known that I have something that I want show you guys. I have a thought that I think can really help and the company can make third party vendor more efficient. (TB5)

These retellings suggest collaborating with external parties presents a viable path for firms to cope with and potentially remedy consistent compatibility issues between client data and TBAT capabilities.

Prior engagement issues stemming from a TBAT

Nearly a third of all participants experience prior issues stemming from a TBAT that prompts them to engage in disruptive institutional work. These auditors suggest they engage in negative rhetoric related to the TBAT that caused issues on a prior engagement. Such behavior, while seemingly benign given its likely frequent occurrence, insidiously undermines important

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values of audit firms' TBAT practices. Not only can this hinder a firm's ability to implement and

perpetuate firm TBAT practices, but it may also curtail future audit firm efforts to promulgate new

TBAT guidelines. In the quotes that follow, several auditors share accounts of how negative

rhetoric related to TBATs takes shape:

I then told the team to stay away from IDEA as much as they could… (TB5)

We talk a lot about how it's not user friendly, and about how it's like if you don't have good data, then it's basically useless. (TC1)

It's usually, "oh, how is Caseware Connector not working for your today?" (TK4)

It's kind of not looked on well by the vast majority of people, except for at the higher levels, because they can sell it to the client that, "We have this great, internally generated secure transfer site that outlines our PBC list. It all makes sense." I'd say director and up… but manager and down, I don't think anybody's really too keen on it. (TI6)

Engagement budget

Most participants reiterate the importance of "getting the job done," in spite of limited

engagement hours budgeted as an antecedent of *disrupting behaviors* in institutional work, which

is consistent with theoretical predictions (Smets and Jarzabkowski 2013; Lawrence et al. 2011).

Therefore, it is not surprising that some in-charges specifically point to the engagement budget as

a common explanation for engaging in *disrupting* behaviors, including avoiding interactions with

boundary participants and participating workaround behaviors. The quotes below offer examples:

…maybe if we had worked with the client's IT team and maybe had a call between them and their accounting software provider, we might have been able to find a way for them to export it into Excel versus us just attempting to take the PDF. (TB5)

It got to the point where we kept putting time into it, kept thinking about it, kept getting new files from the client, we went back and forth a lot. It kind of got to the point where, at least for this year that I'm thinking of specifically, we were unable to get that implemented with ACL, and we'd kind of sink a lot of time into it, and then we had to still revert back to the old manual process for that

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year. It ended up being more of a time sink, because we thought we would be able to do it and just weren't able to. (TC3)

Although interviews with in-charges suggest auditors are acutely aware of the engagement budget, perhaps what is more surprising is that associations between the engagement budget and *disrupting* behaviors are not unanimous among participants. This suggests some audit firms are prioritizing and communicating the importance of audit quality over that of audit productivity.

It kind of takes some time also to test out these new ideas. So, it could increase a ton on your budget, even if you're going to gain efficiencies in future years. Sometimes partners can be not as accepting of those changes due to those factors. But our partners are, they understand that it takes some effort, and it takes some time and to see those changes, and they don't want us to get behind that technology curve. They don't want us to get behind on the way we perform audits and what we tell our clients we're capable of doing. (TC3)

V.   IMPLICATIONS FOR PRACTICE

In addition to important theoretical contributions, results also offer a windfall of insights about how firms can promote proactive behaviors in auditors and implement mechanisms related to TBATs to enhance audit quality. It seems unlikely that firm management would be apathetic toward improved audit quality stemming from increased use of TBATs; however, at present, results suggest partners are either unaware of the full spectrum of benefits attached to implementing TBATs on assurance engagements or choosing not to reward auditors' efforts to enhance engagements through the use of TBATs.

Results offer several ways firm leaders can weave support for TBATs into firm culture to support audit quality. Audit firms may consider delegating a small team of partners within each office to stay abreast of emerging TBATs so they can disseminate related knowledge to other firm management personnel. If these partners are able to operate as technological liaisons for their office, it may help elevate higher-ups' appreciation and understanding for the application of

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TBATs, without depleting significant firm resources in order to gain this knowledge. Bridging the gap between partner knowledge of TBATs and their understanding of how TBATs can support audit quality may be an important way to continue motivating in-charge auditors to innovate on TBATs.

Firms may also wish to implement and maintain innovation channels aimed toward soliciting feedback on current and proposed TBATs. Results suggest channels are associated with *creating* forms of institutional work that promote audit quality. Importantly, firms should be mindful to source ideas to responsive teams and reinforce the importance of employee participation in providing constructive feedback as a firm value. TBAT feedback channels can also be used to combat frustrated employees disseminating negative affect related to a TBAT in a non-constructive way, firms can implement a feedback loop to catch these sentiments. Designing TBAT feedback loops targeted at tracking and compiling TBAT issues will help firms identify and prioritize TBAT problems that need attention. The mere existence of such a feedback structure may in itself prove an effective strategy to transform and stop the spread of negative affect around problematic TBATs into a productive mechanism.

Results also suggest firm values related to TBATs are infrequently – if ever – manifested as performance goals. Audit firms may consider integrating specific TBAT-related performance review goals as a way to reward TBAT-enhancing behaviors in auditors. This may also provide the benefit of galvanizing audit personnel who are apathetic or even resistant toward TBATs to pivot to proactively embrace TBAT tools and related practices within assurance engagements. Firms should continue to build and maintain a firm culture that promulgates long horizon perspectives on TBAT use to foster positive forms of institutional work related to TBATs.

In addition to strengthening the alignment between audit firm culture and TBATs through the aforementioned mechanisms, audit firms can consider efforts to innovate current TBAT trainings. Results suggest training teams, training materials, and level trainings as discrete inputs that impact the ultimate quality of TBAT trainings. First, firms may be best served by assigning training duties to teams of individuals of different backgrounds in IT and auditing. This will ensure a training team will encompass sufficient knowledge of TBAT capabilities while delivering content that remains relevant for its audience of trainees. Second, firms can improve trainings by incorporating a mix of cases, scenarios, and examples on how to use a TBAT with imperfect data inputs (e.g., incomplete client data, non-preferred document formats, etc.). Finally, firms can segregate foundational skills from advanced skills training programs for TBATs, while incorporating common trouble-shooting tips in each course. Therefore, audit firms should consider functional implications of trainers' relative perspectives, backgrounds, and experiences when planning formal trainings on TBATs.

VI. CONCLUSION

Findings have important implications for our theoretical understanding of how institutional work can unfold at the process level within organizations. Data provide convincing evidence that institutional work can indeed manifest from nontraditional sources, being institutional agents who hold limited organizational power (e.g., in-charge auditors). I also provide evidence of specific contextual factors that may promote individual agents to form collectives to engage in institutional work, which has not previously been documented in the institutional work literature. Therefore this research contributes to literature within institutional theory by analyzing institutional work in a context focused on individual agents. Findings also help develop audit researchers' understanding of the current practice environment within NGNFs as they relate to TBATs.

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Practical implications of results suggest audit firms are well positioned to control several important antecedents that are associated with three distinct forms of institutional works: creation; maintenance; and disruption. I suggest several practice-based solutions audit firms can implement to promote beneficial creating and maintaining behaviors related to TBATs among in-charge auditors to support audit quality. Several recommendations audit firms can employ include communicating and reinforcing values related to TBAT innovation behaviors; revising TBAT training programs to account for complexities of messy client data; and integrating performance goals to be explicitly aligned with proactive uses of TBATs.

I also discuss strategies firms can employ to curtail ceremonial maintenance practices and disrupting behaviors. This is important because ceremonial maintenance and disrupting forms of institutional work threaten the institutional integrity and persistence of not only appropriate TBAT practices within audit firms, but other areas of audit practice within the firm. These behaviors have significant potential to severely undermine audit quality. To lessen negative implications attached to inefficient maintenance and disrupting behaviors, audit firms should consider pursuing the following measures: engaging with boundary participants to address compatibility issues between client data and TBAT capabilities; establishing internal TBAT support channels to receive, acknowledge, and work toward alleviating common TBAT issues; and promoting a firm culture that values long-term TBAT solutions over ad hoc and reactive workaround behaviors during engagements.

This study is subject to two limitations. First, analysis and presentation of qualitative data is innately subjective. However, I pursued my instrument design, interviews, and rigorous coding after taking significant care to revisit methodological considerations from recent seminal works on qualitative methods (Kenno et al. 2017; Malsch and Salterio 2016; Power and Gendron 2015;

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Saldaña 2015; Miles et al. 2014; Cassell and Symon 2004; Miles and Huberman 1994) and highly regarded qualitative accounting papers to support the internal validity of the study (e.g., Durocher et al. 2015; Hazgui and Gendron 2015; Westermann et al. 2015). The second limitation is the broad sample of in-charge auditors I interviewed, with between one and three participants from each of ten separate firms. While a broad sample is appropriate for an exploratory study using a constructivist approach (Power and Gendron 2015); without having more participants from each type of firm, it limits my ability to generalize findings across firms.

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TABLE 1: DEMOGRAPHIC INFORMATION

Professional Rank	Count	Percentage
Senior Associate	23	82.14%
Manager	4	14.29%
Senior Manager	1	3.57%
Total	28	100.00%

Gender	Count	Percentage
Male	15	53.57%
Female	13	46.43%
Total	28	100.00%

Educational Background	Count	Percentage
Bachelor's Degree	14	51.85%
Coursework Beyond Bachelor's Degree	4	14.81%
Master's Degree	9	33.33%
Total Survey Responses	27	100.00%

Professional Certifications	Count	Percentage
Certified Public Accountant	20	74.07%
Other	1	3.70%
None	6	22.22%
Total Survey Responses	27	100.00%

Experience	Mean	Median
Number of Busy Seasons as a Senior	2.52	3
Total years of Audit Experience	4.83	5
Age	28.26	27
Total Survey Responses	27	

Industry	Count	Percentage
Construction	1	3.70%
Finance, Insurance, and Real Estate	4	14.81%
Government/Nonprofit	2	7.41%
Manufacturing	11	40.74%
Retail Trade	1	3.70%
Services	8	29.63%
Total Survey Responses	27	100.00%

TABLE 2: INSTITUTIONAL WORKS BY DOMAIN

Institutional Work	Behavior	Description
Creating	developing or improving a TBAT process	creating a new TBAT process, improving an established TBAT process, or applying a TBAT to a new setting
Creating	interacting with boundary participants to improve TBAT processes	reaching out to third-party software vendors or clients to facilitate the compatibility of client data with TBAT functionality
Creating	participating in firm TBAT innovation efforts	partaking in TBAT focus groups, joining a TBAT innovation team, or giving TBAT feedback through firm channels
Creating	promoting a new TBAT process	suggesting and priming others to use a new TBAT process
Creating	self-directed TBAT learning	self-acquired TBAT knowledge; leveraging non-formal TBAT trainings to learn (e.g., optional webinars; third-party tutorials; external resources)
Maintaining	engaging in appropriate use of established TBATs	using a firm approved TBAT within an expected or required context
Maintaining	collaborating with colleagues to solve TBAT issues	addressing issues on an ad hoc basis with others while adhering to firm norms
Maintaining	educating established TBAT practices	teaching others firm approved TBAT processes
Maintaining	promoting established TBATs	policing others to use firm TBATs where expected
Disrupting	avoiding interactions with boundary participants	failing to notify clients or third parties about persistent TBAT issues that can be resolved with joint interactions among auditors and external parties
Disrupting	engaging in negative rhetoric related to a TBAT	promulgating negative affect about a TBAT in the workplace
Disrupting	resisting a TBAT process	consciously avoiding using a firm promoted or established TBAT
Disrupting	withholding TBAT feedback from firm channels	not providing TBAT feedback when firm channels are in place and user has experienced an issue
Disrupting	engaging in workaround behaviors	deviating from firm TBAT protocols including engaging in quality threatening behaviors, working outside of systems, and completing processes manually

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TABLE 3: ANTECEDENTS OF INSTITUTIONAL WORK

Antecedents	Source (i.e., emerging theme, prior literature, or theory)
Audit firm TBAT culture	Dowling (2009)
Auditor accountability	emerging theme
Auditor belief in TBATs as conduit to success	emerging theme
Auditor TBAT expertise	emerging theme
Client data characteristics	emerging theme
Engagement budget	Curtis and Payne (2008); Lawrence, Suddaby, and Leca (2011)
Perceived malleability of TBAT process	emerging theme
TBAT issues on prior engagement	emerging theme
TBAT resources	Janvrin, Bierstaker, Lowe (2008), (2009); Lowe, Bierstaker, Janvrin, and Jenkins (2018)
Training (both formal and informal OTJL)	Dowling (2009); Bierstaker, Janvrin, and Lowe (2014)

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FIGURE 1: ANTECEDENTS OF CREATING INSTITUTIONAL WORKS

ANTECEDENTS CREATING INSTITUTIONAL WORKS
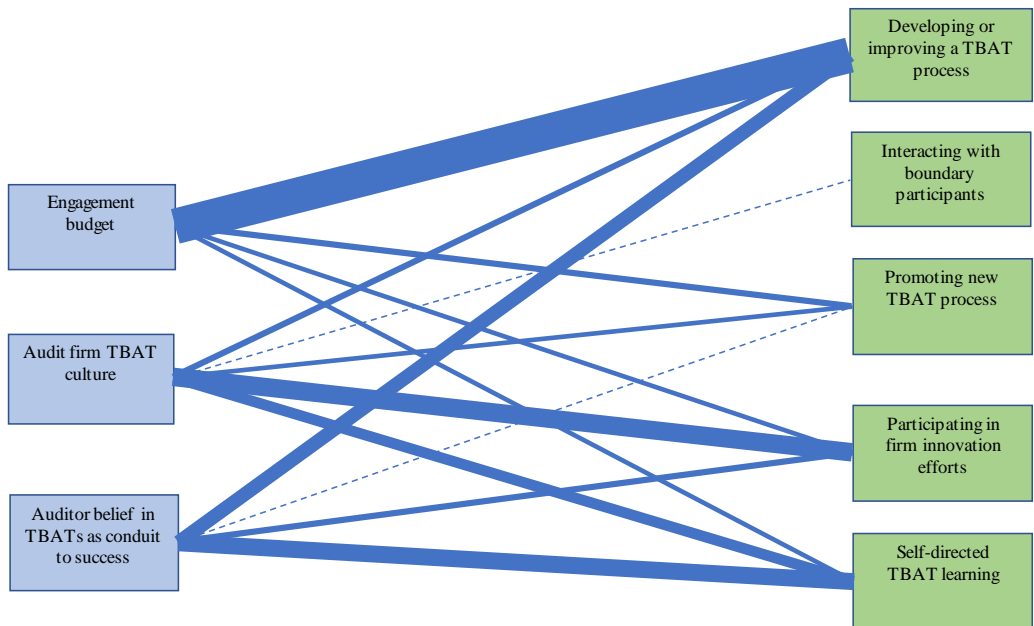
52

FIGURE 2: ANTECEDENTS OF MAINTAINING INSTITUTIONAL WORKS
ANTECEDENTS   **MAINTAINING INSTITUTIONAL WORKS**
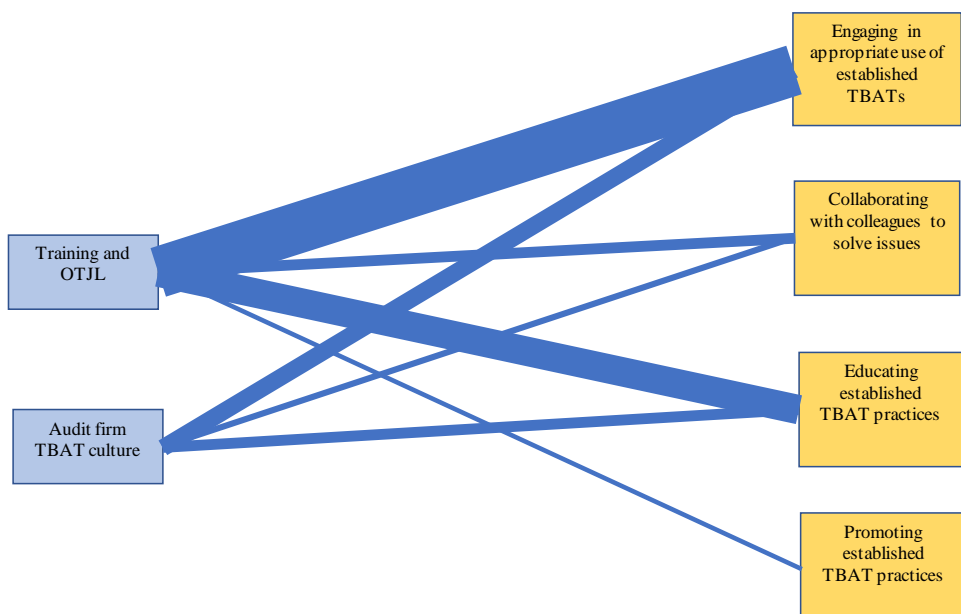
53

FIGURE 3: ANTECEDENTS OF DISRUPTING INSTITUTIONAL WORKS

ANTECEDENTS   **DISRUPTING INSTITUTIONAL WORKS**
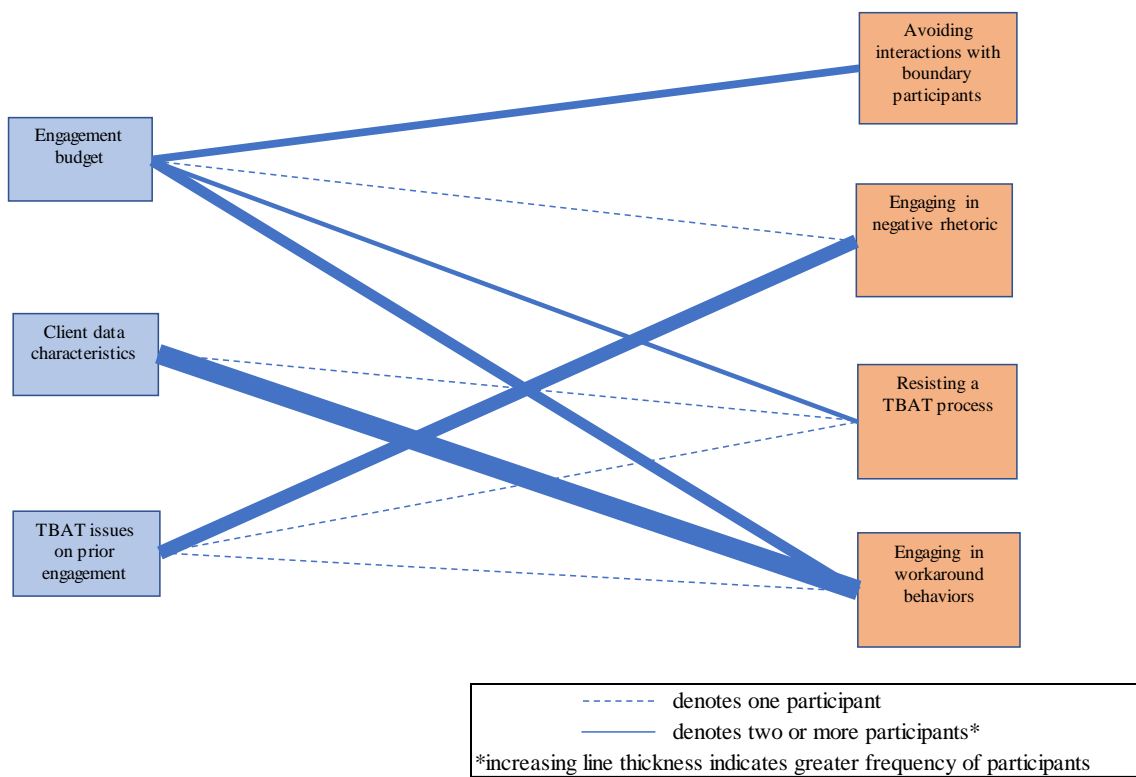
APPENDIX A: INTERVIEW PROTOCOL FOR IN-CHARGE SENIOR AUDITORS

Interview Protocol for In-Charge Senior Auditors

<u>Interview Questions:</u>

1. In the pre-interview questionnaire, we asked you to think about an assurance engagement that best exemplifies a situation in which a TBAT or TBAT component **facilitated the achievement of audit effectiveness and/or efficiency**, and what factors motivated or enabled you to engage in actions related to those benefits.

   a) Could you first describe the TBAT or TBAT component?

   b) How does this TBAT relate to the performance of specific assurance procedures?

   c) How did this TBAT enhance assurance effectiveness and/or efficiency on this specific engagement?

      i) How did that make you feel?

      ii) How was the benefit related to the TBATs leveraged within the engagement (e.g., use of new tool, development of new process)?

      iii) If you personally took action:
         (a) What factors, resources, and/or circumstances do you think motivated you to take action?

   d) Did the TBAT decrease any specific difficulties during the engagement you're thinking of?

   e) Is use of this TBAT required in this specific context?
      i) If so, is it required on all engagements and by whom?

   f) What implications did this TBAT have for the client, firm, engagement team, or you personally, and why?
      i) Was the benefit related to the TBAT acknowledged by your engagement team? If so, how?
         (1) How do you talk about this TBAT when speaking with your peers?

         (2) How do you feel about this TBAT?

      ii) How was your performance on this engagement evaluated?
         (1) Do you have any professional goals aligned with TBAT use?

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APPENDIX A: INTERVIEW PROTOCOL FOR IN-CHARGE SENIOR AUDITORS

      iii) Were you able to promote the benefit(s) associated with the TBAT to be leveraged on other engagements?
          (1) If you did, has this been successful? Why or why not?

          (2) If you did not, why not?

  g) How did you learn to operate the TBAT used on this engagement?
     i) If there was a formal training:
        (1) Was it representative of your real-world application of the TBAT?

        (2) What amount of time elapsed between having training and application of the TBAT on a client engagement?

    ii) If you have previously helped others use this TBAT, please describe how you have helped others learn to use this TBAT in a similar context.

APPENDIX A: INTERVIEW PROTOCOL FOR IN-CHARGE SENIOR AUDITORS

2. In the pre-interview questionnaire, we asked you to think about an assurance engagement that best exemplifies a situation in which a TBAT or TBAT component **hindered the achievement of audit effectiveness and/or efficiency**, and what factors motivated or enabled you to engage in actions related to those difficulties.

    a) Can you first describe the TBAT or TBAT component?

    b) How does this TBAT relate to the performance of specific assurance procedures?

    c) How did this TBAT hinder assurance effectiveness and/or efficiency on this specific engagement?

        i)   How did that make you feel?

        ii) How was the difficulty related to the TBATs addressed (e.g., point person, internal or external team)?
             (1) Were there any workarounds to address the difficulty related to the TBAT?

        iii) If you personally took action:
             (a) What factors, resources, and/or circumstances do you think motivated you to take action?

    d) Did the TBAT increase any specific difficulties during the engagement you're thinking of?

    e) Is use of this TBAT required in this specific context?
        i)   If so, is it required on all engagements and by whom?

    f) What implications did this TBAT have for the client, firm, engagement team, or you personally, and why?
        i)   Was the difficulty related to the TBAT acknowledged by your engagement team? If so, how?
             (1) How do you talk about this TBAT when speaking with your peers?

             (2) How do you feel about this TBAT?

        ii) How was your performance on this engagement evaluated?
             (1) Do you have any professional goals aligned with TBAT use?

        iii) Were you able to improve or work around the difficulty associated with the TBAT on other engagements?
             (1) If you did, has this been successful? Why or why not?

             (2) If you did not, why not?

    g) How did you learn to operate the TBAT used on this engagement?

APPENDIX A: INTERVIEW PROTOCOL FOR IN-CHARGE SENIOR AUDITORS

     i) *If there was a formal training:*
        (1) Was it representative of your real-world application of the TBAT?
        (2) What amount of time elapsed between having training and application of the TBAT on a client engagement?

     ii) If you have previously helped others use this TBAT, please describe how you have helped others learn to use this TBAT in a similar context.

3. **Wrap-up.**

Is there anything else you'd like to share with us about your experience or perceptions of TBAT usage within the firm?

APPENDIX B: FULL MODELS OF COLLECTIVE NETWORK MAPS

ANTECEDENTS   **CREATING INSTITUTIONAL WORKS**

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ANTECEDENTS

MAINTAINING INSTITUTIONAL WORKS

Audit firm TBAT culture

Auditor accountability

Auditor TBAT expertise

Engagement budget

Client data characteristics

Auditor belief in TBATs as conduit to success

Physical environment

TBAT resources

Training and OTJL

Engaging in appropriate use of established TBATs

Collaborating with colleagues to solve issues

Educating established TBAT practices

Promoting established TBAT

- - - - denotes one participant
——— denotes two or more participants*
*increasing line thickness indicates greater frequency of participants

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ANTECEDENTS

DISRUPTING INSTITUTIONAL WORKS

Audit firm
TBAT culture

Auditor
accountability

Auditor TBAT
expertise

Engagement
budget

Client data
characteristics

Perceived
malleability of
TBAT process

TBAT issues
on prior
engagement

TBAT
resources

Training and
OTJL

Avoiding
interactions with
boundary
participants

Engaging in
negative rhetoric

Resisting a
TBAT process

Withholding
TBAT feedback
from firm
channels

Engaging in
workaround
behaviors

	denotes one participant
	denotes two or more participants*

*increasing line thickness indicates greater frequency of participants

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VOLATILITY SPILLOVERS BETWEEN CHINESE ENERGY, STOCK AND FOREIGN ECAHNGE MARKETS DURING THE SINO-AMERICA TRADE WAR[1]

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Abstract: In this paper, we examine the static and dynamic volatility spillovers between Chinese crude oil futures, stock, and foreign exchange markets using the BEKK-GARCH model and Diebold-Yilmaz (2012, 2014)'s volatility spillover measures, including the total spillover index, directional spillover index, and net spillover index. Empirical results show that there are significant bidirectional volatility spillovers between each pair of the three markets; the crude oil futures market is the net volatility transmitter, while the stock and foreign exchange markets are the net volatility receivers. The unidirectional volatility spillovers from the crude oil futures to the stock is the strongest.

Keywords: Volatility spillover; Sino-America trade war; BEKK-GARCH Model; Spillover index

1. Introduction

On March 22 of 2018, American government declared to impose tariffs on $60 billion of Chinese goods. Being a self-protection, Chinese government announced on the next day (that is, March 23) to impose tariffs on $3 billion of American goods. This indicated the start of Sino-American trade war which has lasted for one and half years up to now, and has brought great influences to both countries' economic and financial markets. Shanghai composite index dropped by nearly 15% from April to August of 2018. On American side, a number of companies and farmers lost a large amount of money due to the raise of tariffs between the two countries. Furthermore, the USD-CNY exchange rate has raised to 7.18 since the trade war started. The volatility of both countries' financial market increased seriously and spilled over across markets. Thus, we would naturally like to investigate such volatility spillovers, trying to clarify the mechanism of risk contagion and provide necessary empirical reference for investors' decision making and government's market regulation. And very coincidentally, Chinese crude oil futures were launched on March 26, 2018 and just witnessed the whole process of Sino-America trade war. So, what and how much impact will the trade war have on the spillover behaviors of Chinese crude oil futures market? This is an issue that is of concern to scholars, governments and investors, and one that we want to make clear. Having such motivations, we will analyze the volatility spillovers between Chinese three main financial markets, i.e. energy, stock and foreign exchange during the trade war, where we use the crude oil futures, Shanghai composite index and USD-CNY exchange rate to be the proxies for these three markets, respectively.

In general, the volatility of a financial market is not only affected by its own cyclical fluctuations, but also may be restricted by volatility from other markets. Such volatility transmission across markets is called

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volatility spillover effect. Since Ross (1989) put forward the above concept, more and more studies have been conducted on the volatility spillover effect. For example, with the help of the univariate GARCH model, Hamao et al.(1990) studied the volatility spillover effects between the stock markets in the United States, the United Kingdom and Japan. Karolyi (1995) used a multivariate GARCH model to study the transmission of returns and volatility between American and Canadian stock markets. Ledoit et al. (2003) investigated the volatility spillover effects between international markets, using a new approach to estimate the parameters in the multivariate GARCH(1,1) model. Arouri et al. (2012) studied the volatility spillovers and hedging effectiveness between European oil and equity markets. Similarly, Salisu and Oloko (2015) examined the return, shock, and volatility spillover effects between American oil and stock markets. Eraslan and Ali (2018) used volatility impulse response analysis to quantify the size and the persistence of different types of oil price shocks on oil and stock return volatility dynamics. To measure the spillovers in returns or volatilities between financial assets, Diebold and Yilmaz (2009) introduced a volatility spillover measure based on forecast error variance decompositions from vector autoregression (VAR). Then in Diebold and Yilmaz (2012, 2014), they proposed measures of both total and directional volatility spillovers, using rolling-sample VAR and variance decomposition to characterize time-varying daily volatility spillovers across different financial markets. After that Diebold & Yilmaz (2015, 2016) further investigated the spillover effects between financial institutions and markets, using directional spillover indexes and spillover network.

For studies on Chinese financial markets, Cong et al. (2008) investigated the relationship between Chinese oil and stock markets. Zhang et al. (2008) examined the volatility spillover effects between Chinese foreign exchange and oil markets. Li et al. (2017) studied the volatility spillover effects between Chinese fuel oil spot, futures and stock markets. Zhang and Ji (2018) used limited data to make a preliminary exploration of the relationship between the international benchmark oil (WTI and Brent) and three Chinese financial markets (the crude oil futures, stock and foreign exchange)

In this paper, we will comprehensively investigate the volatility spillover effects between Chinese crude oil futures, Shanghai composite index and USD-CNY exchange rate for the period of trade war using the BEKK-GARCH model and Diebold-Yilmaz (2012, 2014)'s volatility spillover measures. This will help investors who are interested in the Chinese markets, including the new crude oil futures market, to control their risk under the new background of trade war. As far as we know, this is the first paper to study the volatility spillovers across the three major Chinese financial markets in the setting of Sino-America trade war, which contributes to the existing literature.

The rest of the paper is organized as follows: Section 2 and Section 3 introduce the models and data to be used. Section 4 gives the empirical results, including the analysis and calculation of volatility spillovers, and then Section 5 presents the conclusions and policy implication of this paper.

2. Methodologies

In this section, we introduce the methods to study the volatility spillovers between the three markets. We will first use the bivariate BEKK-GARCH to model the variance-covariance matrixes between the three markets in pairs. Then the likelihood ratio (LR) test is constructed to detect the existence and direction of

volatility spillovers. After that, we use the vector autoregression (VAR) to fit the volatility obtained from the BEKK-GARCH model. In this framework, the generalized forecast error variance decomposition is performed to identify the connectedness between volatilities, and subsequently the volatility spillover indexes proposed by Diebold and Yilmaz (2012,2014) are calculated based on the variance decomposition matrix.

2.1 The bivariate BEKK-GARCH model

The univariate GARCH model proposed by Bollerslev (1986) can effectively characterize the conditional volatility for a single variable, but cannot describe the interaction of volatility between multi-variables. Thus, Engle and Kroner (1995) extended Bollerslev's (1986)'s model to a multivariate setting and developed the BEKK-GARCH model which can be used to analyze the volatility spillover between financial markets. The bivariate case of the BEKK-GARCH model is given as follows:

$$H_t = C'C + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'H_{t-1}B \tag{1}$$

where C is a 2×2 triangular matrix representing the intercept. A is a 2×2 square matrix of parameters and measures the effect of previous shocks on the current conditional variances. B is also a 2×2 square matrix of parameters and measures the effect of last conditional variances on current conditional variances. The matrix form of equation (1) is

$$\begin{bmatrix} h_{11,t} & h_{12,t} \\ h_{21,t} & h_{22,t} \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} \\ 0 & c_{22} \end{bmatrix}' \begin{bmatrix} c_{11} & c_{12} \\ 0 & c_{22} \end{bmatrix} + \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix}' \begin{bmatrix} \varepsilon_{1,t-1} \\ \varepsilon_{2,t-1} \end{bmatrix} \begin{bmatrix} \varepsilon_{1,t-1} \\ \varepsilon_{2,t-1} \end{bmatrix}' \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix}$$

$$+ \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix}' \begin{bmatrix} h_{11,t-1} & h_{12,t-1} \\ h_{21,t-1} & h_{22,t-1} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix} \tag{2}$$

From above equation, we have

$$h_{11,t} = c_{11}^2 + \left(\alpha_{11}^2 \varepsilon_{1,t-1}^2 + 2\alpha_{11}\alpha_{21}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + \alpha_{21}^2 \varepsilon_{2,t-1}^2\right)$$

$$+ \left(\beta_{11}^2 h_{11,t-1} + 2\beta_{11}\beta_{21}h_{12,t-1} + \beta_{21}^2 h_{22,t-1}\right) \tag{3}$$

$$h_{22,t} = c_{12}^2 + c_{22}^2 + \left(\alpha_{22}^2 \varepsilon_{2,t-1}^2 + 2\alpha_{22}\alpha_{12}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + \alpha_{12}^2 \varepsilon_{1,t-1}^2\right)$$

$$+ \left(\beta_{22}^2 h_{22,t-1} + 2\beta_{22}\beta_{12}h_{21,t-1} + \beta_{12}^2 h_{11,t-1}\right) \tag{4}$$

$$h_{12,t} = h_{21,t} = c_{11}c_{12}$$

$$+ \left[\alpha_{11}\alpha_{12}\varepsilon_{1,t-1}^2 + (\alpha_{11}\alpha_{22} + \alpha_{12}\alpha_{21})\varepsilon_{1,t-1}\varepsilon_{2,t-1} + \alpha_{21}\alpha_{22}\varepsilon_{2,t-1}^2\right]$$

$$+ \left[\beta_{11}\beta_{12}h_{11,t-1} + (\beta_{11}\beta_{22} + \beta_{21}\beta_{12})h_{12,t-1} + \beta_{22}\beta_{21}h_{22,t-1}\right] \tag{5}$$

where $h_{11,t}$ and $h_{22,t}$ are respectively the conditional variances of variables 1 and 2 at time t, i.e. the return volatility. $h_{12,t} = h_{21,t}$ are the conditional covariance between the two variables at time t. Coefficients α_{21} and β_{21} reflect the ARCH-type and the GARCH-type volatility spillovers from market 2 to market 1, respectively (see Mensi, 2014; Salisu and Oloko, 2015; Chang, 2018). The former occurs when the return shocks from market 1 affect the volatility of market 2. The latter occurs when the volatility of market 2 is transmitted to market 1 directly. The meanings of coefficients α_{12} and β_{12} are similar. Referring to Bollerslev and Wooldridge (1992), we use the quasi-maximum likelihood (QML) method with robust standard errors to estimate the bivariate BEKK-GARCH model.

We use the null hypothesis $H_0: \alpha_{21} = \beta_{21} = 0$ and $H_0': \alpha_{12} = \beta_{12} = 0$ to test the existence of volatility spillovers from market 2 to market 1 and the opposite, respectively. This goal can be achieved by likelihood

ratio (LR) test, and the idea is as follows. Firstly, by applying the QML approach to estimate all the eleven parameters in equation (2), we can obtain the maximum likelihood value ll_u of the unconstrained equation. Next, by fixing α_{21} and β_{21} to be zero and applying QML approach again to estimate the remaining nine parameters, the maximum likelihood value ll_c of the constrained equation can be obtained. If the parameter constraints are valid, then imposing them on the model will not cause a significant reduction of the maximum likelihood value, that is, the likelihood ratio $\lambda = ll_c/ll_u$ should be close to one. On the contrary, if λ is too small, the constraints are invalid and the hypothesis $H_0: \alpha_{21} = \beta_{21} = 0$ should be rejected. It can be proven that, under the condition of large samples, the statistic of likelihood ratio test is

$$LR = -2\ln(\lambda) = 2[\ln(ll_u) - \ln(ll_c)] \sim \chi^2(q) \qquad (6)$$

That is, LR is asymptotically distributed as χ^2 with degree of freedom q that is equal to the number of constraints. Here $q = 2$. The rejection region of the test is given by $\{LR \geq \chi^2_{1-\alpha}(q)\}$. The hypothesis H_0' can be tested similarly.

2.2 Measures of volatility spillovers

In this paper we will use the measures proposed by Diebold and Yilmaz (2012, 2014) to study the volatility spillovers between the three markets. Firstly, we establish the following VAR(p) model:

$$V_t = \sum_{i=1}^{p} \phi_i V_{t-i} + \epsilon_t \qquad (7)$$

where $V_t = (V_{1t}, V_{2,t}, \dots, V_{n,t})'$ is the $n \times 1$ volatility vector. ϕ_i, $i = 1,2,..,p$ are $n \times n$ square matrixes of parameters. $\epsilon_t \sim (0, \Sigma)$ is the vector of independently and identically normal distributed errors with covariance matrix Σ.

The moving average presentation of equation (7) is

$$V_t = \sum_{h=0}^{\infty} A_h \epsilon_{t-h} \qquad (8)$$

where $A_h, h = 0,1, \dots$ are $n \times n$ square matrixes of parameters, obeying the recursion $A_h = \phi_1 A_{h-1} + \phi_2 A_{h-2} + \cdots + \phi_p A_{h-p}$. Note that A_0 is an identity matrix and $A_h = 0$ for $h < 0$.

Based on the VAR framework above, the elements of the H-step generalized variance decomposition matrix can be calculated by

$$\theta_{i \leftarrow j}^{(H)} = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (e_i' A_h \Sigma e_j)^2}{\sum_{h=0}^{H-1} (e_i' A_h \Sigma A_h' e_i)}, H = 1,2, \dots \qquad (9)$$

where σ_{jj} denotes the j-th diagonal element of Σ, i.e. the variance of error term for j-th autoregression equation. e_i is an $n \times 1$ selection vector with the i-th element being one and zeros otherwise. $\theta_{i \leftarrow j}^{(H)}$ are the i-th row and j-th column elements of the variance decomposition matrix, representing the fractions of the H-step-ahead error variances in forecasting V_i contributed by V_j, for $i, j = 1,2, \dots n$. Consequently, the variance decomposition products $\theta_{i \leftarrow j}^{(H)}$ represent the own variance shares for $i = j$, and the cross variance shares for $i \neq j$, that is, the volatility spillovers from market j to market i.

However, sum of each row in the decomposition matrix calculated from equation (10) is not necessarily equal to 1. To make the different elements in this matrix comparable, we normalize them by

$$\tilde{\theta}_{i\leftarrow j}^{(H)} = \frac{\theta_{i\leftarrow j}^{(H)}}{\sum_{j=1}^{n} \theta_{i\leftarrow j}^{(H)}} \qquad (10)$$

After the transformation, it can be concluded that $\sum_{j=1}^{n} \tilde{\theta}_{i\leftarrow j}^{(H)} = 1$ and $\sum_{i,j=1}^{n} \tilde{\theta}_{i\leftarrow j}^{(H)} = n$.

Based on the normalized decomposition matrix, three kinds of volatility spillover measures can be defined as follows.

(1) **Total spillover index**

$$S^{(H)} = \frac{1}{n} \sum_{i,j=1;i\neq j}^{n} \tilde{\theta}_{i\leftarrow j}^{(H)} \qquad (11)$$

The total spillover index measures the contribution of volatility spillovers across all the n financial markets to the total forecast error variance. In this paper, it will be used to reflect the total volatility spillover effect in the considered economic system consisting of Chinese crude oil futures, Chinese stock market and the USD-CNY exchange rate.

(2) **Directional spillover index**

$$S_{i\leftarrow\cdot}^{(H)} = \sum_{j=1;i\neq j}^{n} \tilde{\theta}_{i\leftarrow j}^{(H)} \qquad (12)$$

$$S_{\cdot\leftarrow j}^{(H)} = \sum_{i=1;i\neq j}^{n} \tilde{\theta}_{i\leftarrow j}^{(H)} \qquad (13)$$

$S_{i\leftarrow\cdot}^{(H)}$ is called "from others", which measures the directional volatility spillover received by market i form all other markets. Thus, it reflects the systematic risks suffered by market i to some extent. While $S_{\cdot\leftarrow j}^{(H)}$ is called "to others", which measures the directional volatility spillover transmitted by market i to all other markets.

(3) **Net spillover index**

$$S_i^{(H)} = S_{\cdot\leftarrow i}^{(H)} - S_{i\leftarrow\cdot}^{(H)} \qquad (14)$$

The net spillover index is the difference between the "to others" and "from others" of a market, which reflects the net volatility spillover effect from market i to all other markets.

3. Data and description

The daily data of Chinese crude oil futures price (COF), Shanghai composite index (SHCI) and the onshore rate of the US dollar to CNY (USDCNY), from March 26, 2018 to October 30, 2019, are analyzed in this paper, where the start date is the time when Chinese crude oil futures were issued. In addition, the ongoing trade war between China and America started from March of 2018, which is basically covered by the period we choose. So, from the data in this period we can analyze the volatility spillover behaviors between Chinese crude oil, stock and currency markets in the context of the trade war. Furthermore, we choose the SC01 futures prices as a proxy of Chinese crude oil futures, which are the continuous prices of the most active futures contract every month. All the calculations in this paper are made by R software.

(Insert Fig. 1)

Fig. 1 gives the price and return series of the three markets, in which we use the logarithmic returns. It can be seen that COF price fluctuated constantly in 2018, showing an inverted "V" trend throughout the year. Specifically, before October 2018, COF price continued rising due to the concerns about oil supplies raised by America's withdrawal from the Iran nuclear deal and sanctions against Iran, one of the world's largest oil

exporters. However, since early October 2018, COF price had dropped sharply, and did not rise again until January 2019. The main reasons for the reversal are as follows. Firstly, America's sanctions against Iran did not work as well as expected. Secondly, other oil exporters such as Saudi Arabia and Russia had increased crude oil production, making up for the shortfall in Iran's oil supply. Finally, the Sino-America trade war reached a climax in late 2018,[3] which caused some impact on the expected economic growth of China, thus inhibiting the consumption and demand for crude oil. For these reasons, despite the resumption of America's sanctions on Iran on November 5, 2018, COF price failed to rise yet. In early January 2019, China and America formally held trade negotiations and suspended new tariffs on each other, which temporarily eased the trade war and was good to Chinese oil market. SHCI price had generally been declining since April 2018 until January 2019. Then, after a brief three-month rally, SHCI price fell again as the trade war intensified once more in early May 2019.[4] USDCNY price track an almost opposite trajectory of SHCI price, and is generally on an upward trend, indicating that CNY has been depreciating as a result of the trade war.

In terms of returns, except that COF returns exhibited significantly increased volatility from October 2018 to January 2019 and in mid-September 2019, the return volatilities of another two markets did not show obvious change during the period studied. In contrast, COF return series have the largest volatility, followed by SHCI, then USDCNY. It means that Chinese crude oil futures market has the highest risk level, followed by the stock market, while the risks in CNY exchange rate market have been kept under control, because of the strong regulation of Chinese government.

(Insert Table 1)

Table 1 provides the descriptive statistics and necessary diagnoses for the return series. From the table we can see that all the return series have a mean close to zero, among which, the means of COF and USDCNY return series are positive, while that of SHCI is negative. In addition, COF return series have the largest standard deviation and the largest range, followed by SHCI and USDCNY, implying that Chinese crude oil futures market is the most volatile, while the currency market is the most stable. This conclusion is consistent with Figure 1.

Except for USDCNY, the skewness coefficients are negative for another two return series, which means that during the trade war period, Chinese crude oil and stock markets are more prone to have negative returns and CNY is more likely to depreciate. The kurtosis coefficients are above three for all the return series, indicating that their distributions present sharp peaks and fat tails. These findings all show that these return series are not normally distributed, which is also confirmed by the Jarque-Bera statistics.

The ADF and PP unit root tests as well as the KPSS stationarity test are performed. They all show the same result that each of the return series is stationary. Finally, the Ljung-Box statistics $Q(10)$ and $Q^2(10)$ suggest that all the return series have no particularly significant autocorrelation but significant conditional heteroscedasticity. The Lagrange multiplier test also indicates that these return series have significant ARCH effect.

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[3] On September 24, 2018, America began imposing an additional 10% tariff on about $200 billion of Chinese goods, a much larger amount than before.

[4] After several rounds of trade negotiations, America reinstated the tariff plan on May 10, 2019, raising the tariff on $200 billion of Chinese goods from 10% to 25%.

4.   Empirical analysis

4.1 Parameter estimation and preliminary analysis of volatility spillovers

In this section, the VAR(p) model is first used to fit the return series pairwise to extract the residuals containing volatility information. Then each pair of residual series is modeled jointly by the bivariate BEKK-GARCH. Here, the VAR(p) model and the bivariate BEKK-GARCH are called mean equation and volatility equation respectively, and the optimal lagged order of the VAR(p) model is determined by the AIC criterion. The parameter estimation results are presented in the following Table 2.

(Insert Table 2)

Taking a close look at the mean equations, the VAR(1) model is selected for each pair of return series. However, the insignificance of parameters ϕ_{11} and ϕ_{22} implies that the autocorrelation of all return series is weak, which is consistent with the conclusion in Table 1. Consistent with Chen et al. (2010), who show that commodity prices are not effective predictors of asset prices such as exchange rate, we also find no evidence that the crude oil futures prices directly affect the stock and foreign exchange prices. The insignificance of parameters ϕ_{21} and ϕ_{12} indicates there is no return spillover effect between these three markets.

As to the volatility equations, we find that the current volatility of COF and USDCNY is affected by both their own past return shocks (denoted by α_{11} and α_{22}) and past volatility (denoted by β_{11} and β_{22}), while the current volatility of SHCI is only affected by its past volatility, in view of the insignificance of α_{11} in equation SHCI(1)-USDCNY(2) as well as the insignificance of α_{22} in equation COF(1)-SHCI(2).

We also find that there are significant bidirectional GARCH-type volatility spillovers between the three markets, but no significant ARCH-type volatility spillovers, which indicates that return shocks from each one of the markets will not have much direct impact on the others, however volatility transmission does exist from one to another.

Finally, by comparing the absolute values of parameters β_{21} and β_{12} in each equation, the intensity of volatility spillovers can be seen. For example, $|\beta_{21}| > |\beta_{12}|$ in equation COF(1)-USDCNY(2) means that USDCNY has a greater impact on COF when the volatility of COF and USDCNY changes by the same range.

The diagnostic tests for residuals of the bivariate BEKK-GARCH are also reported in table 2. The results show that all the residual series have no conditional heteroscedasticity or ARCH effect. Thus, the model performs well.

4.2 LR test for volatility spillovers

In Section 4.1, we preliminarily judge the existence of volatility spillovers between the three markets according to the significance of parameters. For the sake of rigor, we use the LR test illustrated in Section 2.1 to detect the volatility spillover effect once again. It is a large sample test based on maximum likelihood method, which is more applicable and accurate for the non-normal data considered. Test results are presented in Table 3.

(Insert Table 3)

From Table 3 we can see that all null hypotheses are rejected at 1% significance level, except that there are

no unidirectional volatility spillovers from USDCNY to SHCI. Nevertheless, we can still reject it at 5% significance level at least. The results of LR test are generally consistent with those of parameter estimation, thus we have good reasons to believe that there are significant bidirectional spillovers between these three markets.

4.3 *Time-varying dependency analysis*

Dependency analysis is an indispensable step in the study of volatility spillovers, because volatility spillovers are more likely to occur across markets that are highly dependent. Based on the bivariate BEKK-GARCH, the conditional correlation coefficients ρ_t, which reflect the time-varying dependency of returns, can be calculated by $\rho_t = h_{12,t}/(\sqrt{h_{11,t}}\sqrt{h_{22,t}})$.

(Insert Fig. 2)

Fig. 2 shows the pairwise time-varying correlations of the three markets. It can be found that the correlations between COF and USDCNY shifts between positive and negative, but are positive in most of the time. Therefore, Chinese crude oil and USD-CNY exchange rate tend to move in the same direction in the long run. In other words, the crude oil price may well rise when CNY depreciates (or USD appreciates). It's worth noting that the correlations between SHCI and USDCNY are always negative, while those between SHCI and COF always positive, that is, these two pairs each have a more steady and clear relationship. In most cases, the stock market will behave well when CNY depreciates, and the stock and crude oil markets rise and fall synchronously.

Overall speaking, the correlations between COF and the other two markets fluctuate more sharply. In addition, when extreme risk events occur in the crude oil futures market, it will become more correlated with the stock and foreign exchange markets. For example, the absolute correlations between COF and the other two markets increased significantly in late 2018 and mid-September 2019, both around the time of worldwide oil supply shortages[5], while those between the stock and currency markets did not change so much comparatively. This in some ways suggests that Chinese crude oil market is more vulnerable and sensitive to external shocks than other markets.

4.4 Empirical measurement of volatility spillovers

From the above analysis, we can affirm that there are significant bidirectional volatility spillovers between each pair of Chinese crude oil futures, stock and currency (USD/CNY) markets. In this section, based on the generalized forecast error variance decomposition, we further calculate the spillover indexes illustrated in Section 2.2 to quantitatively analyze the volatility spillover behaviors of the three markets. Before that, we first need to obtain the volatility series of each market. Since the volatility series of each market can be totally estimated twice in different equations in table 2, the average series are used in the following modeling. Table 4 provides the descriptive statistics for these average volatility series. As expected, all of them are stationary but non-normal distributed with a right skew. To meet the requirement of variance decomposition, we follow Paye

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[5] America's sanctions on Iran from early November 2018, and the attack on Saudi oil fields on September 14, 2019 both severely hit the global oil supplies. The attack has cut Saudi oil supplies by 5.7 million barrels a day, which represents about 50% of Saudi daily production and 5% of global oil supplies.

(2012) in using the natural logarithmic volatility series, the distribution of which is approximately normal according to the findings of Andersen et al. (2010).

(Insert Table 4)

4.4.1   Static volatility spillover analysis for full sample

We first analyze the static volatility spillover behaviors of the three markets from a global perspective. Following the method in Section 2.2, the VAR(6) model is selected according to the AIC criterion to fit the logarithmic volatility series under full sample. And when calculating the variance decomposition matrix through formula (9), the predictive horizon H is set to be 12 days, just like Diebold and Yilmatz (2014). The calculation results of the variance decomposition matrix and the spillover indexes are given in Table 5.

(Insert Table 5)

From the table we can find that during the period studied, nearly one third (30.278%) of the volatility in the whole economy is caused by the volatility spillovers across the markets. The variance decomposition matrix in the table shows that the volatilities of COF and USDCNY mostly come from themselves and are less affected by other markets, while that of SHCI is mainly dominated by the volatility spillovers from COF. Besides, the number in bold (55.851%) indicates that the spillover effect from the crude oil market to the stock market is the most powerful in the economy, which prompts the crude oil market to be the only net volatility transmitter, and the stock market the main net volatility receiver. This implies that it is necessary for stock investors to take the crude oil market into consideration when making investment decisions, and build portfolios in time to hedge the risk from the oil market. The currency (USD/CNY) market is also a net volatility receiver in the economy, given its negative net spillover index. Furthermore, we can observe some asymmetries for the volatility spillover effect. For example, COF contributes about 56% to the volatility of SHCI, but SHCI in turn contributes only about 4% to COF.

4.4.2   Dynamic volatility spillover analysis for rolling sample

The static analysis for full sample in last section gives us a good understanding for the volatility spillover behaviors in "average" sense, but the volatility spillover pattern may change over time. To fully understand the risk connectedness of the three markets, it is necessary to further explore the dynamic volatility spillovers with the help of rolling window estimation. Setting the window width w to 45 days and repeating the calculation work in last section on every rolling sample, we obtain the time series of the volatility spillover indexes. Since the observations in each rolling sample become fewer, here the predictive horizon H is set to be 2 days to avoid large error.

(Insert Fig.3)

Fig. 3 shows the dynamic total volatility spillovers for the whole economy. We can find that the total spillover indexes change significantly within the sample period, ranging from about 10% to 60%, which demonstrates the volatile economic environment in China during the sample period. The lower and upper quartiles of the series suggest that for most of the time, the total spillover indexes fluctuate between 26% and 36% approximately. This is the usual level of the total volatility spillovers during the trade war.

Affected by America restarting sanctions against Iran on November 5, 2018, which were mainly aimed at

Iran's energy and financial sectors, the risk in Chinese crude oil market increased sharply, and the total volatility spillovers for the whole economy reached the maximum at the same time. However, the high total spillover indexes began to decrease shortly after, thanks to the 180-day sanction immunity for Chinese oil imports from Iran and the Consensus reached between China and America at the G20 summit in Argentina.[6] In particular, after the second postponement of the imposition of tariffs by America on February 24, 2019, the total spillover indexes dropped rapidly and reached the minimum. There was a sustained trough from about March to April of 2019, then the total volatility spillovers returned to a high level, as America raised tariffs from 10% to 25% on $200 billion of Chinese goods from May 10, 2019. In summary, the total volatility spillovers for the whole economy consisting of Chinese crude oil futures, stock and exchange rate markets are significantly influenced by the Sino-America trade war as well as the geopolitics that affect global oil supplies.

(Insert Fig. 4)

Next, we focus on the total directional spillovers for each of the three markets, and the results are presented in Fig. 4. As shown in Fig. 4 (a), for most of the time, COF has high "to others" spillovers, but low "from others" spillovers, indicating that volatility of the crude oil market will bring great risk to the whole economy, but is less affected by other markets. What's more, the "to others" spillovers for COF rose significantly in early November 2018, early May 2019 as well as mid-September 2019,[7] thus America's sanctions on Iran and the attack on Saudi oil fields not only increased the risk in the crude oil market itself, but also greatly enhanced the risk contagion from this market. However, by contrast, the "to others" spillovers for COF did not change so dramatically whenever the trade war intensified, implying that the short-term spillover behaviors of Chinese crude oil market are less affected by the trade war. This is because Chinese crude oil imports are mainly from the Middle East, while those from America are very limited, accounting for only about 4% of total imports in 2018. In addition, the consistently positive net spillover indexes suggest that the crude oil market has always been a net volatility transmitter in the economy.

As to the exchange rate market, Fig. 4 (b) shows that its two directional spillover indexes both rose sharply in early November 2018, though the "to others" spillovers soon fell back. For the "from others" spillovers, this is obviously because America's sanctions on Iran had strengthened the risk contagion from the crude oil market to the exchange rate market. As for the "to others" spillovers, the reason is that the dollar index weakened after America's midterm elections, which caused a sharp short-term turbulence fell in the USD-CNY exchange rate.[8] In addition, affected by the official release of the lists of goods that America and China impose tariffs on, the "to others" spillovers for USDCNY also rose significantly in mid-June 2018. However, it soon began to decline and have generally remained at a low level since then, except in early November 2018. Obviously, although the trade war has a certain impact on the RMB exchange rate, the risk in this market is basically controllable, and the risk contagion from this market is very limited due to its always low volatility. Finally, the net spillover indexes indicate that the USD-CNY exchange rate is a net volatility receiver on the whole.

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[6] Although starting new sanctions on Iran on November 5, 2019, America allowed eight countries, including China, to continue importing crude oil from Iran for 180 days.
On December 1, 2018, at the G20 summit in Argentina, China and America agreed to have talk on the trade issues.
[7] Worries about the oil supply increased again in April 2019, when the exemption from America's sanctions on Iran expired.
[8] After the 2018 midterm elections, the Republican Party led by Donald Trump lost control of the house of representatives, which means the division of the US congress. Affected by this, the US dollar index fell.

In terms of SHCI, Fig. 4 (c) indicates that except for a significant decline in early March, 2019, which is due to the great progress made in the seventh round of trade negotiations between America and China, the "from others" spillovers for SHCI has always been at a high level. This implies that the stock market is consistently the main volatility receiver in the economy, which is also confirmed by the net spillover indexes. In other words, the stock market is subject to the systematic risk greatly and persistently during the trade war. Compared to the "from others", the "to others" spillovers for SHCI is relatively week. Nevertheless, it will significantly increase as the trade war intensifies and decrease as the trade war eases.

(Insert Fig. 5)

Finally, we investigate the dynamic pairwise directional spillovers for the three markets, and the results are given in Fig. 5. From Fig. 5 (a), we can find that except for a significant increase in volatility spillovers from COF to USDCNY at the end of 2018, which is because of America's sanctions on Iran, the bilateral volatility spillover effects between COF and USDCNY are weak in most of the time. Thus, during the sample period, the trade war did not have too much impact on the risk connectedness between Chinese crude oil and currency (USD/CNY) markets. However, different from the COF-USDCNY pair, the bidirectional spillover effects between SHCI and USDCNY are closely related to the trade war dynamics, and both of them changed clearly near the critical periods of the trade war, for example in mid-June 2018, when America and China officially released the lists of goods subject to tariffs (See Fig. 5 (b)). In addition, the scale of volatility spillovers from SHCI to USDCNY is usually a bit larger than that in the opposite direction, which can be supported by the net spillovers as well. As for the pair of COF and SHCI, we can see from Fig.5 (c) that the volatility spillovers from COF to SHCI are almost always strong, peaking at about 90%, and change dramatically, while those in the opposite direction are negligible. This again demonstrates that there is a significant asymmetry in the bidirectional spillover effects between the crude oil and stock markets, and that most of the time, the unidirectional spillovers from Chinese crude oil futures to stock is the strongest across the whole economy.

It is worth nothing that the strong and sustained volatility spillover effect from the crude oil futures to the stock market is an exciting finding, which helps to understand the economic source of change in volatility for Chinese stock market. Furthermore, the information contained in the crude oil futures volatility may be used to improve the accuracy of the short-term stock volatility prediction. In this regard, Wang et al. (2018) have demonstrated that WTI and Brent volatility can be powerfully predictive of the S&P 500 index volatility. Plausible explanations for this strong volatility spillovers are mainly two aspects. Firstly and fundamentally, crude oil is a key input of industrial production. Oil price shocks would certainly cause stock price changes by affecting real economic activities (Hamilton, 1983; Kilian, 2009), current and future cash flows (Jones and Kaul, 1996) and monetary policy (Leeper et al. 1996). Secondly, commodity futures are now increasingly favored by portfolio investors in addition to stocks and bonds. Crude oil has always been one of the most important commodities. As a newly issued investment product, Chinese crude oil futures have attracted a lot of attention since its appearance. Investors' asset reallocation between the crude oil futures and stocks further intensifies the volatility spillovers between the crude oil futures and stock market.

4.4.3   Robustness assessment

In the process of calculating the dynamic spillover indexes with the method proposed by Diebold and Yilmaz (2012, 2014), two model parameters are set, that is the predictive horizon H and the window width w. Now, we analyze the robustness of our results to the choice of these two model parameters. Specifically, we compare the total spillover index plots for different parameter combinations to investigate the influence of each parameter on the results. The alternative predictive horizon H includes 4 and 6 days, in addition to 2 days. And the alternative window width w includes 35 and 55 days, in addition to 45 days. The results are presented in Fig. 6.

(Insert Fig.6)

As shown in Fig. 6, given the predictive horizon, the total spillover indexes are the wiggliest when the window width is set to 35 days, but become smoother as we increase the window width to 55 days. In columns, with the increase of the predictive horizon, the total spillover indexes do not change significantly except for a few time points. Overall, the total spillover indexes in each subgraph show a similar evolutionary trajectory. Therefore, the calculation of the dynamic total spillover indexes under rolling sample is robust to the selection of predictive horizon H and window width w.

5. Conclusions

In this paper, we systematically analyze the volatility spillovers between Chinese crude oil futures, stock and USD-CNY exchange rate markets in the context of Sino-America trade war. Through the parameter estimation of the bivariate BEKK-GARCH model, we first preliminarily judge the existence and direction of the volatility spillovers across the three markets. Then, the LR test is introduced to detect the spillover effect furthermore. In addition, the time-varying dependency for these market pairs is also investigated, see section 4.3 for detail. Finally, referring to Diebold and Yilmaz (2012, 2014), the forecast error variance decomposition is performed, based on which, several spillover indexes are calculated to analyzed the spillover effect quantitatively.

The main findings and corresponding discussion are as follows. There exist significant bidirectional volatility spillovers between each pair of Chinese crude oil futures, stock and USD-CNY exchange rate markets. Within the sample period, on average, nearly one third volatility of the entire economy is due to the volatility spillovers across the three markets. Besides, the dynamic total spillover indexes vary widely, influenced by the complex political and economic environment. In the economy, the crude oil market is the only net volatility transmitter, while the stock and USD-CNY exchange rate markets serve as net volatility receivers. What's more, the unidirectional volatility spillovers from the crude oil futures to the stock market is the strongest among these market pairs, followed by that from the stock to USD-CNY exchange rate market. In addition, we find that during the sample period, the spillover behaviors of the crude oil futures market are mainly dominated by America's sanctions on Iran, which has a severe impact on worldwide crude oil supplies, but is less affected by Sino-America trade war in the short term, due to Chinese limited oil imports from America. Even so, the trade war will still create downside risk for Chinese crude oil market in the long run. Because it will lower the expected macroeconomic growth, thus dampening consumer demand for crude oil, inflaming fears of the price decline and then making the crude oil market more volatile. Meanwhile, the risk contagion from this market may gradually become stronger as well with the increase of volatility. As for USD-CNY exchange rate, the impact of the trade war on its volatility and spillover effect is basically under control, which benefits from the combined efforts of the government and the market. Firstly, as the ability to deal with large short-term exchange rate volatility has been enhanced, Chinese government can take measures timely to stabilize market expectations and confidence. Secondly, with the improvement of Chinese foreign exchange settlement and sale system, the market can fully play a regulating role through price leverage to reduce the risk exposure of the RMB exchange rate. In the case of the stock market, its short-term spillover behaviors are the most relevant to the trade war dynamics. In a word, the escalating trade war, which intensifies the uncertainty of economic growth, has a great shock on the stock market sentiment, thus exacerbating the market turbulence and risk contagion.

The findings in this paper may provide valuable reference for investors' decisions and government's risk regulation. The close connection between the volatility of Chinese crude oil futures, stock and USD-CNY exchange rate makes investors in any one market have to concern about the risk information from other markets. In particular, it is essential for stock investors to guard against risk contagion from the crude oil market. For this purpose, when anticipating a crisis in the crude oil market, on the one hand, stock investors can hedge the risk

to lock in gains or losses, through put options for example. On the other hand, they can diversify the risk by building additional portfolios. And it may be a good idea to add the USD-CNY exchange rate into their portfolios. Because it has a stable negative correlation with the stock market (see Section 4.3), and is less affected by the crude oil volatility. In addition, for short-term investment decisions and risk prevention, stock investors should keep a close eye on the trade war dynamics, while crude oil futures investors should pay more attention to the events hitting the oil supply, like American's sanctions on Iran. As a newly listed derivative, Chinese crude oil futures have strong volatility spillovers to other Chinese financial markets, but receives less volatility spillovers in reverse. Zhang and Ji (2018) illustrated that Chinese crude oil futures now are mainly affected by volatility spillovers from the international markets, such as WTI and Brent. Thus, it is necessary for Chinese government to strength the risk regulation for the crude oil market, enhance the capacity to cope with foreign risk contagion, and innovate the cross-border regulatory cooperation mechanism to prevent cross-border manipulation.
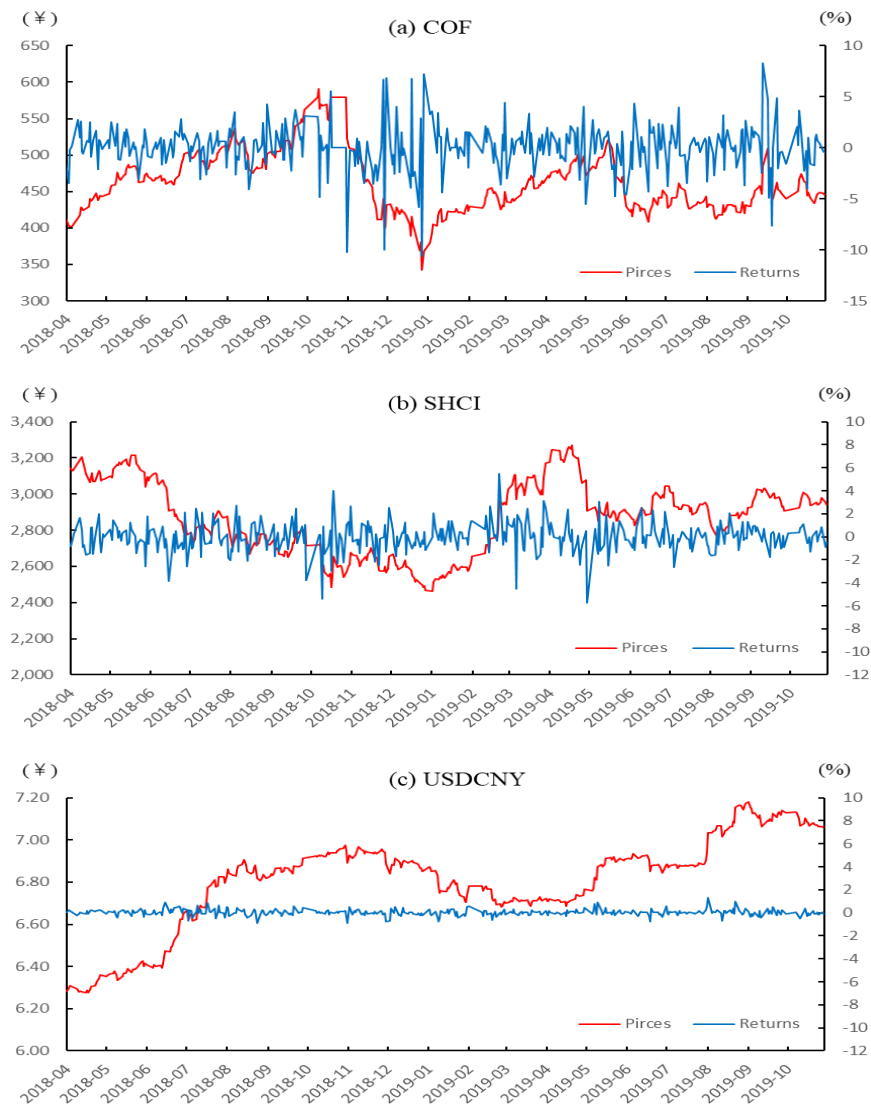
Fig. 1 Price and return series for the three markets.

Note: Subgraph (a), (b) and (c) are for the crude oil futures market, stock market and foreign exchange market respectively.
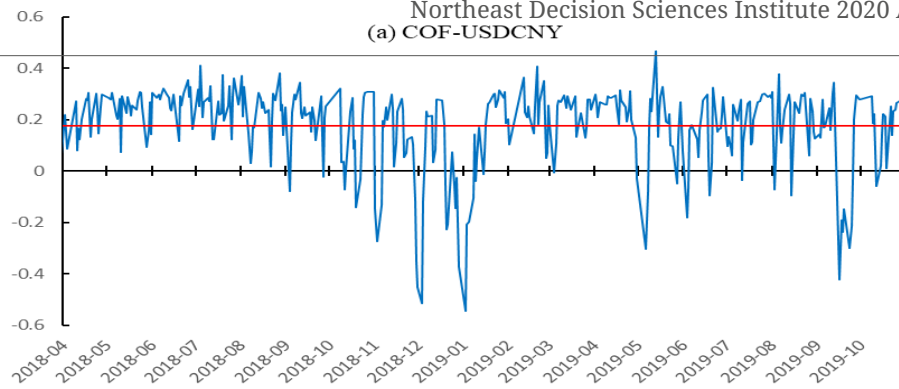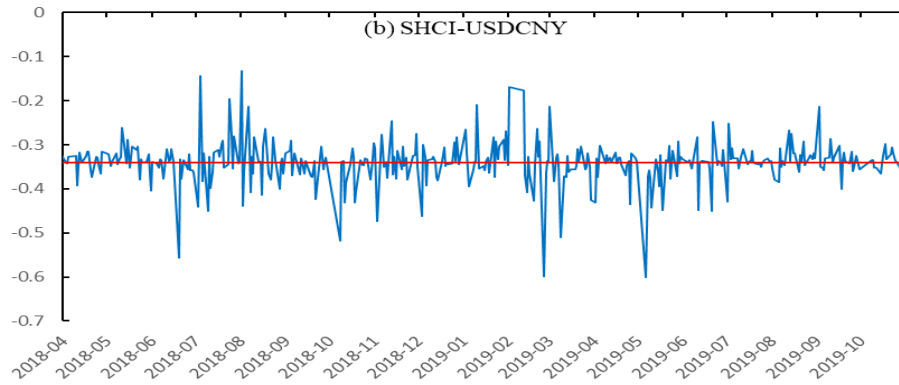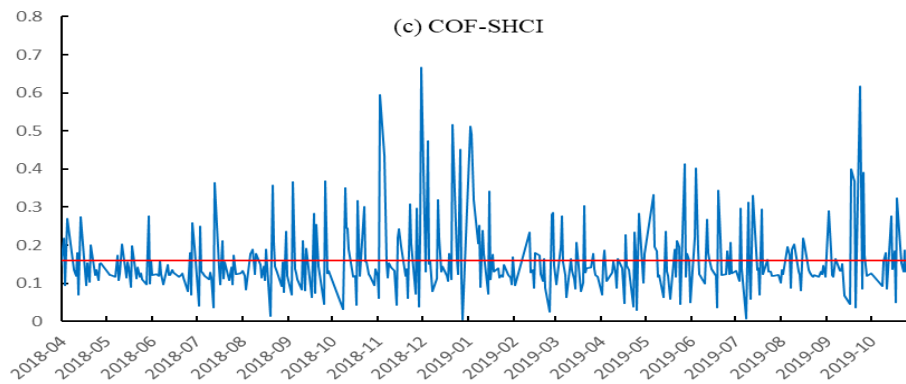
Fig. 2 Time-varying correlations between the three markets.

Note: Subgraph (a) is for the crude oil futures and foreign exchange markets; Subgraph (b) is for the stock and foreign exchange markets; Subgraph (c) is for the crude oil futures and stock markets. Red lines denote the mean of the correlation coefficients
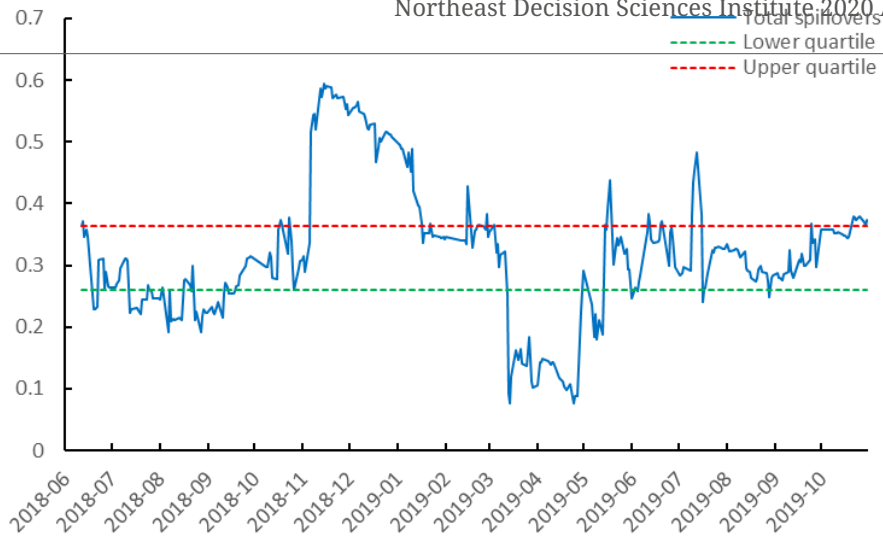
Fig. 3 The total spillover indices for the whole economy.

Note: The dotted green line and dotted red line are the lower and upper quartile of the total spillover index series respectively.
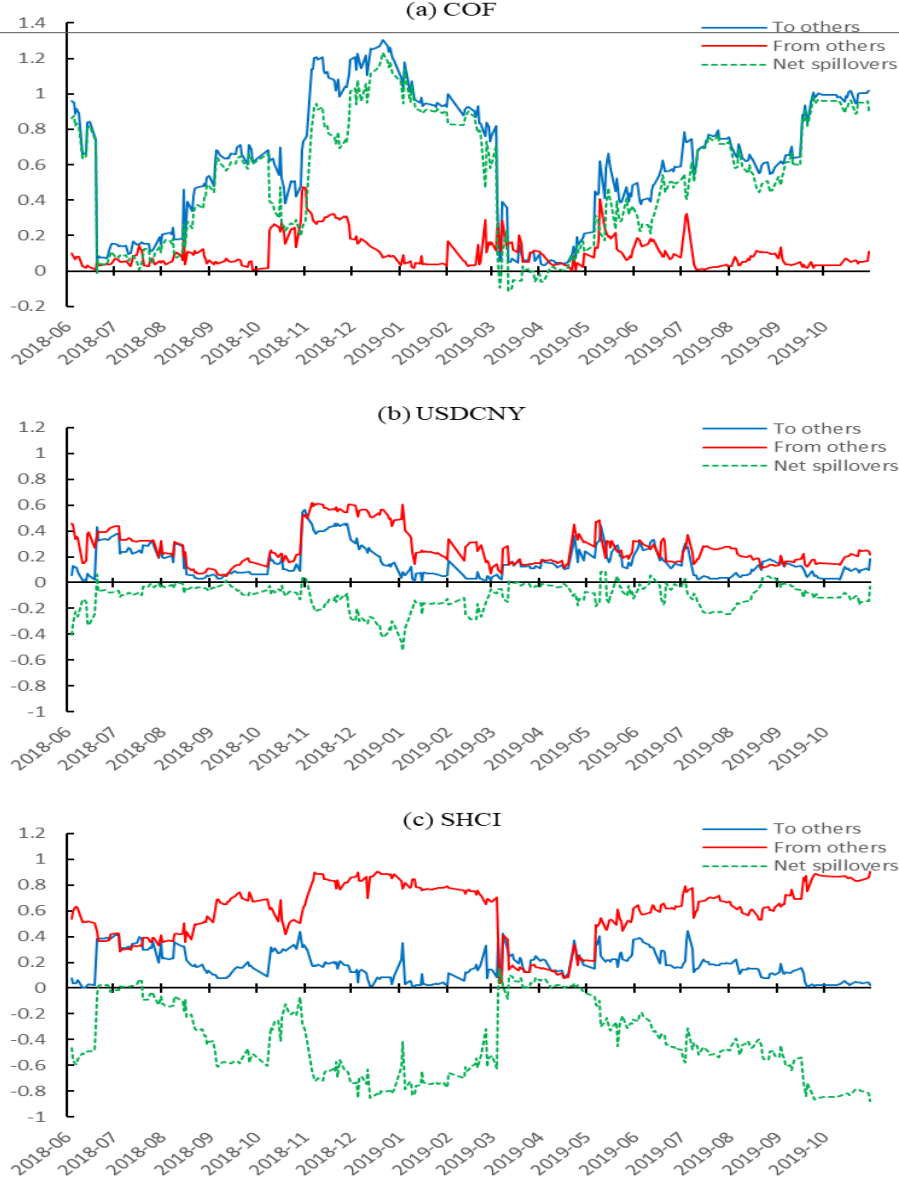
Fig. 4 The total directional spillover indices for the three markets.

Note: Subgraph (a), (b) and (c) are for the crude oil futures market, foreign exchange market and stock market respectively. In each subgraph, the blue line denotes the "to others" spillovers, the red line denotes the "form others" spillovers, the dotted green line denotes net spillovers, i.e. the difference between "to others" spillovers and "from others" spillovers.
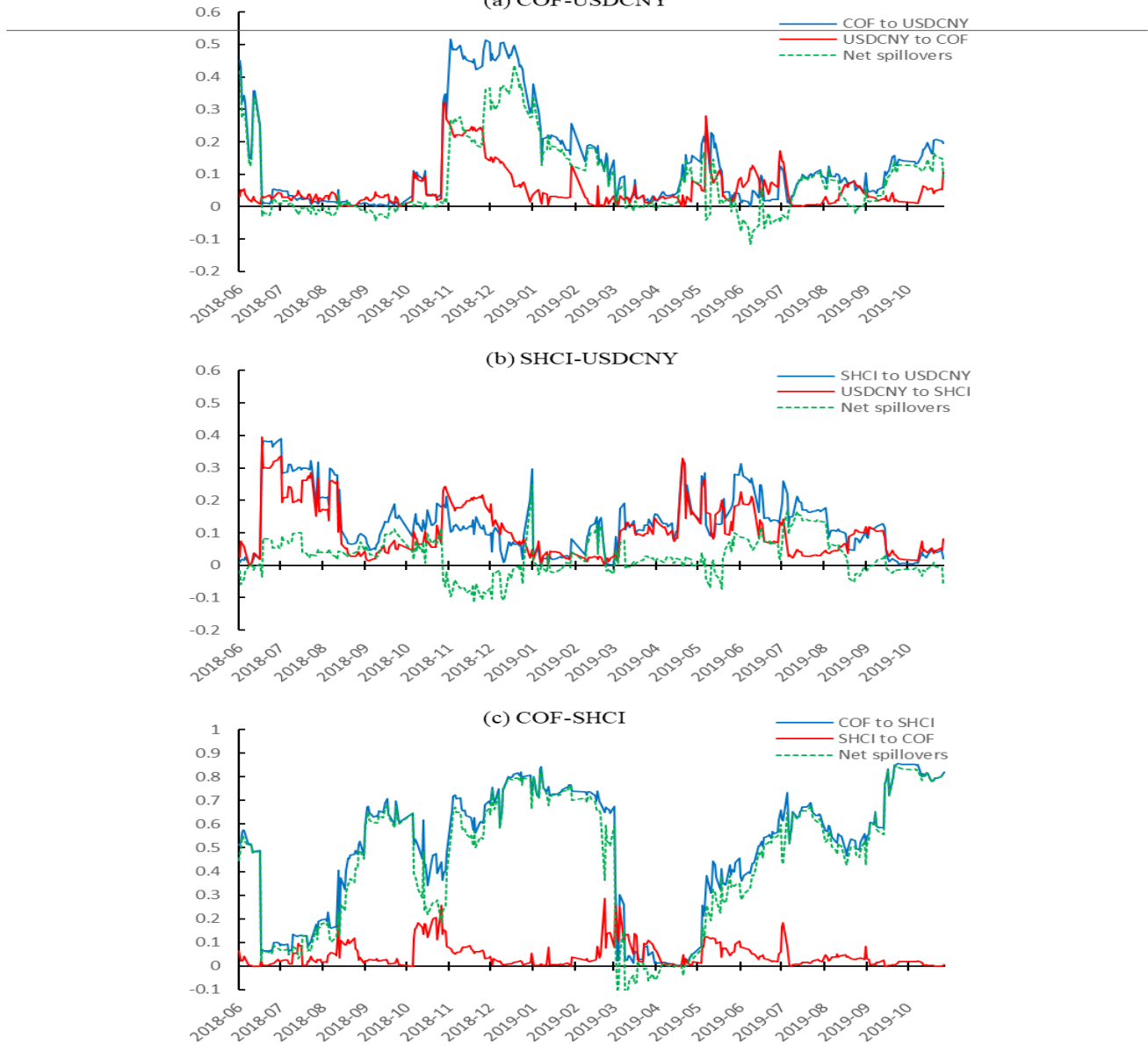
Fig. 5 The dynamic volatility spillovers across each pair of the three markets.

Note: Subgraph (a) is for the crude oil futures and foreign exchange markets. Subgraph (b) is for the stock and foreign exchange markets. Subgraph (c) is for the crude oil futures and stock markets. The net spillovers denoted by green dash line is the difference between the blue and red lines.
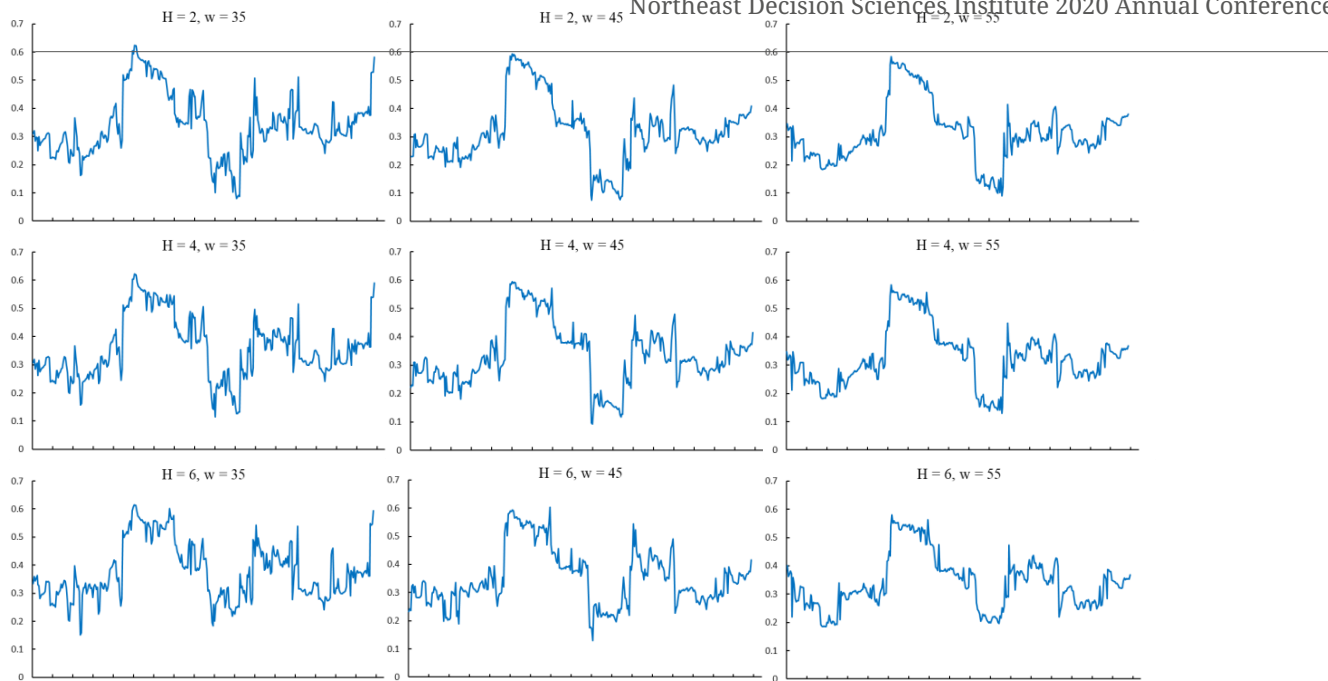
Fig. 6 Robustness of the total spillover indices.

Note: The total spillover index plots for different parameter combinations are compared to investigate the influence of each model parameter on the results. The two model parameters are the predictive horizon H and the window width w. The alternative predictive horizon H includes 2, 4 and 6 days. The alternative window width w is 35, 45 and 55 days, respectively.

Appendix B: Tables in the paper

Table 1 Statistical properties of return series.

	COF	USDCNY	SHCI
1. Descriptive statistics			
Mean	0.00009	0.00030	-0.00017
Median	0.00067	0.00023	-0.00040
Max.	0.08269	0.01339	0.05449
Min.	-0.10615	-0.00902	-0.05745
Std. Dev.	0.02231	0.00273	0.01249
Skewness	-0.56063	0.24980	-0.21987
Kurtosis	6.97451	5.64703	5.93257
Observations	388	388	388
2. Statistical diagnosis			
Jarque-Bera	275.71***	117.31***	142.16***
ADF	-6.9298***	-7.1202***	-7.2414***
PP	-405.50***	-372.35***	-421.57***
KPSS	0.0679	0.2796	0.1476
$Q(10)$	18.403*	13.897	18.623*
$Q^2(10)$	42.309***	22.953**	24.470***
ARCH-LM(10)	22.573**	21.928**	23.803**

Notes: Jarque-Bera is the Jarque-Bera normality test. ADF, PP and KPSS refer to the Augmented Dickey and Fuller (1979) unit root test, the Philips and Perron (1988) unit root test and the Kwiatkowski et al. (1992) stationarity test, respectively. $Q(10)$ and $Q^2(10)$ refer to the Ljung-Box test up to the 10-th order for autocorrelation of the return and squared return series, respectively. ARCH-LM(10) is the Lagrange multiplier test to check the existence of ARCH effect.

"***", "**" and "*" denote the rejection of the null hypothesis of normality, no autocorrelation, unit root, non-stationarity, and conditional homoscedasticity at the 1%, 5% and 10% significance level, respectively.

Table 2 Estimation results of the VAR(p)-BEKK-GARCH model.

	COF(1)[a.]-USDCNY(2)	SHCI(1)-USDCNY(2)	COF(1)-SHCI(2)
1. Mean equations[b.]			
ω_1	0.0001	-0.0002	0.0001
	(0.0011)	(0.0006)	(0.0011)
ω_2	0.0003[**]	0.0003[**]	-0.0002
	(0.0001)	(0.0001)	(0.0006)
ϕ_{11}	-0.0737	-0.0457	-0.0673
	(0.0508)	(0.0552)	(0.0517)
ϕ_{21}	-0.0004	0.0091	0.0053
	(0.0062)	(0.0121)	(0.0289)
ϕ_{12}	0.2289	0.1094	-0.0644
	(0.4164)	(0.2531)	(0.0923)
ϕ_{22}	0.0512	0.0674	-0.0567
	(0.0509)	(0.0552)	(0.0517)
2. Volatility equations			
c_{11}	-0.0161[***]	0.0117[***]	0.0072[**]
	(0.0018)	(0.0004)	(0.0039)
c_{12}	-0.0021[***]	-0.0000	-0.0101[***]
	(0.0002)	(0.0001)	(0.0026)
c_{22}	0.0005[*]	-0.0002	-0.0023
	(0.0004)	(0.0003)	(0.0086)
α_{11}	0.4540[***]	0.1513	0.5238[***]
	(0.0478)	(0.1280)	(0.0776)
α_{21}	0.3616	-0.0806	-0.2180[*]
	(0.5822)	(0.5239)	(0.1522)
α_{12}	-0.0149[*]	-0.0072	-0.0116
	(0.0101)	(0.0198)	(0.0465)
α_{22}	0.1990[**]	0.4572[***]	0.0421
	(0.1022)	(0.0961)	(0.1057)
β_{11}	0.5471[***]	0.3454[***]	0.6547[***]

	(0.0697)		(0.0597)		(0.0922)	
β_{21}	0.8327**		0.5062***		-1.0216***	
	(0.3508)		(0.1502)		(0.3005)	
β_{12}	-0.0679***		-0.2064***		0.2529**	
	(0.0060)		(0.0128)		(0.1084)	
β_{22}	-0.1312**		-0.2921***		-0.4078***	
	(0.0668)		(0.0719)		(0.1027)	
3. Diagnostic tests	(1)[c.]	(2)	(1)	(2)	(1)	(2)
Q(10)	8.099	14.085	15.327	12.238	7.113	14.760
Q^2(10)	10.199	13.796	15.668	15.383	5.227	13.049
ARCH-LM(10)	11.177	15.074	2.713	15.671	7.018	6.563

Notes: Q(10) and Q^2(10) are the Ljung-Box statistics for serial correlation in the model residuals and squared residuals, respectively. ARCH-LM(10) refers to the Engle LM test for the ARCH effect in the residuals, computed with 10 lags.

"***", "**" and "*" represent significance at 1%, 5% and 10% level, respectively.

a. COF(1) means that COF is denoted by subscript 1 both in the mean and volatility equations here.

b. The specification of the mean equation is as follows. It is a VAR(1) model.

$$\begin{bmatrix} r_{1,t} \\ r_{2,t} \end{bmatrix} = \begin{bmatrix} \omega_1 \\ \omega_2 \end{bmatrix} + \begin{bmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{bmatrix} \begin{bmatrix} r_{1,t-1} \\ r_{2,t-1} \end{bmatrix} + \begin{bmatrix} u_{1,t} \\ u_{2,t} \end{bmatrix}$$

c. (1) denotes the residual series 1. Here it is the residual series of COF.

Table 3 LR test results for volatility spillovers.

	Null hypothesis		LR statistic	P-value
COF-USDCNY	$H_0: \alpha_{21} = \beta_{21} = 0$ (USDCNY $\neq>$ COF)		15.231***	0.000
	$H_0: \alpha_{12} = \beta_{12} = 0$	(COF $\neq>$ USDCNY)	32.321***	0.000
SHCI-USDCNY	$H_0: \alpha_{21} = \beta_{21} = 0$	(USDCNY $\neq>$ SHCI)	6.427**	0.040
	$H_0: \alpha_{12} = \beta_{12} = 0$	(SHCI $\neq>$ USDCNY)	22.685***	0.000
COF-SHCI	$H_0: \alpha_{21} = \beta_{21} = 0$ (SHCI $\neq>$ COF)		23.769***	0.000
	$H_0: \alpha_{12} = \beta_{12} = 0$ (COF $\neq>$ SHCI)		14.818***	0.001

Notes: "$\neq>$" denotes that there are no unidirectional volatility spillovers from the left to the right.

"***" and "*" indicate significance at 1% and 10% level, respectively.

Table 4 Descriptive statistics for the average volatility series of the three markets.

	COF	USDCNY	SHCI
Mean	5.174E-4	7.753E-6	1.574E-4
Max.	30.95E-4	27.67E-6	2.630E-4
Min.	3.496E-4	6.410E-6	1.502E-4
Std. Dev	3.239E-4	2.193E-6	0.122E-4
Skewness	4.911	4.345	4.927
Kurtosis	32.29	28.67	34.87
Jarque-Bera	15385[***]	11846[***]	17943[***]
ADF	-5.465[***]	-6.160[***]	-5.849[***]
Q(10)	170.32[***]	20.359[**]	42.192[***]

Notes: Jarque-Bera is the Jarque-Bera normality test. ADF refers to the Augmented Dickey and Fuller (1979) unit root test. "***" and "*" indicate significance at 1% and 10% level, respectively.

Table 5 Volatility spillover measures under full sample.

	COF	USDCNY	SHCI	From others
COF	94.446	1.799	3.755	5.554
USDCNY	14.954	73.244	11.803	26.756
SHCI	**55.851**	2.672	41.477	58.523
To others	70.805	4.471	15.557	Total spillovers
Net spillovers	65.250	-22.285	-42.966	30.278

Notes: The 3×3 square matrix in the upper left corner of the table is the variance decomposition matrix, and the number in **bold** is the maximum non-diagonal element in the matrix, and represents the most powerful unidirectional volatility spillover effect. The values in the table are all in percentages.

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Big Data, Business Analytics and Knowledge Management - Abstracts

A Comparison Of Machine Learning Methods In Multi-Class Text Classification

Big Data, Business Analytics and Knowledge Management

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Text classification can be described as the construction of methods that classifies new phrases or documents into previously defined classes. Text classification has been a prominent research area due to recent technological advances in machine learning algorithms. Researchers continue to develop new classification systems while also improving existing ones to obtain higher computational efficiency and accuracy. The purpose of this study is to investigate these approaches using the same problem domain and to provide a comparative analysis in terms of classification accuracy and computational efficiency.

A Hybrid Approach to Context-based Sentiment Analysis

Big Data, Business Analytics and Knowledge Management

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Sentiment analysis is an approach in natural language processing (NLP) that identifies the emotional tone behind the body of the text. However, the challenge is to extract a single sentiment from large context-sensitive text. This study presents a new hybrid approach to predict text-level sentiments based on generating a context-rich text feature vector by combining single words and word sequences to form a multi-dimensional word embedding structure using the Word2Vec model. The proposed approach improves on the traditional bag of words and TF-IDF models by efficiently detecting sentiment expressions in large textual phrases that contain various contexts of conversations.

A Hybrid Graph-based Model for Content Analysis on Social Media

Big Data, Business Analytics and Knowledge Management

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Social media platforms like Twitter and other microblogging services allow for the application of dynamic user-generated tagging to support others to easily find messages with a specific theme or content. This study aims to identify relationships between hashtags to detect interlinked themes of conversation. We propose a hybrid graph-based model that combines the co-occurrence of hashtags, and semantic-occurrence of hashtags by identifying siblings or semantically related hashtags which normally do not co-occur. Previous studies indicate that hashtags are semantically related based on their word sets. Overall, this serves as an alternative for content analysis on social media platforms.

A Learning Analytics Decision Model for Urban Mobility Systems Planning

Big Data, Business Analytics and Knowledge Management

Mr . Tristan Stull [1]

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This paper sets out a decision model for Urban Mobility Planning in the context of a learning analytics approach. The system's design goals are efficacy, efficiency and social congruence. The model is a meta-model comprising individual and community decision models. In efficacy, the system must support individual travelers in completing their trips. In efficiency, it optimizes both individual goals and community objectives. In social congruence, the objectives and resulting solutions are derived from and learned by the individuals themselves. The contribution is a novel transdisciplinary composition in the practical application of the management sciences to a large public policy concern.

AI in Knowledge Sharing and Learning: Redesigning Roles, Processes, and Incentives

Big Data, Business Analytics and Knowledge Management

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The recent growth in the use of artificial intelligence (AI) by organizations has increasingly demanded the redesign of knowledge workers' roles and processes to facilitate their better use of AI. However, very few prior studies have investigated the managerial implication of AI's role in facilitating knowledge sharing and learning in organizations. Our research attempts to address this gap by exploring the impact of AI in transforming knowledge workers' roles and processes in knowledge sharing and learning and investigating the redesign of sharing and learning incentives to accommodate such changes.

ARE MACHINES WITH HUMAN INTELLIGENCE POSSIBLE?

Big Data, Business Analytics and Knowledge Management

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Artificial general intelligence, AGI, aims at building machines with the intelligence of human level. It has been a long-standing contention on whether or not machines can eventually be as intelligent as humans, or whether AGI is possible. Neither side of the contention has provided solid arguments. We argue self-awareness and anxiety of death are not copiable, but computer codes are copiable. So, a duplicatable computer cannot have the un-duplicatable consciousness of self-awareness and anxiety of death. Self-awareness draws a line between biological humans and the digital machines. Computer-based AGI is therefore not possible.

BIG DATA FOR SMALL BUSINESS: A KNOWLEDGE MANAGEMENT MODEL

Big Data, Business Analytics and Knowledge Management

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This paper discusses the synergistic relationship between big data and knowledge management. The study collects eight (8) well-documented cases of successful big data analytics in small business, and conducts a qualitative data analysis in the context of knowledge management. The qualitative analysis reveals a knowledge management model of big data for small business. The model indicates that strategic use of data, knowledge guided big data project planning, IT solutions for small business, and new knowledge products are the major constructs of knowledge management of big data for small business. These constructs form a loop through the causal relationships between them.

Black Swan Theory of Events and the Impact to Hospitality Operators: Literature Review and Proposed Analysis

Big Data, Business Analytics and Knowledge Management

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The Black Swan theory of events is an incident that deviates beyond what is normally expected and is extremely difficult to predict (Talib, 2007). Black Swan events impact the hospitality industry in many ways. Weather, widespread illness, civil unrest, terrorism, and loss of utilities are out of the immediate control of the industry's participants. These events are quickly spread by multiple news sources, and consumers are able to search quickly using search engines. There is a paucity of academic analysis of Black Swan events to determine whether there is a way to reduce the impact as measured by search activity.

Could Marijuana Help Ease the Opioid Crisis? An Empirical Evidence from Drug Overdose Death

Big Data, Business Analytics and Knowledge Management

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Drug overdose death is one primary concern in the United States, and the opioid is the most problematic one among all drugs. In this paper, I conduct a thorough analysis to understand whether the liberalization of marijuana laws could ease the drug overdose crisis. I examine medical marijuana liberation and recreational marijuana liberation and find that accessing recreational marijuana dispensaries, rather than medical marijuana dispensaries, reduces the overall drug overdose death and the death of several drug categories. Therefore, broader access to recreational marijuana can reduce the addictive opioid misuses without significantly increase overdose mortality related to other dangerous drugs.

DENSITY-BASED CLUSTERING VALIDATION OF UNCERTAIN DATA OBJECTS

Big Data, Business Analytics and Knowledge Management

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In data mining, clustering validity indices are numerical values that are used to identify the correct number of clusters or best formed clusters. Uncertain data objects are objects modeled either with a group of points or a probability density function. In this paper, we introduce a clustering validity index for uncertain data objects named the _density-based uncertain clustering validity index_ or DBU.The DBU index captures the exclusive density-based contribution of each object in the data set to compactness and separation of clusters. We show through experiments that the DBU index can outperform both certain and uncertain clustering validity indices.

Development of Collaborative Consumption Pricing: An Econometrics Model Approach of Airbnb

Big Data, Business Analytics and Knowledge Management

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On one hand, the sharing economy provides new opportunities on the other hand, it is also raising several issues as more incidents arise concerning bypassing laws. More and more well-known sharing economy companies such as Airbnb, and Uber are struggling against regulation. To deal with issues such as consumer and supplier safety, and competitive fairness, some of the cities has begun to practice regulations. The aim of this paper is to determine the effect of these regulations on pricing. I apply Difference-and difference (DD) method to identify causal effect and remove unobservable factors that vary in time and listing/room level.

Evaluating the International Technology Achievement Index (TAI) using the Order Rated Effectiveness Model (ORE)

Big Data, Business Analytics and Knowledge Management

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In order to improve the performance of different units of operation producing a variety of results, decision-makers in public and private organizations often apply a number of different multi-criteria benchmarking techniques when comparing and evaluating performance. In this paper we apply the Data Envelopment Analysis (DEA), the Ordered Weighted Average (OWA), and the newly developed Order Rated Effectiveness (ORE) model, (Klimberg and Ratick 2018, 2020a, 2020b), to the Technology Achievement Index (TAI) data, a Weighted Linear Combination (WLC) composite measure. We then compare and evaluate the original TIA results to those obtained using the DEA, OWA and ORE methods.

Household Financial Differences: A Perspective of Couples' Money Management Habits

Big Data, Business Analytics and Knowledge Management

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This research explores how to intelligently connect couples through data-driven money-management applications. Couples' financial management research historically relies upon surveys and interviews to evaluate couples' behavior, often highlighting financial struggles as a primary reason for relationship stress. We extend household financial management theory by conducting a quantitative analysis of account and transactional data of real-world couples. Our proposed approach models peer behavior in households by utilizing data mining methods to identify similarity in couples' finances over time. Our objective is to share insights into how couples manage their individual and shared finances, gaining extraordinary visibility into sharing and pooling behaviors.

Linkage Between Services Trade Liberalization and Country Development Level with Data Mining Techniques

Big Data, Business Analytics and Knowledge Management

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It is obvious that there are several ways for services to help grow economy by providing direct inputs to the manufacturing process, facilitating the flow of intermediate products between different stages of production via more internationalized transport, logistics, finance, information and communication technology (ICT), wholesale and retail trade facilities.

This study attempts to partially fill the gap in the literature and to provide empirical evidence for rise of services trade and its contribution to difference among the development levels of the countries by providing empirical evidence from using datamining techniques.

Key words: Trade in services, development level, datamining

Machine Learning applied to Linear Regression Analysis using a Mean Absolute Deviation Loss Function

Big Data, Business Analytics and Knowledge Management

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We apply machine learning (ML) techniques to regression analysis using a mean absolute deviation (MAD) loss function. This is opposed to the commonly used ordinary least squares (OLS) techniques using a mean square error (MSE) loss function. We employ ML techniques to calculate more robust measures of stock beta. This technique ensures that the loss function is consistent with investor risk aversion. We then perform analysis for all stocks that comprise the SP500 index using both technique to determine which is the better forward forecasting method.

Mining for Latent Sociotechnical Error in Aviation Safety Data

Big Data, Business Analytics and Knowledge Management

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As many as 70-80% of aviation incidents stem from 'human factors' with focus on how technical themes such as maintenance procedures, component design or cockpit layout combine with human cognition issues to form problems. Latent problems often remain undetected for years in readily available data, only to manifest as major catastrophes. Therefore, we study aviation data for safety risks in the form of complex sociotechnical patterns. A data mining approach leveraging techniques for unstructured data helps uncover these latencies. Combined with a carefully designed interpretative stencil, it can help provide the aviation community with new analytical tools to increase safety.

On the Use of Search Volume Data in Retail Decision Making

Big Data, Business Analytics and Knowledge Management

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In this study we explore the use of search volume data in understanding retail sales volumes. We use a large transaction data set of a retail store and match the sales amounts to search volume indices of certain keywords for a product type. Our preliminary results indicate a significant correlation between the two. We hypothesize that if we control for the form of a purchase (online vs. in-store) it may give us an empirical evidence for the difference in impulse buying behavior between buying in-store and buying online. Our results may help retailers in their decision making.

Providing Helpful Information for Online Customers

Big Data, Business Analytics and Knowledge Management

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Helpfulness of the online reviews has been widely studied; however, the study of customer similarity is too rare in the literature. Drawing upon the customer similarity concept, we develop a research model to explain how customer similarity affects the review helpfulness, which in turn helps the customers to make better purchase decisions. We use data from Amazon.com to test our model empirically. We then use machine learning algorithms to develop our predictive model, which can provide the customers with personalized information helping them in making better purchase decisions.

Supply Chain Contract Management in Blockchain Environment

Big Data, Business Analytics and Knowledge Management

__Dr . Nikhil Varma__ [1]*, Dr . Chirag Surti* [2]

1. *Ramapo College ,* **2.** *Rider University*

The combined use of machine learning and blockchain in analyzing historic transactional data will result in improved understanding of risk and improved administration of contracts in supply chain, known as smart contracts. In this research we use process mining to provide prescriptive analytics for smart contract development in a blockchain environment.

Teaching Business Analytics in a Business School

Big Data, Business Analytics and Knowledge Management

Prof . Ronald Klimberg [1] *, Dr . Matthew Liberatore* [2] *, Prof . Linda Boardman Liu* [3] *, Prof . Kevin Mentzer* [4] *,*
Prof . Gregory Vaughan [5]

1. *Saint Joseph's University ,* **2.** *Villanova University ,* **3.** *Boston College ,* **4.** *Bryant University ,* **5.** *Bentley University*

The private and public sectors are embracing the Business Analytics (BA) revolution. The academic world is reacting by offering new undergraduate majors and minors, Masters of Science degrees, certificates and concentrations within MBA programs. The emphasis of these courses and programs vary greatly. This panel will discuss various aspects of teaching business analytics at the undergraduate and graduate levels. We will cover a wide range of pedagogical issues including skills, topic coverage, course materials, software, and assessments.

The Graduate Education Landscape for Data Science and Analytics: A Preliminary Investigation of Program Content and Structure

Big Data, Business Analytics and Knowledge Management

Dr . William Hampton-Sosa [1]

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The demand for data professionals continues to grow rapidly. Reasons include a highly networked data generating environment and an increasingly competitive marketplace. Key industries driving the demand for talent include telecommunications, transportation, healthcare, energy, finance, and Internet-related businesses. Institutions of higher education are trying to respond with new or revamped programs. There are questions regarding appropriate program subject matter, structure, and knowledge domains. A preliminary content analysis of 50 graduate programs in the US revealed the similarities and differences among different types of programs. The results of this investigation should provide guidance to institutions as they develop their programs.

Using Predictive Analytics to Forecast Ice Cream Sales

Big Data, Business Analytics and Knowledge Management

Ms . Divyanshi Trakroo [1] *, Ms . Sheila Ansary* [1] *, Mr . Justin Smith* [1] *, Mr . Dino Sanfilippo* [1] *, Dr . Dinesh Pai* [1]

1. *Penn State Harrisburg*

A local ice cream company in Pennsylvania wants to refine their sales forecasts for three of their ice-cream flavors. We develop forecast models for these flavors using time series and causal methods. We also develop ensemble methods. The best forecasting model is Winter's Method and Model Seasonal and Trend. This is due to a widely accepted assumption that ice cream is a seasonal product.

"Teaching Business Analytics – Challenges and Opportunities"

Big Data, Business Analytics and Knowledge Management

Dr . Lillian Kamal [1], Dr . Bharat Kolluri [1]

1. University of Hartford

Our analysis focuses on hurdles in teaching Business Analytics – we reference our own experiences and challenges in teaching theoretical and applied Business Analytics courses, both at undergraduate and graduate levels. In particular, we focus on "Applications of Analytics in Business" (QNT 705) and "Introduction to Business Analytics" (QNT 712). Challenges discussed include the use of full-length case studies, standardized course content, textbook choices, optimal course placement, modeling and inferential issues of "Big Data", and the practical issues of data storage and appropriate software. Issues of student enrollment, support, and the recruiting and retaining of qualified faculty are also discussed.

Big Data, Business Analytics and Knowledge Management - Papers

AI in Knowledge Sharing and Learning: Redesigning Roles, Processes, and Incentives

Abstract

The recent growth in the use of artificial intelligence (AI) by organizations has increasingly demanded the redesign of knowledge workers' roles and processes to facilitate their better use of AI. However, very few prior studies have investigated the managerial implication of AI's role in facilitating knowledge sharing and learning in organizations. Our research attempts to address this gap by exploring the impact of AI in transforming knowledge workers' roles and processes in knowledge sharing and learning and investigating the redesign of sharing and learning incentives to accommodate such changes.

Keywords: Artificial intelligence, Incentives, Knowledge Sharing, Learning, Process

Knowledge workers are the people who create, share, and apply knowledge in their daily jobs. The recent growth in the use of artificial intelligence (AI) by organizations has increasingly demanded the redesign of knowledge workers' roles and processes to facilitate their better use of AI (Daugherty & Wilson, 2019).

Over time, AI has expanded its landscape into multiple disciplines including expert systems, neural networks, case-based reasoning, robotics, Natural Language Processing (NLP), and speech recognition (Liebowitz, 2001). AI is considered as one of the key building blocks for advancing the field of knowledge management (KM), as the AI technologies greatly facilitate the acquisition, processing, and application of knowledge, which help knowledge workers with their decision-making process (Fowler, 2000).

The recent evolution in data analytics and high-performance computing has rekindled the interest in industry and academia into further developing AI, leading the way for cognitive computing (Davenport & Ronanki, 2019). Using advanced AI techniques to mimic the way the human brain works, cognitive computing further strengthens the natural connection between AI and KM (Rhem, 2017). For instance, given the proliferation of structured and unstructured data, there is a continuous need to discover knowledge from the growing big data sources.

Recent studies have explored the implementation of emerging AI technologies for knowledge management, such as big data analytics (Sumbal et al., 2017; Pauleen et al., 2017), machine learning (Delen et al., 2013; Jin et al., 2018), and intelligent agents (Chemchem & Drias, 2015; Gacanin, 2019). AI has also been applied to investigate the action and performance of knowledge workers, for instance, the knowledge hiding behavior among employees (Abubakar et al., 2019).

However, most of prior studies on the role of AI in KM have been conducted from a technical perspective. Very few of them have investigated the managerial implication of AI's role in facilitating knowledge sharing and learning in organizations. Our research attempts to address this gap by exploring the management issues of using AI in motivating knowledge workers to share knowledge and learn. In particular, we explore the impact of AI in transforming knowledge workers' roles and processes in knowledge sharing and learning and how they differ from those in traditional knowledge management systems. Furthermore, our study investigates the redesign of sharing and learning incentives to accommodate the changes of knowledge workers' roles and processes.

We briefly identify the different roles that AI can play in knowledge sharing and learning processes. Business intelligence, data mining, and other AI tools help knowledge providers easily create the content they can share with other workers. Such tools can also inform providers of the trending topics that learners may be interested through inferring learners' daily activities in their jobs and the knowledge and tools needed for accomplishing such activities. The actual sharing process can be automated to improve its efficiency through AI's intelligent communication facilitation and matching algorithms. When learners explicitly search for specific knowledge, they will be matched with the existing knowledge or the expert who can share such knowledge with the best fit. Learners will also be informed of the knowledge they may be interested in based on AI's analysis of their skill needs. The performance of learning can also be significantly enhanced by AI's interactive learning systems that track learners' progress and help overcome their learning obstacles. When learners apply such knowledge in their jobs, AI will monitor its efficacy and use the feedback to further enhance the quality of knowledge to be

created. Our research will incorporate these steps and analyze the changes in the knowledge workers' roles and changes along with appropriate incentive systems to facilitate their adoption.

In summary, AI can fundamentally transform the knowledge sharing and learning process from a traditional sender-receiver framework (Lin, Geng, & Whinston, 2005) to one that emphasizes content development and absorption. Against this backdrop, our research will study how the traditional knowledge sharing and learning incentives should be redesigned to motivate knowledge workers to better participate in such AI-powered processes. With the growing interest in AI and its applications to KM, our research will provide managerial insights for practitioners to effectively adopt AI in managing knowledge assets in organizations.

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ARE MACHINES WITH HUMAN INTELLIGENCE POSSIBLE?

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ABSTRACT

Artificial general intelligence, AGI, aims at building machines with the intelligence of human level. It has been a long-standing contention on whether or not machines can eventually be as intelligent as humans, or whether AGI is possible. Neither side of the contention has provided solid arguments. We argue self-awareness and anxiety of death are not copiable, but computer codes are copiable. So, a duplicatable computer cannot have the un-duplicatable consciousness of self-awareness and anxiety of death. Self-awareness draws a line between biological humans and the digital machines. Computer-based AGI is therefore not possible. Further issues about AI include how far the machine intelligence can go, whether robots will eventually dominate humans intellectually, and the fundamental difference between us and machines.

Key Words: Artificial general intelligence, Computer intelligence; Robot; Artificial Intelligence.

Artificial General Intelligence, AGI, (or strong AI), aims at building machines with the intelligence comparable to that of the human mind (Rouhiainen 2019). In other word, computers of AGI will be able to do whatever humans can do, or even better. Scientists and philosophers have conflicting opinions on the possibility of AGI. The

contentions have focused on whether or not there exists an insurmountable obstacle for machine intelligence.

Before the first industrial revolution which was driven by mechanical machines and electricity, it was difficult for the people to imagine what a machine *could* do. Nowadays, amid the second industrial revolution driven by computer technology, the difficulty is to imagine what a machine *cannot* do. It has been a long-standing contention among scientists on how far intelligent machines can go. Is there a limit of computer intelligence? If there is a limit, what is the "blind spot" of machine intelligence? We show in this paper that, among the unknowns and uncertainties in the future, there is one thing with certitude:- electronic computers will not have the full range human consciousnesses and mental experience because they can never have self-awareness and sense of death as humans do. That is a reasoned thesis, rather than a wild hypothesis.

1. Is Computer Intelligence Unlimited?

It is "a delightful tricky question" that: "Will AI progress eventually stagnate due to insurmountable obstacles, or will AI researchers ultimately succeed in their original goal of building human-level artificial general intelligence? "(Tegmark 2017).

It has been a widely recognized fact that computers are able to do many intelligent things that used to be done only by humans, and that capability is enhancing rapidly. How intelligent a computer can eventually be has been debated for almost sixty years among computer scientists, philosophers, physicists, mathematicians, psychologists, and biologists.

One side of the contention insists that an electronic machine would sooner or later be able to do whatever a human, or a "*meat machine*" by Minsky, is capable of. Here are some assertions:

"If we're a carbon-based complex, computational, collocation of atoms, and we're conscious, then why wouldn't the same be true for a sufficiently complex silicon-based computer?" (Gilder & Richards 2002)

"In principle, and perhaps in actuality three or four decades from now, it should be possible to transfer a human personality into a robot, thereby extending the person's lifetime by the durability of the machine." (Bainbridge, 2004)

"Will these future machines be capable of having spiritual experience? They certainly will claim to. They will claim to be people, and to have the full range of emotional and spiritual experiences that people claim to have." (Kurzweil 2005)

"AI is coming. It is clear we should give conscience to our machines when we can. It also seems quite clear that we will be able to create machines that exceed us in moral as well as intellectual dimensions." (Hall, 2007)

"We saw how the laws of physics allow suitable clumps of matter to remember, compute and learn, and how they don't prohibit such clump from one day doing so with grater intelligence than the matter clumps in our heads." "We can't dismiss the possibility that AGI will eventually reach human levels and beyond." (Tegmark 2017)

On the other hand, many people do not believe that computers can ever be like humans. The strongest among them are the dualists who take it for grant that the mind is something separate, and fundamentally different, from the physical things.   Many scientists and scholars viewed it unimaginable to have machines sharing all of our intelligence and consciousnesses.

"They (computers) are immensely useful devices for simulating brain process. But the simulation of mental states is no more a mental state than the simulation of an explosion is itself an explosion." (Searle 1997)

"I do my best to express, in a dispassionate way, my scientific reasons for disbelieving this perception, and arguing that the conscious minds (of machines) can find no home within our present-day scientific world-view." (Penrose 1999)

"Will emotions be explicitly programmed into a machine? No. That is ridiculous." (Hofstadter 1999)

"Can computers be intelligent? For decades, scientists in the field of artificial intelligence have claimed that computers will be intelligent when they are powerful enough. I don't think so. ... Brains and computers do fundamentally different things." (Hawkins 2004)

No one on either side of the contention has so far provided solid reasons to support his/her assertion. They just "feel" that it "should" or "should not". Furthermore, this issue was thought by Searle to be neither provable nor un-disprovable. *"Someone is bound to ask, can you prove that the computer is not conscious? The answer to this*

question is: Of course not. I cannot prove that the computer is not conscious, any more than I can prove that the chair I am sitting on is not conscious.'' (Searle 2002).

2. A Machine Cannot Have All Human Consciousnesses

Consciousness in this article refers to subjective mental experience of a person such as thinking, reasoning, feelings, emotions, intuitions, and faith. Such consciousnesses require intelligence, sometime high-level intelligence.

A *computer program*, or simply a *program*, refers to the instructions to computers in any computer language.

A program is copiable if the instructional statements in the program can be duplicated so that the original and the copy are literally identical and the result of running the copy is indistinguishable from the result of running the original. For example, program Microsoft Word is copiable because it can be copied from a machine to the others, and the result of running the original is same as the result of running the copy.

Any program for a digital computer is copiable. That is because any computer program can be converted to a set of equivalent 0-1 codes on a universal Turing Machine, according to the Church-Turing Thesis (Russell and Norvig 2010), and the 0-1 codes on the tape of a Turing Machine are obviously copiable.

A computer is copiable if all the programs in the computer are copiable. Actually, all computers as we have at present are copiable since all programs in current computers are copiable.

Self-awareness is a conscious trait "associated with the tendency to reflect on or think about one-self" (Oxford Encycl. 2000).

Anxiety of death is comprehension and dread of the mystery and obscurity of death. Self-awareness is a necessary condition for having the anxiety of death, since anxiety of death is the fear of death of "myself".

Anxiety of death and self-awareness defy copying. Suppose robot R is programmed to have self-awareness and anxiety of death. If all the programmed consciousnesses in a robot R are copied to another robot R', then the self-identities of R

and R' must be the same. R and R' share a same "self". Realizing that it has an identical "self" in R, R' would not fear to die since the "death" of R' would not result in the ordinary sense of death: - disappearance of the world around itself forever. For the same token, robot R would not have anxiety of death either. Therefore, after copying anxiety of death together with self-consciousness from R to R', anxiety of death would disappear on either R or R'. Thus, anxiety of death and self-awareness defy copying and are not copiable.

Now we have come to two facts with opposite traits: Computer programs are copiable, while the consciousness of anxiety of death and self-awareness are not copiable. The logical conclusion from those facts is that it is not possible to program self-awareness and anxiety of death on a computer. Therefore, we cannot obtain the consciousnesses of self-awareness and anxiety of death on computers.

Any intelligent machines at present and in the near future, such as a robot, are controlled by electronic computers. They are therefore lack of self-awareness and anxiety of death. So, they do not have the full range of human and consciousness and do not have the intelligence of human level, as stated in the thesis below:

Thesis:

An electronic robot or machine cannot have human consciousnesses such as self-awareness and anxiety of death, and so cannot have same the mental experience as a human.

The above thesis denies the possibility of AGI. An intelligent machine, like a robot, can never have the intelligence of the same level of human beings.

The argument for the above thesis assumes that self-awareness and anxiety of death are *examples* of human consciousnesses and they are not copiable. Even though people may have disagreements on exact definitions of self-awareness and anxiety of death, the thesis holds true as far as we agree on the fact that self-awareness and anxiety of death are examples of human consciousness. (Wang 2016)

3. Robots vs. Human Beings

We have reasoned that it is not possible to equip an electronic machine with all human mental experience. The blind spots for computer intelligence are self-awareness and anxiety of death. The "duplicatability" of digital programs makes a robot incapable of those uncopiable consciousnesses.

All digital computer programs are copiable. So, the computers as we have now will not have the full range of humans intelligence no matter how complex and fast they will be. All the man-made machines and robots are copiable. So, they will never become "humanoids" which can do whatever we human can. Are we going to have copiable machines in the future? We do not know. The issues like what an un-copiable man-made machine is like, how it works, and how to manufacture such a machine, are still utterly beyond our knowledge.

"Will a robot be one of us?" We now have the answer to this question: "No, since a robot cannot achieve our self-consciousness." Electronic computers have been thought by many to be omnipotent and to surpass humans on every aspect of intelligence and consciousness in a few decades. Our thesis indicates a limit of electronic computers and robots. Even though one could program robots sometime in the future to such a level that they were pretty much human-like, those robots would not be humans because they would miss something we humans have, - our sense on "self" and on "life and death". The electronic robot would not be one of us.

We are in the era in which the difference between humans and machines is blurring. The thesis above tells an unblurred difference between humans and machines which are self-awareness and the related sense of death.

When talking about intelligent machines as a new species created by humans, Kurzweil said, "*Evolution has been seen as a billion-year drama that led inexorably to its grandest creation: human intelligence. The emergence in the early twenty-first century of a new form of intelligence (machine intelligence) on Earth that can compete with, and ultimately significantly exceed, human intelligence will be a development of greater import than any of the events that have shaped human history.*" (Kurzweil 1999) We can

see now that Kurzweil's perspective of machine intelligence is not realistic. The electronic computers as we currently have are not as omnipotent as Kurzweil thought. Even though we do not know how smart electronic computers will be in hundreds and thousands years, they will be incapable of something that we humans are capable of, due to the computers' inherent idiosyncrasy, - copiability or duplicatability.

A super-intelligent machine will remain as a lifeless tool, instead of a "human", as far as it is not self-aware and does not have sense of life and death.

We humbly admit our ignorance about our own consciousness, mind, and spirit. Is there any piece of our consciousnesses, other than self-awareness and anxiety of death, which cannot be realized on electronic machines? How can a person's mind be programmed? Can a robot be a spiritual machine? What is an un-copiable machine like, and how does it work? Is consciousness a "by-product" emerging from sufficiently sophisticate program, as proposed by Hofstadter (1999)? If so, how does such "emerged" process occur? Is the emerged process copiable? These are examples of the issues for us to keep reflecting hereafter.

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BIG DATA FOR SMALL BUSINESS:
A KNOWLEDGE MANAGEMENT MODEL

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ABSTRACT

Big data has raised challenges and opportunities for business, the information technology (IT) industry, and research communities. Nowadays small businesses are dealing with big data using their limited resources. This paper discusses the challenges of big data for small business, and summarizes IT solutions that are available and feasible for small business to utilize big data. The study collects eight (8) well-documented cases of successful applications of knowledge management thought data analytics in small business, and conducts a qualitative data analysis of these cases. The qualitative data analysis of the multiple cases reveals a knowledge management model of big data for small business. The model indicates that strategic use of data, data requirements, IT solutions for small business, and knowledge products are the major constructs of big data for small business. These constructs form a loop through the causal relationships between the constructs.

EXTENDED ABSTRACT*

The big data problem has become an important topic for years (Beyer & Laney, 2012; Zikopoulos et al., 2012). Big data are characterized by volume, velocity, variety, and veracity (Wolff, 2014). Big data not only is a reality for large corporations for years, but also raises opportunities for small businesses. Nowadays small businesses are seeking information technology (IT) solutions to big data management (Schaeffer & Olson, 2014).

Small businesses make significant contribution to the economy. In the United States, small businesses with fewer than 500 employees account for more than half the private GDP and provide around half the private sector employment (SBA, 2020). Small businesses shall play significant roles in big data.

Big data means that a variety of data is now available faster, and the implications of big data for different types of organizations may not be the same (Einav & Levin, 2016). It might be a practical strategy for small businesses to approach big data by "thinking big but starting small." Small businesses can have many advantages in generating and using big data. A small business is usually close to its customers and clients, and know the source of data, the needs for data, and

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* This is an extended abstract of the submitted manuscript for the peer-review process.

the value of data. On the other hand, small businesses have disadvantages in dealing with big data. Undercapitalization is a common problem of small businesses. Small businesses often have insufficient IT resources for data collection and data analysis. Thus, big data management become crucial for small businesses in the big data ear. The major sections of this paper are summarized below.

1. This paper discusses the challenges of big data for small business, examines IT solutions that are feasible for small business to deal with big data.

2. The study collects eight (8) well-documented cases of knowledge management in small business posted on the Internet. The paper include a summary of the eight business cases.

3. The study conducts a qualitative data analyotis of these eight business cases. The paper provides the detailed procedure of the qualitative data analysis.

4. The paper summarizes the results of qualitative data analysis, and proposes a knowledge management model of big data for small business organizations. The model indicates that strategic use of data, data requirements, IT solutions for small business, and knowledge products are the major constructs of big data for small business. These constructs form a loop through the causal relationships between the constructs.

5. Finally, the paper discusses the limitation of the study, and highlights the contribution of this study for the area of big data, data analytics and knowledge management.

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DENSITY-BASED CLUSTERING VALIDATION OF UNCERTAIN DATA OBJECTS

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Abstract

In data mining, clustering validity indices are used to identify the correct number of clusters and best formed clusters. They are numerical values that can be obtained from the output of clustering algorithms and be used for validation of the performance of those algorithms. There are many existing works on clustering validity indices for the traditional type of data objects which are also referred to as certain data objects. Certain data objects are the ones that are only represented by a single point value. Uncertain data objects are the objects that are modeled either with a group of points or a probability density function which is either given or fitted to the points. In comparison with certain data objects, uncertain data objects carry more information captured in form of uncertainty. To our best knowledge, in the literature, there are only two existing clustering validity indices designed solely for uncertain data objects. In this paper, we introduce another one named the *density-based uncertain clustering validity index* or DBU. The DBU index captures the exclusive density-based contribution of each object in the data set to compactness and separation of clusters of uncertain data. We show through several experiments with simulated and real data that for identifying the correct number of clusters, the DBU index outperforms both the clustering validity indices for certain data and the two existing clustering validity indices for uncertain data as it captures the shape of clusters more accurately by taking into account their densities.

Keywords: Clustering, Clustering validity index, Uncertain data

1. Introduction

Uncertain data mining problems, unlike traditional data mining problems referred to as certain data problems, are the problems in which each data object is not only represented with a single point value. In these problems, some amount of uncertainty is assumed for each data object. The uncertainty might be due to many reasons such as multiple measurements, data staleness or simply, measurement errors. There are different ways of treating uncertainty but in uncertain data mining, uncertainty is captured by data objects that are modeled with either a group of points or a probability density function (pdf) that can be assumed as given or obtained by fitting to the group of points (Tavakkol et al. 2017).

An interesting application of uncertain objects are images. An image can be considered as an uncertain object if each of its objects are converted to a sample of two-dimensional points. The image can be modeled as uncertain object by either considering the combined samples of points or by the pdf that can be obtained by fitting to those points.

Converting uncertain data to certain data is easy. The most logical way is to consider only the mean point of each uncertain object instead of considering the whole uncertainty of it. But doing so, can lead to disposing valuable information about each object and can lead to significant errors in the results of any data mining task. This shows the importance of considering uncertain objects as they are and the necessity of developing data mining algorithms that use them in their entirety.

A lot of research has been conducted on developing uncertain data mining algorithms for different categories of data mining such as clustering, classification, outlier detection, frequent pattern mining, etc. In (Aggarwal and Philip 2009) a thorough literature review on the aforementioned topics of uncertain data mining was provided.

One of the main categories of both certain and uncertain data mining, is clustering. Clustering is the task of assigning data objects into different clusters. The goal of most clustering algorithms is to form highly-compact and -separated clusters. Compactness means that the objects within a cluster are close to each other and separation means that objects in different clusters are far from each other. In (Jain and Dubes 1988; Jain et al. 1999; Xu and Wunsch 2005) comprehensive information about clustering and clustering algorithms was provided. In majority of clustering algorithms, the desired number of formed clusters, K, is determined by the user. For certain data, K-means (Likas et al. 2003; Jain 2010; Kanungo et al. 2002;) is maybe the most well-known clustering algorithm in the literature.

Clustering of uncertain data has been the topic of many works such as (Alipour and Jafari 2018, Aggarwal and Philip 2009; Chau et al. 2006; Lee et al. 2007; Gullo et al. 2008, 2008, 2010, 2017, 2013; Kao et al. 2010; Yang and Zhang 2010; Kriegel and Pfeifle 2005). In (Chau et al. 2006), an uncertain K-means clustering algorithm was developed . The developed algorithm uses expected distance to measure the distance between uncertain objects. In (Lee et al. 2007) it is proven that the algorithm of (Chau et al. 2006) can be simplified to the well-known certain K-means algorithm. In addition to the K-means algorithm, (Gullo et al. 2008; Yang and Zhang 2010) developed uncertain K-medoids clustering algorithms that measure the distance between uncertain objects by expected distances. In (Gullo et al. 2010, 2013), clustering uncertain data with mixture models was proposed. Voronoi diagrams and r-tree index for clustering uncertain data were developed in (Kao et al. 2010). In (Gullo et al. 2008) and (Gullo et al. 2017) an algorithm for hierarchical clustering of uncertain data was proposed. Density-based clustering algorithms FDBSCAN and uncertain DBSCAN that measure the distance between uncertain objects by using probabilistic distance measures were developed in (Jiang et al. 2013; Kriegel and Pfeifle 2005). Moreover, an uncertain K-medoids clustering algorithm that measures the distance between uncertain objects by using probabilistic distance measures, was also developed in (Jiang et al. 2013). The developed uncertain K-medoids algorithm is used for clustering in the experiments of this paper.

As it was mentioned earlier, clustering algorithms are used to form any desired number of clusters but how to know what are the correct number and best formed clusters? To find that out, clustering validity indices are used. Clustering validity indices are numerical measures that capture the compactness and separation of clusters. To identify the correct number of clusters, clustering validity indices can be applied on the results of the clustering algorithm for various number of formed clusters. Some clustering validity indices identify the correct number of clusters as the one for which the maximum value of the index is returned while others identify the correct number of clusters as the one for which the minimum value of the index is returned. The same procedure can be used to find the best formed clusters. For any desired number of clusters, a clustering algorithm can be run several times and then a clustering validity index can be applied on the results of each run. Again, the best formed clusters are the ones that depending on the index result in its maximum or minimum value.

For certain data objects, there are a lot of existing clustering validity indices. The most well-known ones are Dunn (Dunn 1973), Davies-Bouldin (Davies and Bouldin 1979), Xie-Beni (Xie

and Beni 1991), Silhouette (Rousseeuw 1987), Calinski-Harbasz (Caliński and Harabasz 1974), and Pakhira-Bandyopadhyay-Maulik (Pakhira et al. 2005). Dunn, Davies-Bouldin, Xie-Beni, and Silhouette, the four most popularly used indices are used in the experiments of this paper to show the deficiency of certain clustering validity indices for identifying the correct number of clusters of uncertain data objects.

For uncertain data objects, to our best knowledge, there are only two existing clustering validity indices, both of which are presented in (Tavakkol et al. 2018) which is a work co-authored by one of the authors of this paper. Those developed indices are uncertain Silhouette and the Order Statistic index. They both can capture uncertain data given as multiple points or pdfs and both use probabilistic distance measures to compute the distance between uncertain data objects. The uncertain Silhouette index takes into account the exclusive contribution of every uncertain object for compactness and separation of clusters. The Order Statistic index uses the average of r smallest inter-cluster distances for separation, and the average of r largest intra-cluster distances for compactness of clusters of uncertain data objects.

In this paper, we propose another uncertain clustering validity index for uncertain data objects named the *density-based uncertain clustering validity index* or *DBU*. Our proposed index captures the exclusive density-based contribution of each uncertain object in both the compactness and separation of clusters.

The main advantage of the DBU index compared to the two existing clustering validity indices, uncertain Silhouette and the Order Statistic is that it more accurately captures the shape of clusters by taking into account their densities. This makes the index capable of identifying the correct number of clusters for various images such as the ones shown in the experiments section of the paper. In addition, the index does not rely on tuning many parameters like the Order Statistic index.

In the experiments section, we examine the performance of the proposed clustering validity index and the existing uncertain and the four well-known certain clustering validity indices. The experiments section includes simulated data sets with different number of objects and dimensions, and real image data sets.

The remainder of this paper is organized as follow. In Section 2, we explain about different existing certain and uncertain indices that can be used for validation of clusters of uncertain data objects. Specifically, the two existing uncertain clustering validity indices, i.e. uncertain Silhouette and the Order Statistic index, are explained in detail. In Section 3, the methodology of our proposed

density-based uncertain clustering validity index is explained. Experiments with simulated and real data are presented in Section 4. In the final section, the main findings are reviewed and the paper is concluded.

2. Existing indices for validation of clusters of uncertain data objects

A possible way of identifying the correct number of clusters or finding the best formed clusters of uncertain data is to use certain clustering validity indices. This can be done simply by only using the mean point of uncertain data objects. Although this is a naïve approach as it discards valuable information recorded as uncertainty for each object, it is the more common approach in the literature. In this paper, for comparison purposes, we use a few of the most popular certain validity indices for identifying the correct number of clusters of uncertain data objects. The used indices are Dunn, Davies-Bouldin, Xie-Beni, and Silhouette. For more detailed explanations of the used indices, see (Tavakkol et al. 2018).

Another way of validating the quality of clusters of uncertain data is to use clustering validity indices that use the whole uncertainty information provided for each object. Such indices are called uncertain clustering validity indices. It seems reasonable to expect that use of uncertain clustering validity indices for uncertain data results in better validation of clusters as opposed to use of certain clustering validity indices for uncertain data. The reason is that in uncertain clustering validity indices, the whole information of uncertain objects is utilized in validation. However, in certain clustering validity indices, an important chunk of information for each object- captured in form of uncertainty-is disregarded.

Although it seems crucial to use a variety of uncertain clustering validity indices for validation of uncertain data, to the best of our knowledge, in the literature, they are only two uncertain clustering validity indices named uncertain Silhouette and the Order Statistic index. In this section, we briefly explain the two existing clustering validity indices for uncertain data objects. Later, in the experiments section, the two indices are used for comparison purposes.

2.1. Uncertain Silhouette

The uncertain Silhouette index, developed in (Tavakkol et al. 2018), is one of the two existing clustering validity indices for uncertain data. In uncertain Silhouette, the distance between uncertain objects is captured by probabilistic distance measures (Lohani et al. 2018; Rauber et al.

2008; Vasconcelos 2004; Juang and Rabiner 1985). Probabilistic distance measures are numerical measures mostly used in the literature to capture the distance between two pdfs or two groups of points. They have applications in fields such as pattern recognition, signal processing, and asymptotic theory. In this paper, we use Bhattacharyya (Cha 2007, Aherne et al. 1998, Bhattacharyya 1946), one of the most widely-used probabilistic distance measures, for computing the uncertain Silhouette index. The definition of the Bhattacharyya index is shown in Eq. (1).

$$pd_B(\boldsymbol{X}, \boldsymbol{Y}) = -\ln(\int_{\boldsymbol{u}} \sqrt{p_X(\boldsymbol{u})p_Y(\boldsymbol{u})}d\boldsymbol{u}), \tag{1}$$

where $p_X(\boldsymbol{u})$ and $p_Y(\boldsymbol{u})$ denote the pdfs of uncertain objects $\boldsymbol{X}$ and $\boldsymbol{Y}$ and $\boldsymbol{u} \in R^{\boldsymbol{p}}$. When uncertain objects are in form of groups of points, to calculate the distance, histograms can be built.

The uncertain Silhouette index proposed in (Tavakkol et al. 2018), is shown in Eq. (2):

$$USI_K = \frac{1}{n}\sum_{i=1}^{n} \frac{(ub_i - ua_i)}{\max(ua_i, ub_i)}. \tag{2}$$

The index captures two components for each uncertain object: ua_i, ub_i. The former captures the contribution of each object to compactness and the latter captures the contribution of each object to separation of clusters. The component for compactness uses the average pairwise probabilistic distance between each object and all other objects assigned to the same cluster as the object. The component for separation uses the minimum of average pairwise probabilistic distances between each object and the objects in other clusters. The number of clusters with the largest index value, is identified as the correct number of clusters.

The uncertain Silhouette index is conceptually similar to the certain Silhouette index except that it uses probabilistic distance measures as opposed to the certain Silhouette index in which the Euclidean distance is used.

2.2. Order Statistic index

The second existing clustering validity indices for uncertain data objects is named Order Statistic (OS). The definition of the OS index is shown in Eq. (3).

$$OS_K = \frac{\sum_{i=1}^{K-1} sp_{(i)} \Big/ K - 1}{\sum_{j=2}^{K} cp_{(j)} \Big/ K - 1} \tag{3}$$

In this equation, in the numerator, the average of the K-1 smallest inter-cluster distances, $sp_{(i)}, i = 1, \dots, K - 1$, is considered. To capture $sp_{(i)}$, the average of the s smallest pairwise probabilistic distances between objects in the two considered clusters are used.

In the denominator, the average of the K-1 largest intra-cluster distances, $cp_{(j)}, j = 1, \dots, K - 1$, is calculated. To capture $cp_{(j)}$, the average of the t largest pairwise probabilistic distances between objects in cluster C_j are used. The uncertain Silhouette index returns large values for compact and well-separated clusters.

3. The proposed density-based uncertain clustering validity index

In this section, we propose a new clustering validity index that can be used for validation of clusters of uncertain data objects. We call the proposed validity index the density-based uncertain clustering validity index or DBU. Denoting the uncertain data objects in a data set by X_i, $i = 1, \dots, n$, the DBU index is defined as follow:

$$DBU_K = \frac{1}{n} \sum_{i=1}^{n} [Pr(C_{l_i}|X_i) - \max_{k' \neq l_i} Pr(C_{k'}|X_i)]. \tag{4}$$

In the equation, $Pr(C_{l_i}|X_i)$ denotes the conditional probability that uncertain object X_i belongs to cluster $C_{l_i}, l_i \in \{1, \dots, K\}$ which is the cluster that the object has been assigned to by a clustering algorithm. $\max_{k' \neq l_i} Pr(C_{k'}|X_i)$ returns the maximum probability for object X_i to belong to a cluster $C_{k'}, k' \neq l_i$ other than its assigned cluster.

The first component of the index i.e. $Pr(C_{l_i}|X_i)$ somewhat captures compactness for object X_i. Large values of this component indicate object X_i is in a compact region of cluster C_{l_i}. The second component of the index captures separation of object X_i from other clusters. Small values of the component indicate object X_i is well-separated from other clusters. In the index, the difference between compactness and separation for each object is calculated and eventually the average difference value over all data objects is returned.

The conditional probabilities in Eq. (5) can be computed based on the Bayes theorem (Efron 2013; Lindley 1958). According to the Bayes theorem, $Pr(C_j|X_i)$, known as posterior probability, can be computed as:

$$Pr(C_j|X_i) = \frac{Pr(X_i|C_j)P(C_j)}{\sum_j [Pr(X_i|C_j)P(C_j)]}, \tag{5}$$

where $\sum_{j \in \{1,2,\dots,K\}} Pr(C_j|X_i) = 1$ and $P(C_j)$ which is known as prior, can be computed as $P(C_j) = \frac{n_j}{n}$. The class-conditional probability, $Pr(X_i|C_j)$, can be computed using multivariate kernel density estimation for uncertain data as follow:

$$Pr(X_i|C_j) = \int_X \hat{f}_{H_j}(X) dX, \tag{6}$$

where H_j is the matrix of bandwidth parameters for uncertain objects in cluster C_j. Given n_j multivariate objects, the class-conditional multivariate kernel density function for cluster C_j can be estimated as follows:

$$\hat{f}_{H_j}(X) = \frac{1}{n_j} \sum_{t=1}^{n_j} K_{H_j}(X - X_t) = \frac{1}{n_j} \sum_{t=1}^{n_j} |H_j|^{-\frac{1}{2}} E\left[K\left(H_j^{-\frac{1}{2}}(X - X_t)\right)\right], \tag{7}$$

where $K(.)$ is the kernel function. $Pr(X_i|C_j)$ can be further expanded to get:

$$Pr(X_i|C_j) = \frac{1}{n_j} \sum_{t=1}^{n_j} |H_j|^{-\frac{1}{2}} \iint K\left(H_j^{-\frac{1}{2}}(X_i - X_t)\right) . f(X_i) . f(X_t) dX_i dX_t. \tag{8}$$

Given uncertain data objects in form of multivariate normal pdf, i.e. $X_i \sim N(\mu_i, \sum_i), \ i = 1, \dots, n$, and considering multivariate Gaussian kernel (Kristan et al. 2011), we can use the convolution of multivariate normal distributions to simplify the formulation as follows:

$$Pr(X_i|C_j) = P(\mu_i, \Sigma_i|C_j) = \frac{1}{n_j} \sum_{t=1}^{n_j} (2\pi)^{-\frac{d}{2}} . \frac{e^{-\frac{1}{2}(\mu_i - \mu_t)'(\Sigma_i + \Sigma_t + H_j)^{-1}(\mu_i - \mu_t)}}{|\Sigma_i + \Sigma_t + H_j|^{\frac{1}{2}}}, \tag{9}$$

where we propose $H_j = (\frac{4}{d+2})^{\frac{1}{d+4}} n_j^{-\frac{1}{d+4}} \Sigma^j$. Here, $\Sigma^j = \sum_{m_j} + \frac{\sum_{t=1}^{n_j} \Sigma_t}{n_j}$ which is the covariance matrix for uncertain data objects defined by (Tavakkol et al. 2018). $\sum_{m_j}$ is the covariance matrix considering only the mean points of uncertain objects in cluster C_j.

Considering uncertain objects given with multiple points (s points per uncertain object), we can write:

$$Pr(X_i|C_j) = \frac{1}{n_j}\sum_{t=1}^{n_j}\sum_{c=1}^{s}\sum_{d=1}^{s}|H_j|^{-\frac{1}{2}}K\left(H_j^{-\frac{1}{2}}(X_i^c - X_t^d)\right).P(X_i^c).P(X_t^d), \qquad (10)$$

where X_i^c and X_t^d are the c-th and d-th points in respectively the i-th and t-th uncertain objects. Also, $P(X_i^c)$ and $P(X_t^d)$ are the probabilities according to probability distributions of X_i and X_t.

4. Experiments

To evaluate the performance of our proposed clustering validity index, we conducted experiments on both simulated and real data with different number of objects and dimensions. We compare the performance of the proposed density-based validity index with that of the four well-known clustering validity indices for certain data i.e. Dunn, Davis-Bouldin, Xie-Beni, and Silhouette; and also, the two existing clustering validity indices for uncertain data i.e. uncertain Silhouette and the Order Statistic index. The performances are compared by applying the aforementioned indices on the clusters formed by using the uncertain K-medoid clustering algorithm (Jiang et al. 2013). For the Order Statistics, in majority of experiments, we considered two settings: 1) $s=t=3$, 2) $s=t=5$. As suggested by (Tavakkol et al. 2018), generally, for the Order Statistic index, if the objects in the clusters are not widely scattered, smaller values of s and t are recommended.

4.1. Experiments with simulated data

With simulated data, experiments include four different two-dimensional simulated data sets named D1, D2, D3, and D4 for which the correct number of clusters of uncertain data were two, three, four, and five, respectively. The objects in these data sets follow multivariate normal distributions. For simulating the objects, following the framework in (Tavakkol et al. 2017, 2018, 2019), the mean points of the objects were generated according to multivariate normal distributions and the covariance matrices were generated according to inverse Wishart distributions (Nydick 2012). In addition, we conducted experiments with variations of the four data sets as well where different number of objects i.e. 50, 100, 200, and 500, were generated for each cluster of each data set. Moreover, experiments were conducted with variations of the four data sets with dimensions higher than 2 including 3, 5, and 10. Fig. 1 shows the uncertain objects in the versions of the four data sets with 2 dimensions and 50 objects per cluster. Ellipses in the figure are contours of

bivariate normal pdfs that are used to model the objects and objects in different clusters are depicted with different colors.
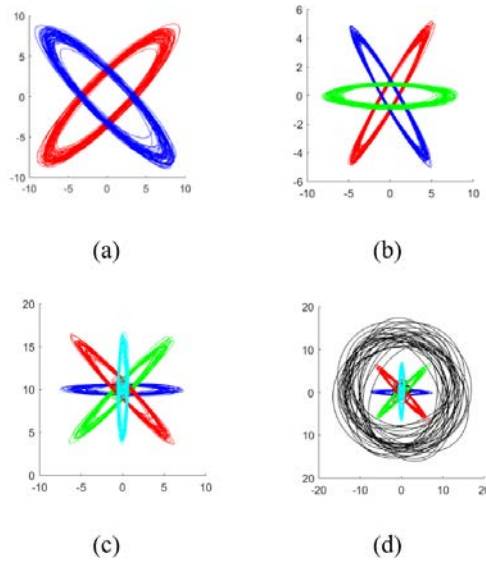
Fig. 1 Four two-dimensional simulated data sets of uncertain data objects, a) D1, b) D2, c) D3, and d) D4 with respectively 2,3, 4, and 5 clusters.
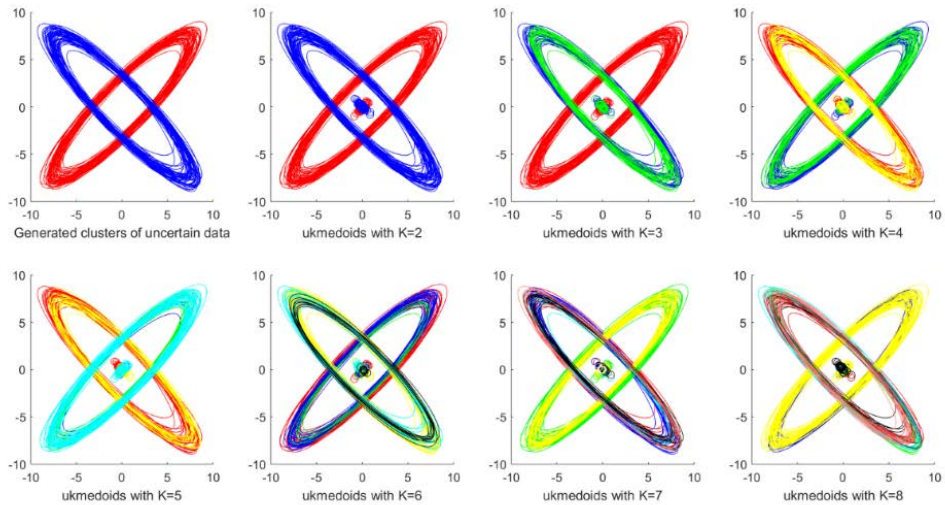
Fig. 2 The best formed clusters for data set D1, obtained by running the uncertain K-medoids clustering algorithm with different values of desired formed clusters.
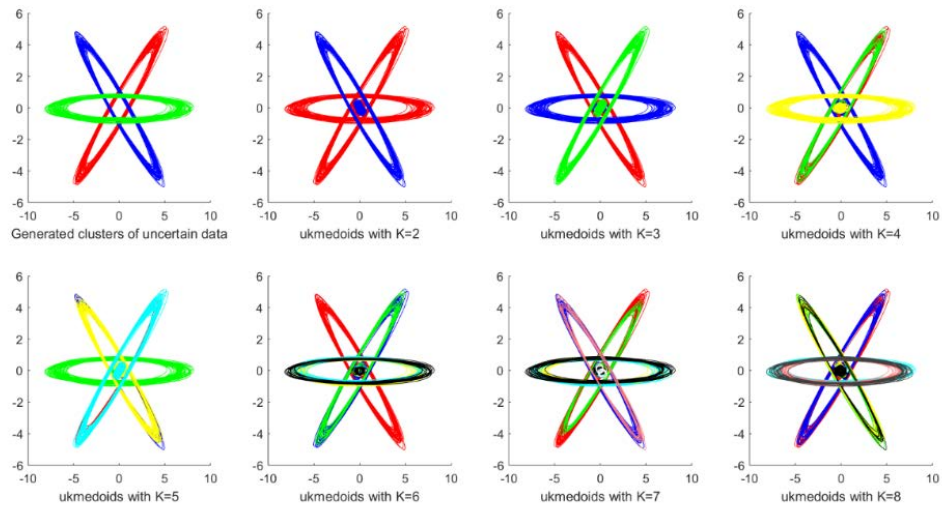
Fig. 3 The best formed clusters for data set D2, obtained by running the uncertain K-medoids clustering algorithm with different values of desired formed clusters.
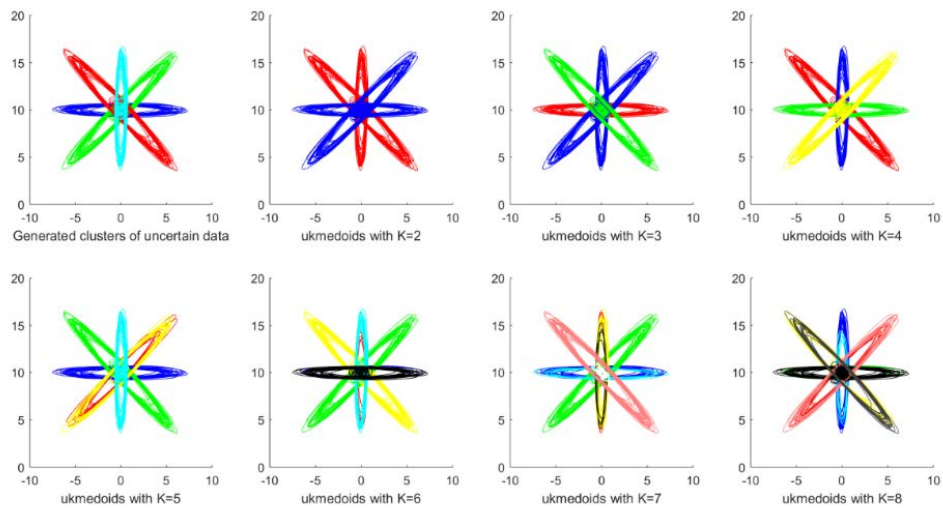
Fig. 4 The best formed clusters for data set D3, obtained by running the uncertain K-medoids clustering algorithm with different values of desired formed clusters.
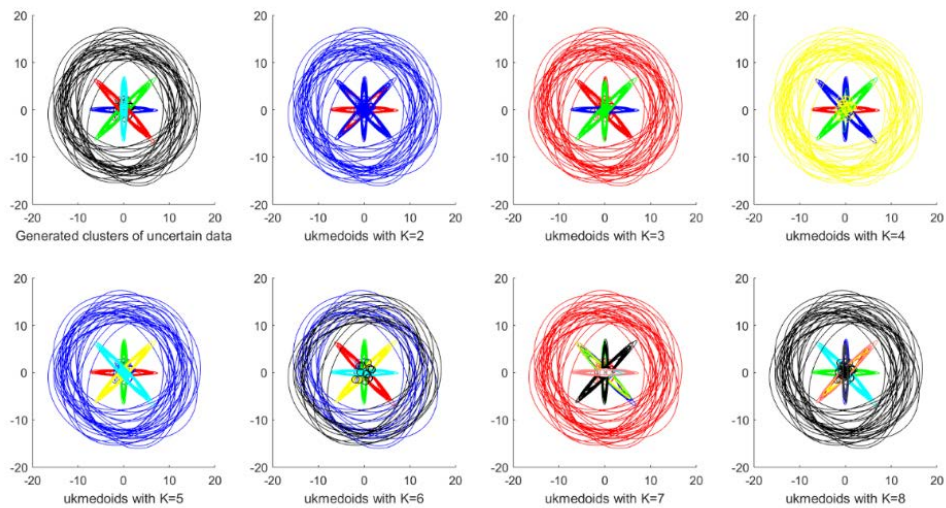
Fig. 5 The best formed clusters for data set D5, obtained by running the uncertain K-medoids clustering algorithm with different values of desired formed clusters

The results of using the benchmark and proposed validity indices on data set D1 are shown in Table 1. The results suggest that with the exception of the certain validity indices: Dunn and Davies-Bouldin, other indices correctly identify two as the correct number of clusters for data set D1. The results of using the benchmark and proposed validity indices on the other data sets i.e. D2-D4 are presented in Tables 2-4. The results suggest that for data set D2, only the proposed DBU index and the uncertain Silhouette index, correctly identify three as the correct number of clusters and all other indices fail. For data set D3, only the DBU index, uncertain Silhouette, and the OS index with $s=t=3$, are successful in identifying four as the correct number of clusters, and finally for data set D4, all the uncertain validity indices identify five as the correct number of clusters while the certain validity indices fail.

As we mentioned earlier, we conducted experiments with higher number of objects and higher dimensions as well. For the number of objects, in addition to 50 objects per cluster, we conducted experiments with 100, 200, and 500 objects per cluster for all the four data sets. With regards to dimensions, in addition to the original two dimensions, we considered cases with 3, 5, and 10 dimensions.

In Fig. 6, the outputs of the benchmark and proposed validity indices on variations of the D1 data set in terms of number of objects, are presented. As the results suggest, all the uncertain

clustering validity indices including our proposed DBU index correctly identify two clusters as the correct number of clusters for variations of the D1 data set. In addition to the uncertain validity indices, the Silhouette index consistently and correctly identifies two as the correct number of clusters. Other certain clustering validity indices demonstrate inconsistent performance.

Fig. 7 presents the outputs of the eight clustering validity indices on variations of the D1 data set in terms of dimension. As the results suggest, the proposed DBU index and uncertain Silhouette are the only indices that consistently detect two as the correct number of clusters for different dimensions.

Table 1 The results of using the benchmark and proposed validity indices on data set D1

K	Dunn	Davies-Bouldin	Xie-Beni	Silhouette	Uncertain Silhouette	OS $r=K$-1 $s=t=3$	OS $r=K$-1 $s=t=5$	DBU
2	0.0037	8.6905	**0.3776**	**0.0200**	**0.9879**	**7.6929**	**9.0120**	**0.3842**
3	0.0037	13.1973	1.5233	-0.0373	0.6402	4.6928	5.2362	0.2691
4	0.0037	10.5011	1.1315	-0.1450	0.2474	4.1587	4.6759	0.0125
5	**0.0042**	**5.3280**	0.4471	-0.3673	0.1250	0.6799	0.6729	0.1079
6	0.0026	9.9933	3.7198	-0.4087	0.1407	0.1599	0.2394	-0.0085
7	0.0030	7.9396	2.2271	-0.6657	0.2323	0.3462	0.4888	-0.0200
8	0.0042	6.3188	1.8870	-0.6513	0.2500	0.1811	0.2856	0.0928

Table 2 The results of using the benchmark and proposed validity indices on data set D2

K	Dunn	Davies-Bouldin	Xie-Beni	Silhouette	Uncertain Silhouette	OS $r=K$-1 $s=t=3$	OS $r=K$-1 $s=t=5$	DBU
2	**0.0047**	**39.2977**	5.1558	**-0.0311**	0.6906	0.8431	0.8504	0.4115
3	0.0006	11.1467	0.7822	-0.0358	**0.9907**	7.4156	8.2321	**0.4156**
4	0.0006	9.2194	**0.5902**	-0.1408	0.7705	**7.4651**	**8.5622**	0.2915
5	0.0006	10.6172	1.6662	-0.3255	0.5340	3.1558	3.5853	0.2608
6	0.0007	15.0395	6.5057	-0.3408	0.5530	3.1100	3.5956	0.1876
7	0.0007	8.5073	1.4898	-0.5135	0.2915	3.1447	3.6644	0.1403
8	0.0007	9.4098	3.8861	-0.5716	0.2588	0.2400	0.3168	0.0162

Table 3 The results of using the benchmark and proposed validity indices on data set D3

K	Dunn	Davies-Bouldin	Xie-Beni	Silhouette	Uncertain Silhouette	OS $r=K$-1 $s=t=3$	OS $r=K$-1 $s=t=5$	DBU
2	**0.0053**	11.1012	**0.5135**	**0.0030**	0.5435	0.8276	0.8569	0.2231
3	0.0047	10.3906	0.8177	-0.0647	0.7331	1.2149	1.2822	0.3271
4	0.0047	16.2995	5.6464	-0.0875	**0.9698**	**3.5934**	3.9619	**0.3751**
5	0.0047	17.1370	7.3001	-0.2365	0.8037	2.2566	2.5290	0.3076
6	0.0040	**7.6627**	1.4267	-0.6669	0.6776	3.4794	**4.0484**	0.2810
7	0.0030	9.6653	3.0142	-0.6592	0.5860	1.0354	1.2481	0.2226
8	0.0044	9.0939	4.6622	-0.5488	0.3276	2.6402	3.1881	0.1505

Table 4 The results of using the benchmark and proposed validity indices on data set D4

K	Dunn	Davies-Bouldin	Xie-Beni	Silhouette	Uncertain Silhouette	OS $r=K$-1 $s=t=3$	OS $r=K$-1 $s=t=5$	DBU
2	**0.0014**	**9.8853**	**0.3661**	**-0.0951**	0.3167	0.7145	0.7428	0.0925
3	**0.0014**	12.7258	2.7792	-0.2487	0.5617	0.7969	0.8287	0.1386
4	**0.0014**	13.7690	8.6632	-0.1519	0.7498	1.3166	1.4702	0.1763
5	**0.0014**	25.3539	59.0531	-0.2910	**0.9695**	**3.9424**	**4.5125**	**0.2690**
6	**0.0014**	21.9844	95.7457	-0.4458	0.8276	3.1977	3.7352	0.2589
7	**0.0014**	21.2677	30.0297	-0.7095	0.3910	0.4021	0.4658	0.0527
8	**0.0014**	19.3778	70.6940	-0.6763	0.6935	1.4867	1.7700	0.1210

The outputs of the eight clustering validity indices on variations of the D2 data set in terms of number of objects, are presented in Fig. 8. The results indicate the poor performance of the certain clustering validity indices for identifying the correct number of clusters for this data set: three. On the other hand, the uncertain clustering validity indices perform well. DBU and uncertain Silhouette are the most consistent indices and the Order Statistics produces reasonable results as well.
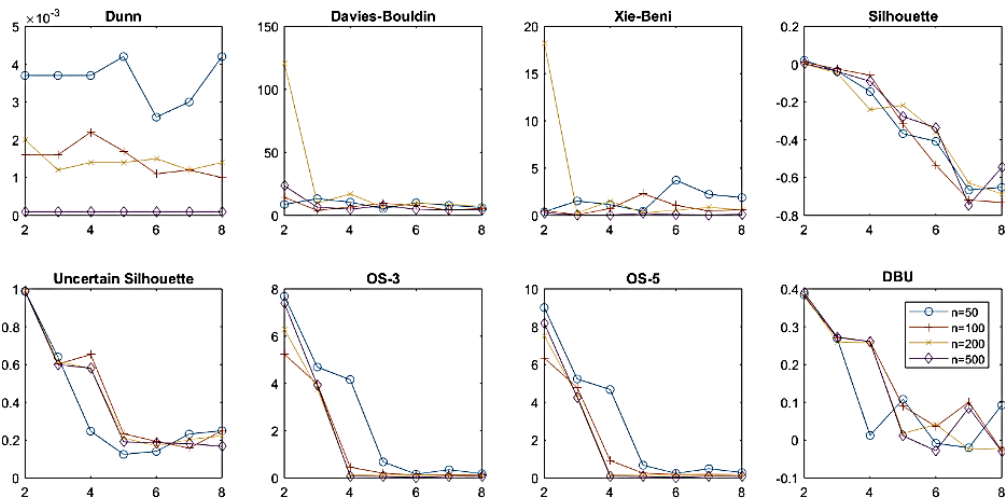
Fig. 6 The outputs of clustering validity indices for different variations of D1 data set in terms of number of objects per cluster: 50, 100, 200, 500
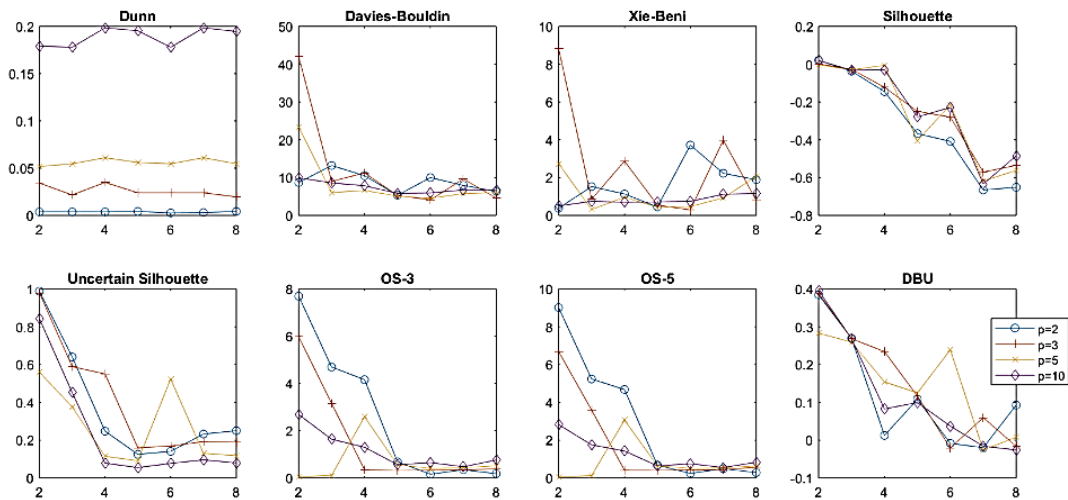
Fig. 7 The outputs of clustering validity indices for different variations of D1 data set in terms of number of dimensions: 2, 3, 5, 10

The outputs of the eight clustering validity indices on variations of the D2 data set in terms of dimension, are presented in Fig. 9. The results suggest the same conclusions as the one for Fig. 8. Again, the certain clustering validity indices perform poorly in identifying three as the correct number of clusters while DBU and uncertain Silhouette consistently perform well, and the Order Statistics index produces reasonable results.
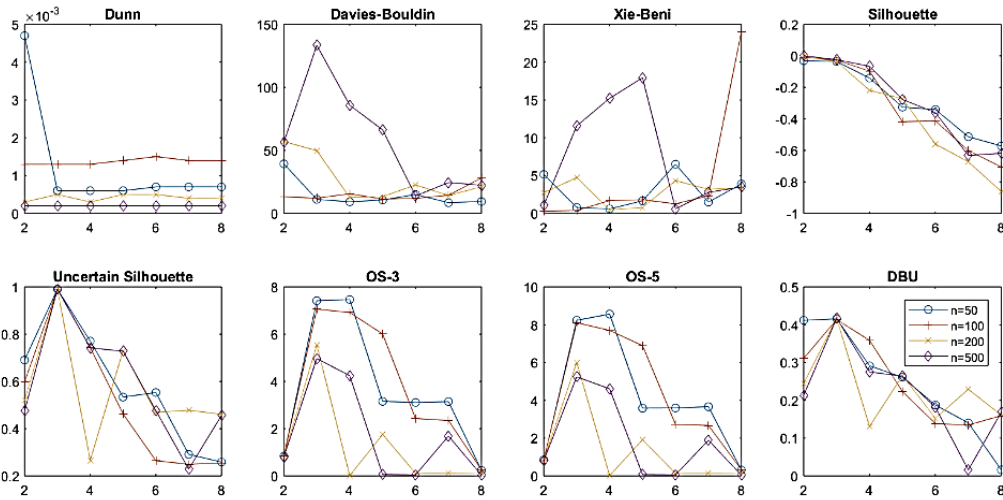
Fig. 8 The outputs of clustering validity indices for different variations of D2 data set in terms of number of objects per cluster: 50, 100, 200, 500
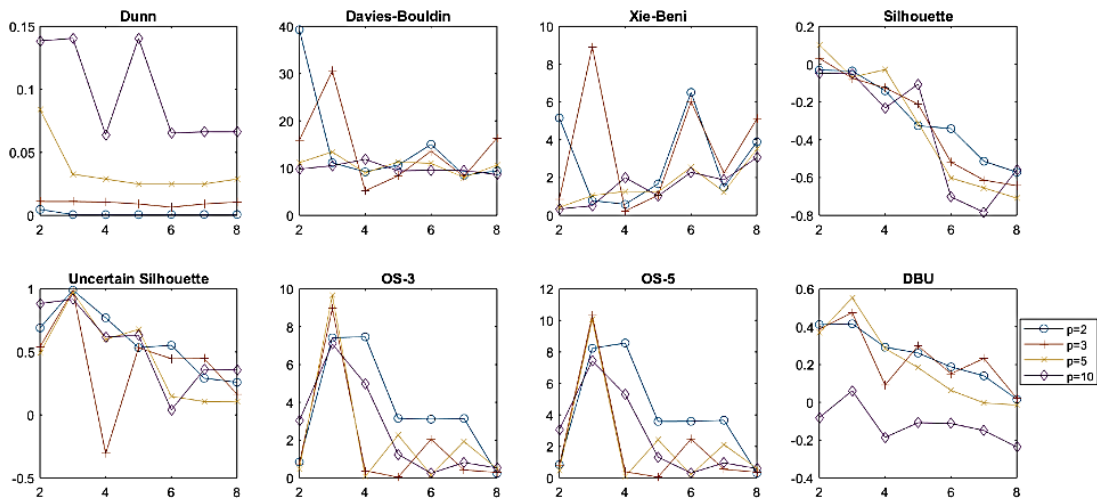
Fig. 9 The outputs of clustering validity indices for different variations of D2 data set in terms of number of dimensions: 2, 3, 5, 10

In Fig. 10, the outputs of the eight clustering validity indices on variations of the D3 data set in terms of number of objects, are presented. As the results suggest, the uncertain clustering validity indices DBU and uncertain Silhouette correctly identify four clusters as the correct number of clusters for variations of the D3 data set. The OS index shows less consistent behavior but still

identifies four as the correct number of clusters for most of the cases. All the certain clustering validity indices perform poorly.

Fig. 11 presents the outputs of the clustering validity indices on variations of the D3 data set in terms of dimension. As the results suggest, only the uncertain validity indices are capable of correctly identifying the correct number of clusters and the certain validity indices fail.
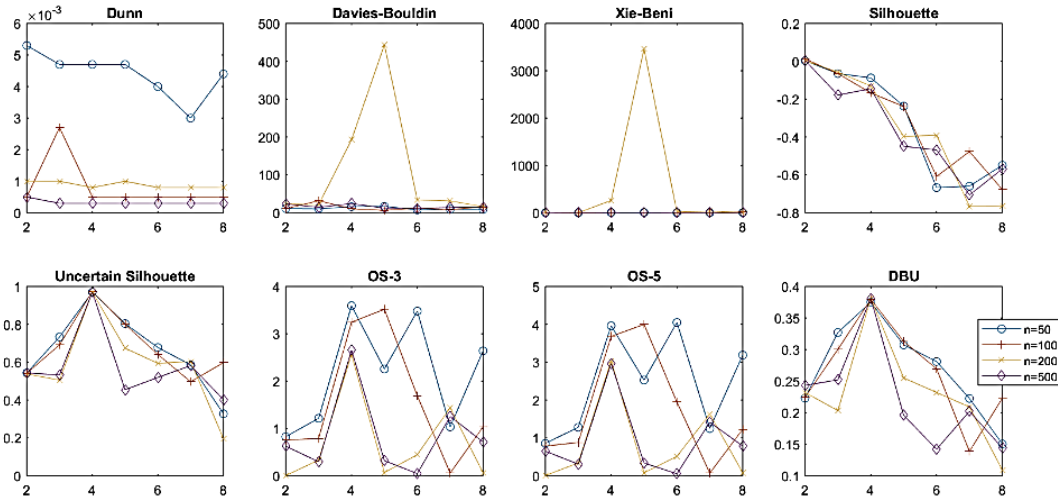
Fig. 10 The outputs of clustering validity indices for different variations of D3 data set in terms of number of objects per cluster: 50, 100, 200, 500
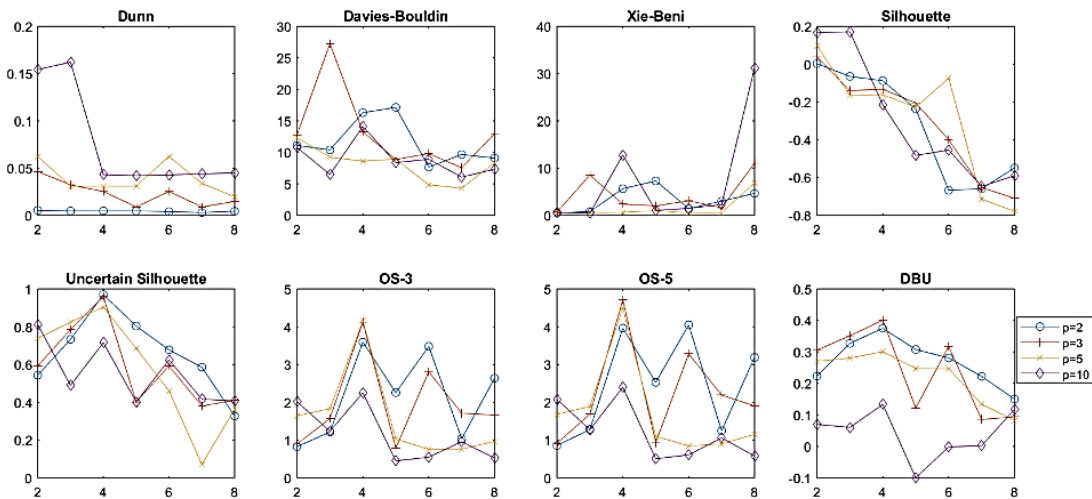
Fig. 11 The outputs of clustering validity indices for different variations of D3 data set in terms of number of dimensions: 2, 3, 5, 10

In Fig. 12, the outputs of the eight clustering validity indices on variations of the D4 data set in terms of number of objects, are presented. As the results suggest, while all the certain validity indices fail in correctly identifying five as the correct number of clusters, all the uncertain clustering validity indices achieve so. The results presented in Fig. 13, suggest the same conclusions as for Fig. 12. For different variations of the D4 data set in terms of number of dimensions, the uncertain validity indices perform well but the certain validity indices perform poorly.
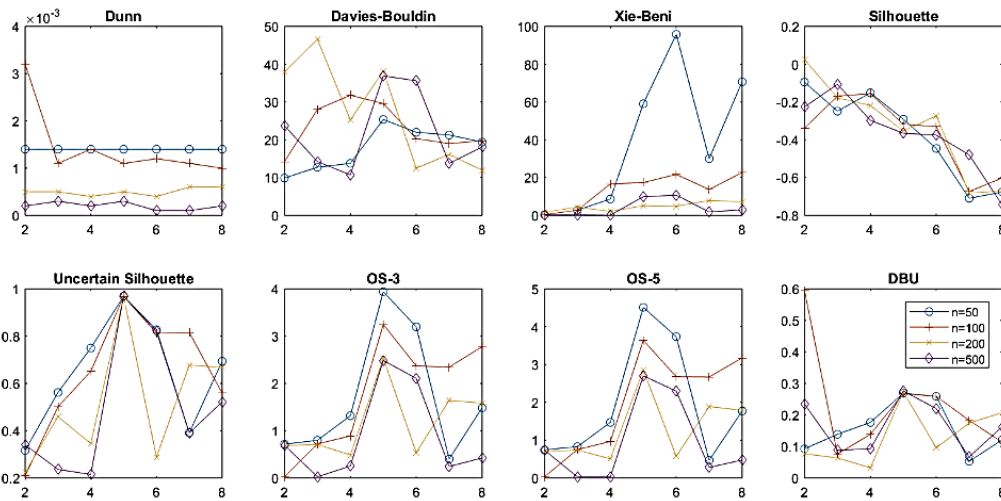
Fig. 12 The outputs of clustering validity indices for different variations of D4 data set in terms of number of objects per cluster: 50, 100, 200, 500
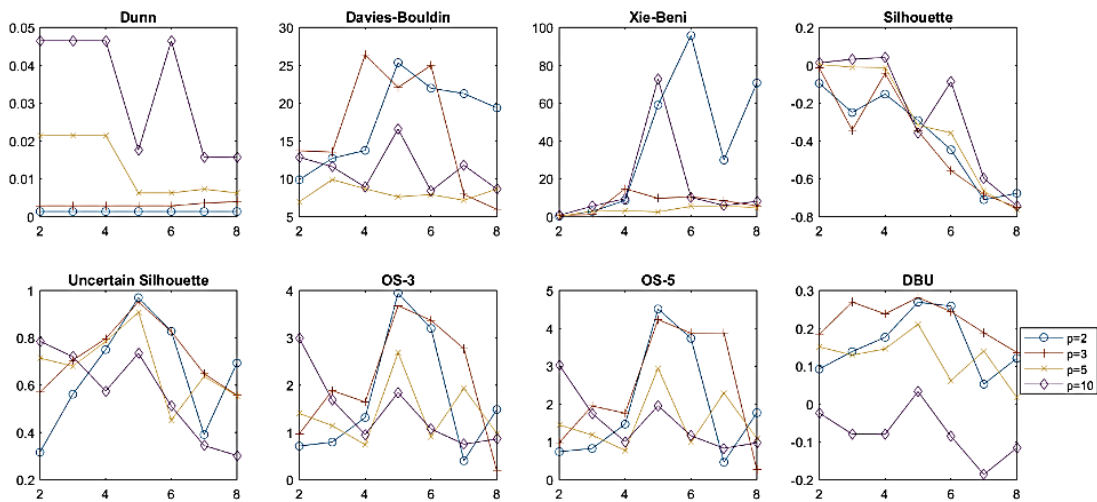
Fig. 13 The outputs of clustering validity indices for different variations of D4 data set in terms of number of dimensions: 2, 3, 5, 10

4.2 Experiments with real data

For further evaluation of the proposed clustering validity index, we compared its performance with those of the eight existing certain and uncertain clustering validity indices on real data as well. The studied real data sets in this were images. Images can be considered as uncertain data by representing the objects within them by samples of points. In our experiments, we considered replicates of four groups of images. An example of images in Group 1 is shown in Fig. 14. As it can be seen, there are two different images in this group, one showing a handwritten letter *X* and the other one showing a handwritten letter *O*. An example of images in Group 2 appears in Fig. 15 where there are three different images showing the three different modes of a traffic light. Examples of images in the Group 3 and Group 4 are presented in Fig. 16 and Fig. 17, respectively. As it can be seen, the images in those two groups are crosswords.

The images in all the four groups were first converted to samples of 100 normalized points between 0 and 1, and then 50 replicates of each sample (or uncertain object) were generated by adding random noise between -0.05 and 0.05 to each dimension of the original images. Doing so, eventually, 100 image replicates (or uncertain objects) were generated for Group 1, 150 image replicates were generated for Group 2, 100 image replicates were generated for Group 3, and 150 image replicates were generated for Group 4. After preparing the data, for each group, clustering was performed with different number of formed clusters and by using the uncertain K-medoids algorithm (Jiang et al. 2013). Fig. 18 to Fig. 21 show the converted groups of images to two-dimensional points. Well-performing clustering validity indices should respectively identify 2, 3, 2, and 3 clusters for Group 1-4.

(a)   (b)

Fig. 14 The first group of images containing handwritten letters *X* and *O*
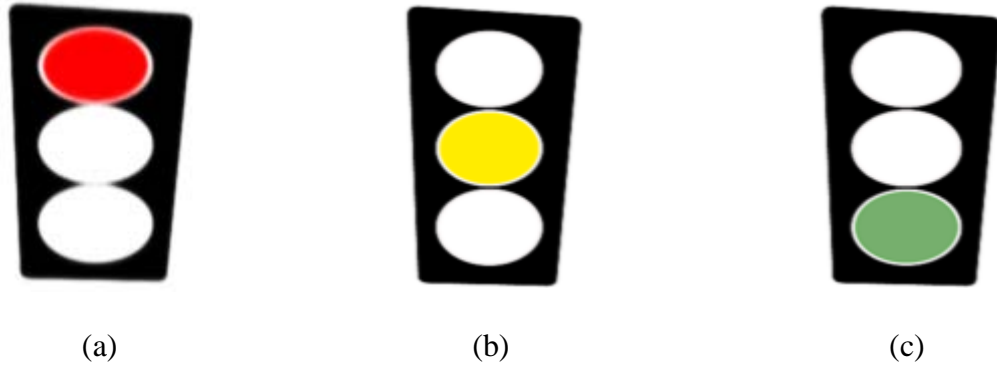
Fig. 15 The second group of images containing the three modes of traffic light a) red, b) yellow, and c) green
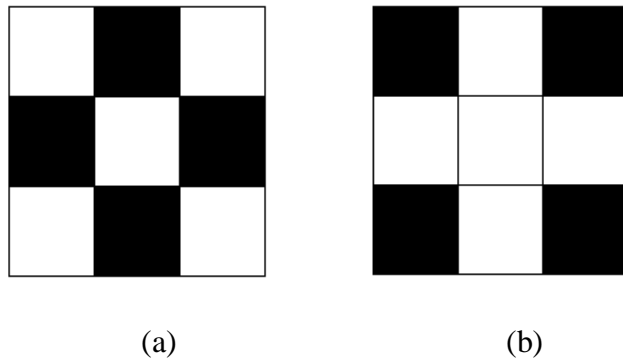
Fig. 16 The third group of images containing two different crosswords
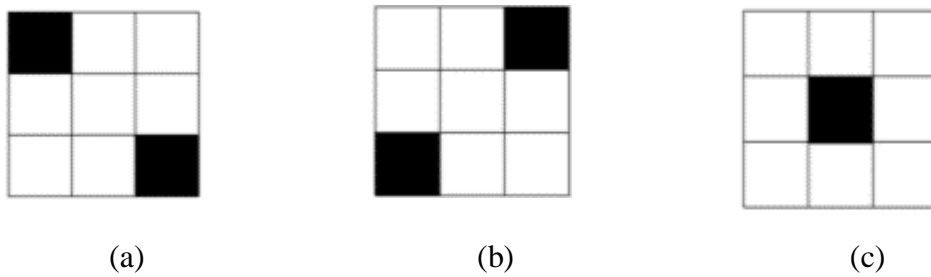
Fig. 17 The third group of images containing three different crosswords
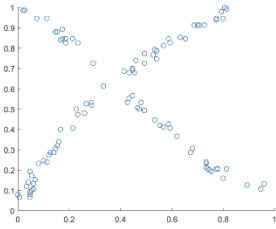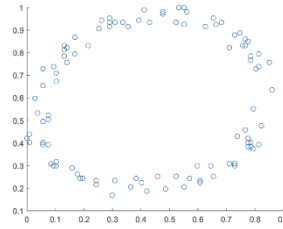
(a)   (b)

Fig. 18 The converted images of the first group to two-dimensional points
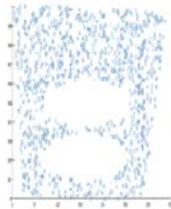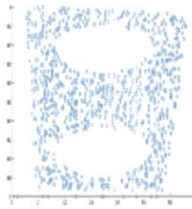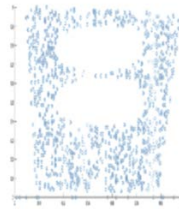
(a)   (b)   (c)

Fig. 19 The converted images of the second group to two-dimensional points
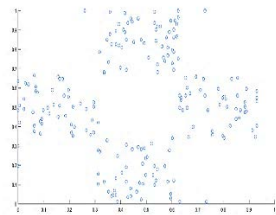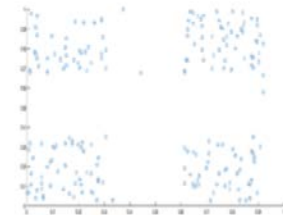
(a)   (b)

Fig. 20 The converted images of the third group to two-dimensional points
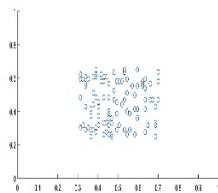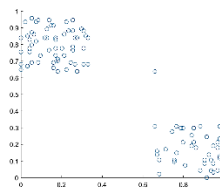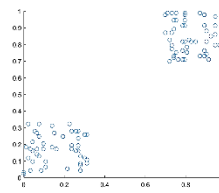
(a)   (b)   (c)

Fig. 21 The converted images of the fourth group to two-dimensional points

The outputs of the eight clustering validity indices on the four groups of images, are presented in Tables 5-8.

Table 5 The outputs of clustering validity indices for Group 1 of images

K	Dunn	Davies-Bouldin	Xie-Beni	Silhouette	Uncertain Silhouette	OS $r=K$-1 $s=t=2$	OS $r=K$-1 $s=t=3$	DBU
2	0.0692	1.2208	0.0212	0.3314	0.9969	49.2978	49.2978	**0.8287**
3	0.0764	1.0575	0.0211	0.5300	0.9985	49.7892	49.7892	0.5686
4	0.0666	**0.0229**	**0.0000**	0.7254	**1.0000**	**5.260E15**	**5.260E15**	0.4669
5	**24.7697**	0.8385	0.0299	0.7170	0.8441	1.0045	1.2247	0.4777
6	0.0473	0.8614	0.0621	**0.9997**	0.8569	1.4265	1.5502	0.4810
7	0.0692	0.7353	0.0380	0.5267	0.8593	2.0384	2.0384	0.4700
8	0.0517	0.8121	0.0455	0.2918	0.8337	2.0676	2.0689	0.4432

Table 6 The outputs of clustering validity indices for Group 2 of images

K	Dunn	Davies-Bouldin	Xie-Beni	Silhouette	Uncertain Silhouette	OS $r=K$-1 $s=t=2$	OS $r=K$-1 $s=t=3$	DBU
2	**30.2859**	**0.0190**	**0.0000**	**0.9998**	0.4714	0.0043	0.0045	0.2450
3	0.0057	3.8284	0.2785	0.1561	**0.9896**	**45.4711**	**50.0756**	**0.2892**
4	0.1999	0.6300	0.0857	0.6997	0.9000	33.5489	36.2320	0.2270
5	0.0044	0.5092	20.6225	0.4133	0.5887	0.0432	0.0442	0.0737
6	0.1748	0.8057	0.1067	0.7107	0.7155	18.4059	21.4590	0.1146
7	0.1999	0.8545	0.1379	0.6444	0.6889	0.0921	0.0971	0.0611
8	0.0081	0.8619	0.3366	0.6017	0.4422	0.0316	0.0321	0.0543

The results of Table 5 suggest that for Group 1, only the proposed DBU index correctly identifies two as the correct number of clusters. It can be seen from Table 6 that for Group 2, all the certain clustering validity indices performs poorly and are unable of identifying three as the correct number of clusters. On the other hand, all the uncertain clustering validity indices perform satisfactorily. For Group 3, the results of Table 7 suggest that again the proposed DBU index is the only index capable of identifying two as the correct number of clusters. Finally, for Group 4,

the results presented in Table 8 show that while all the certain clustering validity indices fail in identifying the correct number of clusters which is three, the proposed DBU index along with the uncertain Silhouette index and the OS index with $s=t=5$, perform well.

Table 7 The outputs of clustering validity indices for Group 3 of images

K	Dunn	Davies-Bouldin	Xie-Beni	Silhouette	Uncertain Silhouette	OS $r=K$-1 $s=t=2$	OS $r=K$-1 $s=t=3$	DBU
2	0.1823	0.5975	0.0447	0.7640	0.9957	90.4804	136.9553	**0.6294**
3	0.3343	0.5151	0.0314	**0.9152**	0.8787	76.8622	103.9180	0.3395
4	0.3147	**0.0945**	0.0852	0.6337	0.8814	**271.6485**	**278.9241**	0.0198
5	**6.1085**	0.8154	0.1754	0.7703	**0.9987**	2.2120	2.6231	0.3595
6	0.2210	1.0533	0.1899	0.6295	0.8821	4.4199	6.8820	0.0002
7	0.1777	1.1873	**0.0005**	0.6098	0.8728	2.3467	2.3676	0.0001
8	0.1503	1.9005	0.2022	0.5663	0.8457	2.0919	2.1810	0.0001

Table 8 The outputs of clustering validity indices for Group 4 of images

K	Dunn	Davies-Bouldin	Xie-Beni	Silhouette	Uncertain Silhouette	OS $r=K$-1 $s=t=2$	OS $r=K$-1 $s=t=3$	DBU
2	**19.958**	**0.0338**	**0.0001**	**0.9913**	0.6992	66.1973	73.7769	0.9726
3	0.3966	0.6549	2.1137	0.8524	**0.9997**	88.7204	**158.3218**	**0.9949**
4	0.2649	0.6730	0.1490	0.8162	0.8674	**95.5621**	98.9241	0.6761
5	0.2665	0.8006	0.1385	0.5020	0.7729	23.3135	32.7289	0.3570
6	0.2517	0.8124	0.1537	0.5001	0.7626	14.3628	16.8820	0.3422
7	0.2443	0.8336	0.1784	0.4884	0.7290	10.0407	12.3676	0.3318
8	0.2380	5.7126	0.1939	0.4806	0.7013	8.6815	12.1810	0.2993

5. Conclusion

In this paper, we proposed a density-based clustering validity index for uncertain data objects. The proposed index can be used to find the best and correct number of clusters of uncertain data objects. To our best knowledge, besides the proposed index, there are only two uncertain clustering validity

indices in the literature, designed to handle uncertain objects given in forms of multiple points or probability density functions.

The results of the experiments with simulated and real data indicate that the new index outperforms the certain clustering validity indices in validating clusters of uncertain data objects. The results also indicate that the new index performs better and more consistent than the two existing clustering validity indices for uncertain data objects. The main reason is that it more accurately captures the shape of clusters by taking into account their densities and hence is more capable of detecting the correct number of clusters of uncertain data objects. The new index also does not require much of parameter tuning, unlike the Order Statistic index.

As the number of existing clustering validity indices for uncertain data objects is less than a handful, it is worth expansive future research to develop further clustering validity indices.

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Evaluating the International Technology Achievement Index (TAI) using the Order Rated Effectiveness Model (ORE)

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Abstract

In order to improve the performance of different units of operation producing a variety of results, decision-makers in public and private organizations often apply a number of different multi-criteria benchmarking techniques when comparing and evaluating performance. In this paper we apply the Data Envelopment Analysis (DEA), the Ordered Weighted Average (OWA), and the newly developed Order Rated Effectiveness (ORE) model, (Klimberg and Ratick 2018, 2020a, 2020b), to the Technology Achievement Index (TAI) data, a Weighted Linear Combination (WLC) composite measure. We then compare and evaluate the original TIA results to those obtained using the DEA, OWA and ORE methods.

Keywords: Technology Achievement Index (TAI), Performance measurement, Benchmarking, Operational Effectiveness, Ordered Weighted Average, Data Envelopment Analysis

1. Introduction:

To provide a range of effective, efficient and fair measures that can yield representative relative rankings for the units that are being compared and evaluated, decision-makers often employ multi-criteria benchmarking techniques such as: The Weighted Linear Combination (WLC), Data Envelopment Analysis (DEA), the Ordered Weighted Average (OWA), and a newly develop technique the Order Rated Effectiveness (ORE) model. These four techniques aggregate contributory measures of efficiency and effectiveness (called here constituent indicators) into a composite index measure. In this paper we apply these techniques to the constituent indicator data that comprises the Technology Achievement Index, a composite indicator measure used by the United Nations Development Programme to measure a country's capacity to participate in technological innovations. (Desai et al, 2002). In section 2, we summarize the four aggregation techniques and give a brief evaluation of their strengths and weaknesses. In section 3 we apply, compare and evaluate

the application of four techniques to the TAI constituent indicator data; and provide a summary and conclusion in section 4.

2. Brief Development of the WLC, DEA, OWA and ORE techniques: (For more in-depth development of these methods see Klimberg and Ratick 2018 and 2020a).

2.1 WLC

A straightforward example aggregating constituent indicators into a composite index is the weighted average or Weighted Linear Combination (WLC) model (equations 1 and 2):

WLC Model

$$(1) \qquad C_j = \sum_{i=1}^{n} W_i V_{ij} \qquad\qquad \forall\, j \in J$$

Subject to:

$$(2) \qquad \sum_{i=1}^{n} W_i = 1$$

Where:

C_j = composite performance index value for evaluation unit (j); DMU(j).

W_i = importance weight assigned to performance measure (i).

V_{ij} = value of performance measure (i) for evaluation unit (j).

n = the number of performance measure contributing to the evaluation.

J = set of evaluation units (DMUs).

The WLC has the advantage that it is easy to implement, and is the aggregation method used in the TIA. While straightforward to apply, the WLC does have the problem that lower values can "average out" higher values in any units being evaluated (for the TIA data, the evaluation "units" are countries)

2.2 The Ordered Weighted Average (OWA)

The notion of averaging out - lower values compensating for high values (or vice versa, depending on whether a high value is considered good or poor) - is termed "trade-off" (Eastman et al 1996, Machado and Ratick, 2018). An aggregation method that addresses this trade-off issue is the Ordered Weighted Average (OWA), which uses "order weights," that are assigned based on the relative rank of the constituent measures in the composite index within each evaluation unit (Decision Making Units DMUs).

Equations 3 and 4 below present the mathematical formulation for generating the OWA composite performance index (adapted from Ratick and Osleeb 2013, Klimberg and Ratick 2018, 2020a):

The Ordered Weighted Average (OWA) Model

$$(3) \quad OC_j = \sum_{i=1}^{n} W_{k(i)} \ V_{k(i)j} \qquad \forall \ j \in J$$

$$(4) \qquad \sum_{i=1}^{n} W_{k(i)} = 1$$

Where:

OC_j = composite performance OWA index value for evaluation unit (j); DMU(j).

$V_{k(i)j}$ = value of constituent performance measure (i) with order k for DMU (j).

n = the number of constituent performance measures contributing to the evaluation.

$k_{(i)}$ = the order k for the constituent performance measure in the ith rank .

$W_{k(i)}$ = the order weight for the constituent performance measure in the ith rank with order k.

Yager (1988) introduced the concept of OWA as a family of mean aggregation operators for multi-criteria evaluation. Since its development, OWA has been widely applied in many fields including: business analytics, artificial intelligence, social network analysis, land use suitability assessment, environmental management and engineering, and vulnerability assessments, among others (see Yager and Kacprzyk 1997; Jiang and Eastman

2000; Smith 2001; Yager et al. 2011, and Machado and Ratick 2018, for overviews and examples).

The relative distribution of the order weights among the constituent performance measures determines the trade-off, which increases as the weights are more evenly distributed, and decreases with weights that are less evenly distributed. The degree of skew of those order weights towards the AND or the OR fuzzy set operators determines the "decision strategy," the relative importance to performance evaluation of high or low constituent indicator measures within an evaluation unit (DMU) (Yager 1988; Eastman 1999; Malczewski 1999; Rinner and Malczewski 2002; Majdan and Ogryczak 2012, Machado and Ratick 2018). The degree of trade-off is specified by a measure called ORness that ranges from 0 to 1. When ORness is 0, all the weight is given to the lowest ranking (has the lowest value) constituent indicator, when ORness is 1, all the weight is given to the highest ranking (has the largest value) indicator, and when ORness is 0.5 the OWA is similar to the WLC, the weights are evenly distributed among the constituent indicators. There are different sets of order weights that may produce the same ORness levels for a given set of indicators, for the application in this paper we utilized maximum entropy weighting, obtained from a non-linear optimization, that gives each constituent indicator the highest possible weight, based upon its relative ranking among the constituent indicators for that decision making unit, assuring that the pattern of weights corresponds to the chosen level of ORness. (See Runfola et al 2017, Machado and Ratick 2018, and Klimberg and Ratick 2018, 2020a for more detail on the OWA and maximum entropy weighting).

2.3 Data Envelopment Analysis

Data Envelopment Analysis (DEA) was developed to address the problem of determining the efficiency of comparable units, called decision making units (DMUs), which utilize similar multiple inputs and outputs (Charnes et al 1978). DEA takes into account these multiple inputs and outputs to produce a single aggregate measure of the relative efficiency of each comparable unit and defining technical efficiency as the efficient utilization of resources; i.e., getting the most output from a given set of inputs. Traditional

DEA applications calculate the efficiency score for a DMU_r, E_r, as the ratio of weighted outputs to weighted inputs:

$$E_r = \text{Efficiency of DMU}_r = \frac{\text{Weighted Sum of Outputs}_r}{\text{Weighted Sum of Inputs}_r}$$

where a score of 1 (or 100%) represents the benchmark of efficiency (Klimberg 1998; Klimberg et al 2001; Bosetti and Buchner 2009; Cherchye et al 2014, Cooper et al 2006, Shimshak et al 2009, Emrouznejad and Yang, 2018).

DEA utilizes linear programming optimization to produce measures of the relative efficiency of DMUs employing multiple inputs and multiple outputs. The original DEA CCR formulation (Charnes et al 1978) is:

Original CCR DEA model

$$(5) \qquad MAX \ E_r \ = \sum_{i=1}^{n} W_i M_{ir}$$

Subject to:

$$(6) \qquad \sum_{s=1}^{S} V_s I_{sr} \ = 1$$

$$(7) \qquad \sum_{i=1}^{n} W_i M_{ij} \ - \sum_{s=1}^{S} V_s I_{sj} \ \leq 0 \qquad \forall j$$

$$(8) \qquad W_i, \ V_s \ \geq \ \varepsilon \qquad \forall i, s$$

Where:

$s = 1, \ldots, S$ Inputs used by DMU

$i = 1, \ldots, n$ Outputs produced at DMU

$j = 1, \ldots, r, \ldots, J$ DMUs

E_r = efficiency of DMU r

M_{jj} = amount of the ith output for the DMU j

I_{kj} = amount of the kth input for the DMU j

ε = is a very small value

W_i = the weight assigned to the ith output;

V_k = the weight assigned to the kth input.

In our performance evaluation application, the sum of the inputs is set to 1 for all evaluation units to simplify the example and facilitate the exposition. The outputs are the different scaled constituent performance measures. The model to implement DEA considering only outputs is a modification of the Original CCR DEA model:

Outputs only DEA

(9) $MAX\ E_r\ = \displaystyle\sum_{i=1}^{n} W_i M_{ir}$

st.

(10) $\displaystyle\sum_{i=1}^{n} W_i M_{ij}\ \leq\ 1 \qquad \forall j$

(11) $W_i,\ V_k\ \geq\ \varepsilon \quad \forall i,k$

Where:

E_r = the composite DEA performance index (DEA score) for the DMU (r) under consideration.

W_i = the weight obtained for constituent performance measure (i) in DMU (r).

M_{ij} = the output value of constituent measure i in DMU (***j***).

This use of the Outputs only DEA model to aggregate constituent performance measures into a composite performance measure (Clark et al 1998) has also been called the Benefit of the Doubt (BOD) model (Cherchye, et al 2007, Karagiannis and Karagiannis, 2018, OECD 2008). The Outputs only DEA (BOD) model is a function similar to the WLC, but derives the weights in that function objectively (endogenously) through the solution of a series of optimization models.

2.4 The Order Rated Effectiveness Model

Varying ORness levels in the OWA method measures the operational effectiveness of DMUs under these different decision strategies. To operationalize the concept that DMUs may employ different decision strategies, we developed a new approach for comparative assessments: the Order Rated Effectiveness (ORE) model (Klimberg and Ratick 2018, 2020a, 2020b). The ORE model utilizes the ranks from applying different OWA ORness level assessments as its output measure within an Outputs only DEA (BOD) type optimization formulation. To implement the ORE model:

1. Create the OWA scores by varing ORness levels from 0.5 to 1, incrementing by 10% as we did in Table 10 (or any other range of ORness levels feasible to the application).

2. Rate the resultant OWA scores for each ORness level as shown in Table 13. Because these values will be used to optimize effectiveness in the Outputs only DEA (BOD) model structure, the highest valued performance measure should equal the number of DMUs, in our example they are standardized to a rank of 30, lower values will have lower numbered ranks.

3. Apply the Outputs only DEA (BOD) type model structure to the rank data (as "Outputs" from step 2, see Table 13 below) within the Order Rated Effectiveness (ORE) model (equations 18, 19 and 20):

Order Rated Effectiveness (ORE) model

(12) $$MAX \ EF_r \ = \sum_{i\,=\,1}^{n} W_i R_{ir}$$

st.

(13) $$\sum_{i\,=\,1}^{n} W_i R_{ij} \ \leq \ 1 \qquad \forall j$$

(14) $$W_i, \ \geq \ \varepsilon \quad \forall i$$

Where:

EF_r = the composite ORE effectiveness performance index value for DMU (r).

W_i = the ORE weight obtained for ORness level i.

R_{ij} = is the rated value (here rank) of DMU j resulting from applying OWA with ORness level i.

3. Application of the WLC, DEA, OWA and ORE techniques to the Technology Achievement Index (TAI).

To further evaluate the efficacy of the ORE model methodology we applied it, and the Original DEA, to data from the Technology Achievement Index (TAI). TAI is a composite indicator measure used by the United Nations Development Programme to measure a country's capacity to participate in technological innovations. (Desai et al, 2002). The TAI composite performance index uses eight standardized constituent performance indices (Tables 1 and 2) and combines them using the WLC.

The TAI dataset has eight constituent indicators, with the 8 variables and TAI index for the top 41 countries based on data from 1997 to 2000 is listed in Table 1 below. There are several blank cells for Patents and Royalties. For these empty cells in calculating the TAI index, zeroes were used. In our analysis we also assigned zeroes.

#	Country	Patents	Royalties	Internet	Exports	Telephones (log)	Electricity (log)	Schooling	University	TAI
1	Finland	187	125.6	200.2	50.7	3.08	4.15	10	27.4	0.744
2	United States	289	130	179.1	66.2	3	4.07	12	13.9	0.733
3	Sweden	271	156.6	125.8	59.7	3.1	4.14	11.4	15.3	0.703
4	Japan	994	64.6	49	80.8	3	3.86	9.5	10	0.698
5	Korea	779	9.8	4.8	66.7	2.97	3.65	10.8	23.2	0.666
6	Netherlands	189	151.2	136	50.9	3.02	3.77	9.4	9.5	0.63
7	United Kingdom	82	134	57.4	61.9	3.02	3.73	9.4	14.9	0.606
8	Canada	31	38.6	108	48.7	2.94	4.18	11.6	14.2	0.591
9	Australia	75	18.2	125.9	16.2	2.94	3.94	10.9	25.3	0.589
10	Singapore	8	25.5	72.3	74.9	2.95	3.83	7.1	24.2	0.587
11	Germany	235	36.8	41.2	64.2	2.94	3.75	10.2	14.4	0.583
12	Norway	103	20.2	193.6	19	3.12	4.39	11.9	11.2	0.579
13	Ireland	106	110.3	48.6	53.6	2.97	3.68	9.4	12.3	0.566
14	Belgium	72	73.9	58.9	47.6	2.91	3.86	9.3	13.6	0.5533
15	New Zealand	103	13	146.7	15.4	2.86	3.91	11.7	13.1	0.548
16	Austria	165	14.8	84.2	50.3	2.99	3.79	8.4	13.6	0.544
17	France	205	33.6	36.4	58.9	2.97	3.8	7.9	12.6	0.535
18	Israel	74	43.6	43.2	45	2.96	3.74	9.6	11	0.514
19	Spain	42	8.6	21	53.4	2.86	3.62	7.3	15.6	0.481
20	Italy	13	9.8	30.4	51	3	3.65	7.2	13	0.471
21	Czech Republic	28	4.2	25	51.7	2.75	3.68	9.5	8.2	0.465
22	Hungary	26	6.2	21.6	63.5	2.73	3.46	9.1	7.7	0.464
23	Slovenia	105	4	20.3	49.5	2.84	3.71	7.1	10.6	0.458
24	Hong Kong	6		33.6	33.6	3.08	3.72	9.4	9.8	0.455
25	Slovakia	24	2.7	10.2	48.7	2.68	3.59	9.3	9.5	0.447
26	Greece			16.4	17.9	2.92	3.57	8.7	17.2	0.437
27	Portugal	6	2.7	17.7	40.7	2.95	3.53	5.9	12	0.419
28	Bulgaria	23		3.7	30	2.6	3.5	9.5	10.3	0.411
29	Poland	30	0.6	11.4	36.2	2.56	3.39	9.8	6.6	0.407
30	Malaysia			2.4	67.4	2.53	3.41	6.8	3.3	0.396
31	Croatia	9		6.7	41.7	2.63	3.39	6.3	10.6	0.391
32	Mexico	1	0.4	9.2	66.3	2.28	3.18	7.2	5	0.389
33	Cyprus			16.9	23	2.87	3.54	9.2	4	0.386
34	Argentina	8	0.5	8.7	19	2.51	3.28	8.8	12	0.381
35	Romania	71	0.2	2.7	25.3	2.36	3.21	9.5	7.2	0.371
36	Costa Rica		0.3	4.1	52.6	2.38	3.16	6.1	5.7	0.358
37	Chile		6.6	6.2	6.1	2.55	3.32	7.6	13.2	0.357
38	Uruguay	2		19.6	13.3	2.56	3.25	7.6	7.3	0.343
39	South Africa		1.7	8.4	30.2	2.43	3.58	6.1	3.4	0.34
40	Thailand	1	0.3	1.6	48.9	2.09	3.13	6.5	4.6	0.337
41	Trinidad/Tobago			7.7	14.2	2.39	3.54	7.8	3.3	0.328

Table 1: the TAI dataset

- **Patents:** # of patents granted to residents (per million people)

- **Royalties:** # of receipts of royalty and license fees (US$ per 1,000 people)

- **Internet:** # of Internet hosts (per 1,000 people)

- **Exports:**

- **Telephones (log):** log of the # of telephones (mainlines and cellular, per 1,000 people)

- **Electricity (log):** log of electricity consumption (kilowatt-hours per captia)

- **Schooling:** Mean years of schooling (age 15 and above)

- **University:** Gross tertiary science enrollment ratio (%)

We standardized all 8 performance measures to be within the range of 0 to 1 by dividing their original values by the maximum for each performance measure in all the 41 countries (Table 2).

#	Country	Patents	Royalties	Internet	Exports	Telephones (log)	Electricity (log)	Schooling	University
1	Finland	0.188	0.802	1.000	0.627	0.987	0.945	0.833	1.000
2	United States	0.291	0.830	0.895	0.819	0.962	0.927	1.000	0.507
3	Sweden	0.273	1.000	0.628	0.739	0.994	0.943	0.950	0.558
4	Japan	1.000	0.413	0.245	1.000	0.962	0.879	0.792	0.365
5	Korea	0.784	0.063	0.024	0.825	0.952	0.831	0.900	0.847
6	Netherlands	0.190	0.966	0.679	0.630	0.968	0.859	0.783	0.347
7	United Kingdom	0.082	0.856	0.287	0.766	0.968	0.850	0.783	0.544
8	Canada	0.031	0.246	0.539	0.603	0.942	0.952	0.967	0.518
9	Australia	0.075	0.116	0.629	0.200	0.942	0.897	0.908	0.923
10	Singapore	0.008	0.163	0.361	0.927	0.946	0.872	0.592	0.883
11	Germany	0.236	0.235	0.206	0.795	0.942	0.854	0.850	0.526
12	Norway	0.104	0.129	0.967	0.235	1.000	1.000	0.992	0.409
13	Ireland	0.107	0.704	0.243	0.663	0.952	0.838	0.783	0.449
14	Belgium	0.072	0.472	0.294	0.589	0.933	0.879	0.775	0.496
15	New Zealand	0.104	0.083	0.733	0.191	0.917	0.891	0.975	0.478
16	Austria	0.166	0.095	0.421	0.623	0.958	0.863	0.700	0.496
17	France	0.206	0.215	0.182	0.729	0.952	0.866	0.658	0.460
18	Israel	0.074	0.278	0.216	0.557	0.949	0.852	0.800	0.401
19	Spain	0.042	0.055	0.105	0.661	0.917	0.825	0.608	0.569
20	Italy	0.013	0.063	0.152	0.631	0.962	0.831	0.600	0.474
21	Czech Republic	0.028	0.027	0.125	0.640	0.881	0.838	0.792	0.299
22	Hungary	0.026	0.040	0.108	0.786	0.875	0.788	0.758	0.281
23	Slovenia	0.106	0.026	0.101	0.613	0.910	0.845	0.592	0.387
24	Hong Kong	0.006	0.000	0.168	0.416	0.987	0.847	0.783	0.358
25	Slovakia	0.024	0.017	0.051	0.603	0.859	0.818	0.775	0.347
26	Greece	0.000	0.000	0.082	0.222	0.936	0.813	0.725	0.628
27	Portugal	0.006	0.017	0.088	0.504	0.946	0.804	0.492	0.438
28	Bulgaria	0.023	0.000	0.018	0.371	0.833	0.797	0.792	0.376
29	Poland	0.030	0.004	0.057	0.448	0.821	0.772	0.817	0.241
30	Malaysia	0.000	0.000	0.012	0.834	0.811	0.777	0.567	0.120
31	Croatia	0.009	0.000	0.033	0.516	0.843	0.772	0.525	0.387
32	Mexico	0.001	0.003	0.046	0.821	0.731	0.724	0.600	0.182
33	Cyprus	0.000	0.000	0.084	0.285	0.920	0.806	0.767	0.146
34	Argentina	0.008	0.003	0.043	0.235	0.804	0.747	0.733	0.438
35	Romania	0.071	0.001	0.013	0.313	0.756	0.731	0.792	0.263
36	Costa Rica	0.000	0.002	0.020	0.651	0.763	0.720	0.508	0.208
37	Chile	0.000	0.042	0.031	0.075	0.817	0.756	0.633	0.482
38	Uruguay	0.002	0.000	0.098	0.165	0.821	0.740	0.633	0.266
39	South Africa	0.000	0.011	0.042	0.374	0.779	0.815	0.508	0.124
40	Thailand	0.001	0.002	0.008	0.605	0.670	0.713	0.542	0.168
41	Trinidad/Tobago	0.000	0.000	0.038	0.176	0.766	0.806	0.650	0.120

Table 2: the Standardized TAI dataset

Using the three steps to create the ORE composite performance index values described above: (1) OWA scores for ORness levels from 0.5 to 1, incrementing by 10%

were generated; (2) The OWA scores for each ORness level are assigned ranks (Table 3) (the higher values are given a larger rank, i.e. the largest OWA composite index value is assigned a rank of 41, next highest 40 and so on, since we are maximizing); (3) The ORE model is applied to the rank data in Table 3.

Country	Rank at Different Orness Levels					
#	0.5	0.6	0.7	0.8	0.9	1
1	41	41	41	41	41	41
2	40	40	40	39	37	41
3	39	39	39	40	40	41
4	38	38	38	38	39	41
5	36	36	35	35	31	29
6	37	37	37	36	36	34
7	35	35	34	31	30	34
8	33	33	32	34	35	32
9	30	31	31	33	33	23
10	32	32	33	32	32	25
11	29	29	28	29	29	23
12	34	34	36	37	38	41
13	31	30	29	28	27	29
14	28	27	27	27	23	20
15	27	28	30	30	34	35
16	26	26	26	26	26	30
17	25	25	25	25	25	29
18	24	24	24	24	24	26
19	23	23	21	21	20	18
20	22	22	22	22	22	31
21	20	20	20	20	18	16
22	21	21	19	18	15	15
23	19	18	17	17	19	17
24	18	19	23	23	28	36
25	17	17	16	16	14	14
26	16	16	18	19	21	21
27	15	15	15	15	17	25
28	14	14	14	12	12	11
29	13	13	12	11	11	9
30	12	12	13	13	13	12
31	10	9	9	9	10	13
32	11	11	10	10	9	10
33	8	10	11	14	16	19
34	9	8	8	8	8	4
35	7	7	7	6	6	3
36	6	5	5	4	2	2
37	5	6	6	7	7	7
38	4	4	4	5	5	9
39	2	3	3	3	4	6
40	3	2	1	1	1	1
41	1	1	2	2	3	5

Table 3 – Ranks of OWA scores at different ORness levels.

The ORE model results are shown in Table 4. Columns W(0.5) through W(1.0) show the ORE weights that were assigned to the 6 OWA ORness levels in the ORE optimization. Five of the countries do best under the decision to optimize the average of all 8 constituent indicators (ORness 0.5); 17 countries do best when optimizing one of the 8 constituent indicators (ORness 1.0); and the others (19) are best evaluated under the decision strategies corresponding to ORness levels of 0.6 to 0.9.

| DMU | Weights assigned to Orness level (0.5 to 1) | | | | | | ORE_score |
	W(0.5)	W(0.6)	W(0.7)	W(0.8)	W(0.9)	W(1.0)	
1	0.00001	0.024340244	0.00001	0.00001	0.00001	0.00001	1.000
2	0.00001	0.00001	0.00001	0.00001	0.00001	0.024340244	1.000
3	0.00001	0.00001	0.00001	0.00001	0.00001	0.024340244	1.000
4	0.00001	0.00001	0.00001	0.00001	0.00001	0.024340244	1.000
5	0.00001	0.024340244	0.00001	0.00001	0.00001	0.00001	0.878
6	0.00001	0.024340244	0.00001	0.00001	0.00001	0.00001	0.902
7	0.00001	0.024340244	0.00001	0.00001	0.00001	0.00001	0.854
8	0.00001	0.00001	0.00001	0.00001	0.024340244	0.00001	0.854
9	0.00001	0.00001	0.00001	0.00001	0.024340244	0.00001	0.805
10	0.00001	0.00001	0.024340244	0.00001	0.00001	0.00001	0.805
11	0.00001	0.00001	0.00001	0.024340244	0.00001	0.00001	0.707
12	0.00001	0.00001	0.00001	0.00001	0.00001	0.024340244	1.000
13	0.024340244	0.00001	0.00001	0.00001	0.00001	0.00001	0.756
14	0.024340244	0.00001	0.00001	0.00001	0.00001	0.00001	0.683
15	0.00001	0.00001	0.00001	0.00001	0.00001	0.024340244	0.853
16	0.00001	0.00001	0.00001	0.00001	0.00001	0.024340244	0.732
17	0.00001	0.00001	0.00001	0.00001	0.00001	0.024340244	0.707
18	0.00001	0.00001	0.00001	0.00001	0.00001	0.024340244	0.634
19	0.00001	0.024340244	0.00001	0.00001	0.00001	0.00001	0.561
20	0.00001	0.00001	0.00001	0.00001	0.00001	0.024340244	0.756
21	0.00001	0.00001	0.024340244	0.00001	0.00001	0.00001	0.488
22	0.00001	0.024340244	0.00001	0.00001	0.00001	0.00001	0.512
23	0.00001	0.00001	0.00001	0.00001	0.024340244	0.00001	0.463
24	0.00001	0.00001	0.00001	0.00001	0.00001	0.024340244	0.877
25	0.00001	0.024340244	0.00001	0.00001	0.00001	0.00001	0.415
26	0.00001	0.00001	0.00001	0.00001	0.00001	0.024340244	0.512
27	0.00001	0.00001	0.00001	0.00001	0.00001	0.024340244	0.609
28	0.00001	0.024340244	0.00001	0.00001	0.00001	0.00001	0.341
29	0.00001	0.024340244	0.00001	0.00001	0.00001	0.00001	0.317
30	0.00001	0.00001	0.00001	0.024340244	0.00001	0.00001	0.317
31	0.00001	0.00001	0.00001	0.00001	0.00001	0.024340244	0.317
32	0.00001	0.024340244	0.00001	0.00001	0.00001	0.00001	0.268
33	0.00001	0.00001	0.00001	0.00001	0.00001	0.024340244	0.463
34	0.024340244	0.00001	0.00001	0.00001	0.00001	0.00001	0.219
35	0.00001	0.024340244	0.00001	0.00001	0.00001	0.00001	0.171
36	0.024340244	0.00001	0.00001	0.00001	0.00001	0.00001	0.146
37	0.00001	0.00001	0.00001	0.00001	0.024340244	0.00001	0.171
38	0.00001	0.00001	0.00001	0.00001	0.00001	0.024340244	0.219
39	0.00001	0.00001	0.00001	0.00001	0.00001	0.024340244	0.146
40	0.024340244	0.00001	0.00001	0.00001	0.00001	0.00001	0.073
41	0.00001	0.00001	0.00001	0.00001	0.00001	0.024340244	0.122

Table 4 –ORE model results including scores and weights.

We graphed the composite Original DEA using raw data performance scores against those obtained with the ORE model in Figure 1. Most of the Original DEA with raw scores values are above the ORE=DEA 45^0 line showing equal values. There are 5 countries with both DEA raw and ORE scores of 1, otherwise, for the rest of the countries, the ORE model performance scores are less than the DEA raw scores. These differences allow for a greater degree of differentiation of Countries in evaluating performance.
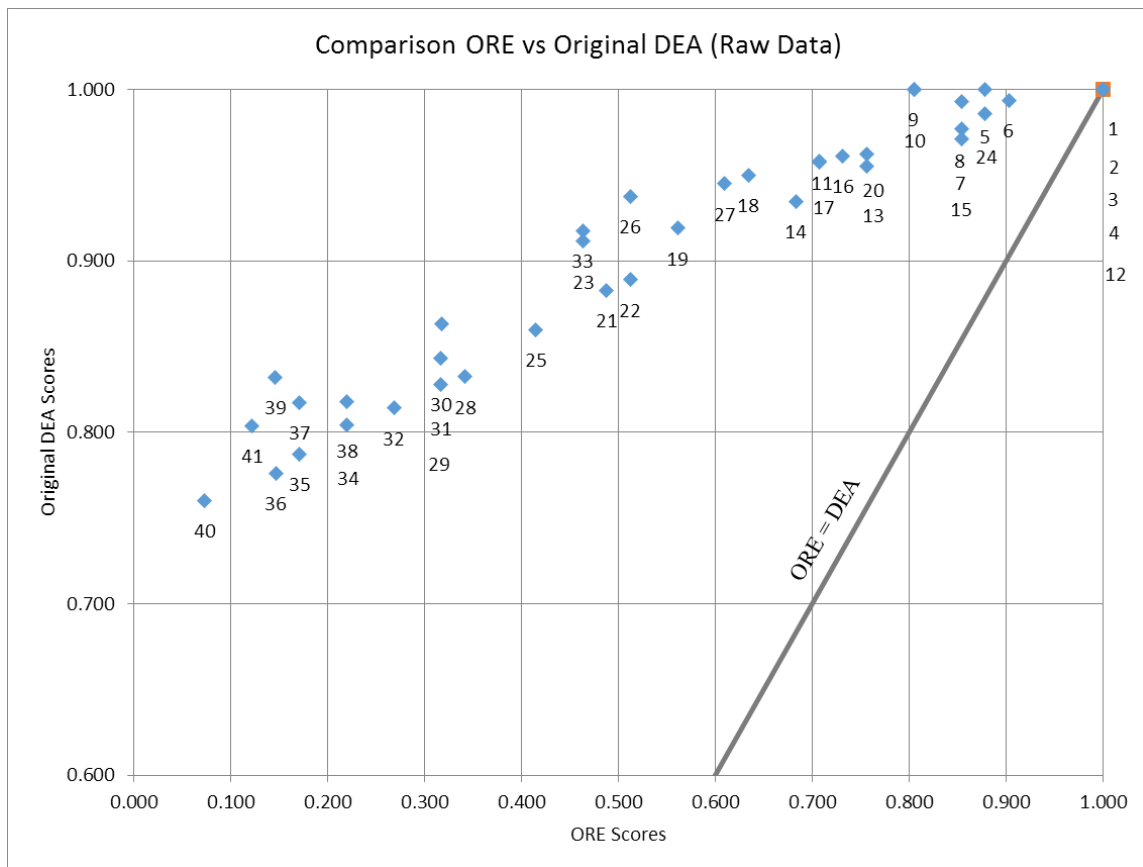
Figure 1 – Shift in performance scores from the Original DEA model to the ORE model.

Countries with a TAI index greater than 0.5 are considered to be Leaders (Desai et al, 2002). Table 5 provides summary statistics for these 18 countries with TAI > 0.5 and for all 41 countries by each of the four measures: TAI, ORE ranks, DEA using the raw data (DEA_raw) and DEA using ranks (DEA_ranks). The DEA_raw scores are not very discriminating having the lowest standard deviation. The DEA_ranks standard deviation is next highest, about twice that for the DEA_raw scores. The ORE_ranks are the most dispersed, 1.5 to 2 times more dispersed than the DEA_ranks.

	Top 18 Countries considered Leaders			
	TAI	ORE ranks	DEA_raw	DEA_ranks
min	0.514	0.634	0.935	0.818
max	0.744	1.000	1.000	1.000
average	0.609	0.843	0.981	0.961
median	0.588	0.853	0.993	1.000
stdev	0.070	0.123	0.022	0.058
	All 41 Countries			
	TAI	ORE ranks	DEA_raw	DEA_ranks
min	0.328	0.073	0.760	0.366
max	0.744	1.000	1.000	1.000
average	0.494	0.577	0.913	0.811
median	0.465	0.609	0.937	0.886
stdev	0.118	0.295	0.078	0.194

Table 5 –Summarized results

Figure 2 shows the results from the Original DEA model using the raw data (DEA_raw), the Original DEA using ranks (DEAranks), ORE model results and the TAI index. As we previously observed the ORE model tends to better distinguish performance among the countries. The ORE methodology seems to provide an equitable representation of the different decision strategies in the construction of the composite performance index scores.
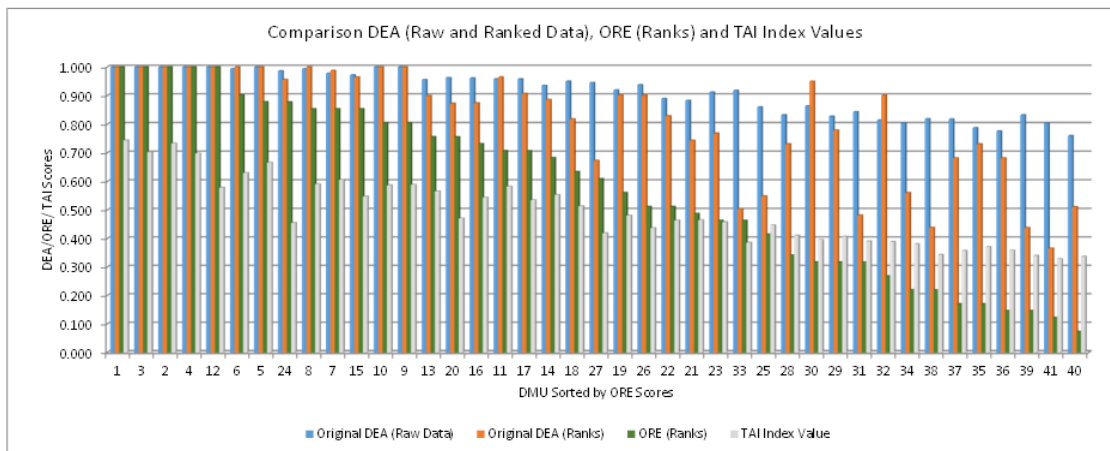
Figure 2 – Comparison of performance scores Original DEA (BOD) model using the raw data, DEA (BOD) model using ranks, and the ORE model.

4. Conclusions

The use of three traditional benchmarking techniques (WLC, OWA, and DEA) provided a wide range of overall relative performance for some of the countries evaluated in the TAI. The most utilized method for assessing performance, the WLC, the method used in the TAI, allows for low values of constituent performance measures to average out larger values. DEA used on the original scaled TAI constituent performance measures, provided the highest "benchmark" values for each country evaluated: the range of relative performance values, however, was the smallest over all techniques, making it difficult to distinguish the best from the rest. Use of OWA provided a range of TAI country rankings that included the original TAI results (ORness level of 0.5), along with that of the DEA (when applying the additional DEA constraint that the weights sum to one). These OWA results demonstrate the sensitivity of the overall ranking of countries evaluated in the TAI the choice of decision strategy, and to the choice of technique for aggregating the constituent performance measures into the composite performance measure. The ORE model aggregated those OWA results into a single composite measure that, we believe, provides a comprehensive, effective, efficient and fair assessment of each of the countries relative abilities to participate in technological innovations.

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Linkage Between Services Trade Liberalization and Country Development Level with Data Mining Techniques

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1.INTRODUCTION

The services sector has increased in importance as a result of rapid changes in science, technology, transportation, communication and production structures, while the relationship between industry and services has also been strengthened. World exports of commercial services have increased by 46 per cent in value terms since 2008 and services exports grew by an average annual rate of 3.9 per cent. The USA was established to be the biggest exporter of services, with a share of 14 per cent in world services exports and 9.8 per cent in imports, totalling US$ 808.2 billion in exports and US$ 536.2 billion in imports. It is, followed by China (205 billion dollars, 4.4 % share), the UK (293 billion dollars, 6.3% share), Germany (286 billion dollars, 6.2% share), France (236 billion dollars, 5.1% share) (WTO, 2018).

It is obvious that there are several ways for services to help grow economy by providing direct inputs to the manufacturing process, facilitating the flow of intermediate products between different stages of production via more internationalized transport, logistics, finance, information and communication technology (ICT), wholesale and retail trade facilities. (Nordas,2010 and OECD,2017)

There are many attempts to reduce the barriers of trade in services which are quantitative restrictions or quotas, outright prohibition of foreign provision of a service, price-based instruments in the form of visa fees and entry-exit taxes, subsidies and licensing and certification requirements accorded by government, discrimination against foreigners in public procurement. (Breinlich and Criuscolo 2011; Ariu 2012; Hokeman and Mattoo 2013). With the WTO's adoption in 1995 of the General Agreement on Trade in Services (GATS) with a growing number of trade agreements including international services trade shows that promotion of services trade is a strategy for expanding the global economy (OECD 2017). Also as known, reduction of barriers to services trade for almost all countries are largely made by bilateral or multilateral Trade Agreements including trade in services. Recently, as big players, EU and the USA announced in 2013 their intention to establish a trade and investment partnership - the Transatlantic Trade and Investment Partnership (TTIP). As, tariff rates between the EU and the USA are already low especially in industrial products, non-tariff barriers and legal harmonization have greater significance (Kirişçi, 2013). Moreover, as widely recognized, within the global value chains, as multinationals are increasingly outsourcing lower-value activities, including labour-intensive manufacturing, service exports have risen exponentially over the past few decades. (Kaplinsky and Morris 2016).

As data mining techniques are effective processes of exploration and analysis of data in order to discover meaningful patterns and rules, this study attempts to partially fill the gap in the literature and to provide empirical evidence for rise of services trade and its contribution to difference among the development levels of the countries by providing empirical evidence from using datamining techniques.

2. LITERATURE REVIEW

- A handful of country specific analyses imply direct link between services trade liberalization and economic growth. (Konan and Maskus 2006; Eschenbach and Hoekman 2006; Hapsari and MacLaren, 2012) It is noted in the sudy of Eschenbach and Hoekman (2006) that liberalization of services had a positive impact on the incomes of transitional economies. Similarly, Konan and Maskus (2006) estimate that total service trade liberalization in Tunisia would raise GDP. Hapsari and MacLaren (2012) also found support for causal links between financial services liberalization and growth in ASEAN countries. With regards to sector, Mattoo et al. (2006) found that liberalization of telecommunication and financial services contributed to cross country variation in growth of gross national income per capita. Maiti (2018) stated in his paper a long and stable positive relation between economic growth and services. Javalgi et.al (2004), underlined the fact that service industries with information technological capabilities become a key driving force of economic progress for countries. Mitra (2011), who analyzed impact of international trade of services found that trade in services is of a crucial importance for overall economic policy.
- With regards to variables,

   Empirical studies indicate that the GDPs of the exporters positively affect trade, as expected, in that higher-income countries are usually more services-oriented, with a larger share of services in their GDPs, so their services exports are expected to be higher (Brandicourt et al., 2008).

   As a restrictiveness index of services and a measure of non-tariff barriers Lejour and Verheijden (2004) used the OECD's product market regulation (PMR) index while Walsh (2006) and Grünfeld and Moxnes (2003) used the Australian Productivity Commission's trade restrictiveness index to show the negative effects on total services trade. Kimura and Lee (2004) used the Economic Freedom Index, calculated by Frase Institute of Canada, for both exporters and importers to measure the consistency of each nation's policies and institutions with economic freedom and showed that economic freedom had a greater impact on trade in services than in goods. Francois et al. (2007) used the OECD's PMR indicator for three dimensions of restrictiveness: barriers to entrepreneurship, state control and barriers to trade. They report that barriers to both entrepreneurship and trade significantly reduce services trade. Nordas et al.(2017) used sector-level STRI indices in a gravity model to assess more directly the impact of regulatory barriers to trade in services. Marel et al.(2013) also found policy barriers as measured by the overall STRI for each sector have a negative and significant effect on total services trade.

   Anderson and Marcouiller (2002) showed that bilateral trade volumes are significantly affected by trading countries' relative institutional quality, with better institutions being conducive to larger trade volumes. Ranjan and Lee (2003) find that bilateral trade volumes are more affected by institutional quality in sectors that they classify as more institutionally intensive. Countries with comparable governance quality levels generally trade more with each other (De Groot, Linders, Rietveld, & Subramanian, 2004). Alfaro, Kalemli-Ozcan, and Volosovych (2008) showed that, capital flows more between rich countries than from rich to poor countries, mainly due to weak institutions in poor countries.

3. Data and Methodology
Research Question

Based on the literature, we seek to find a better understanding of the key variables first for different development level of countries by taking into account especially the linkage between trade in services and development level.

1. *Research Question: What factors might be indicators of different development level of countries?*
2. *Research Question: Does services trade restrictiveness level affect development level of country?*

3.1. Data and Descriptive Statistics

- The dataset covers 34 countries between 2000-2015
- *GDP* and *Population* of exporting country from The United Nations Global Indicators
- *Services value added* of the exporter (SRVSVA)from The World Bank database
- *Goods exports* of countries from UN Com Trade Data Base.
- *Services trade restrictiveness* (STRI), *Employment In Services*, *Research and Development* from the World Bank,
- *Foreign Direct Investment Restrictiveness Indices* (FDIRestr) data were from OECD STAN database
- *Average Tariff* from WTO
- *Country Risk Classification* from OECD StanDatabase
- *Economic Freedom Index* from Heritage Foundation
- *Index of Globalization* (GI), as calculated by the KOF Swiss Economic Institute
- *Human Development Index* from UNDP
- *Corruption Rate*, *Political Stability*, *Government Effectiveness*, *Regulation Quality* from World Development Indicator

3.2. Technique of Estimation& Prediction with Preliminary Results

3.2.1. Principal Component Analysis

- Missing values are imputed by the mean of the variable by the imputePCA function of the missMDA package- There are 3 principal components: D1:Structure of Economy with emphasis on institutional quality and D2:Trade Potential of country D3: Restrictiveness level in services trade

	Dim.1	Dim.2	Dim.3
	-126.5993	216.8669	-55.59003
	-126.0591	220.8158	-57.76871
	-125.5797	217.2427	-57.28837
	-128.1918	224.0856	-58.26309
	-130.8019	233.1639	-62.63869
	-132.9418	238.2333	-63.82934
	-133.7998	241.4317	-68.19195
	-136.5048	249.0417	-70.38989
	-136.8867	250.3835	-72.19341
	-137.9497	251.5011	-71.97962
	-137.9762	252.9319	-72.03677
	-139.8432	256.1065	-74.01093
	-130.4081	218.7167	-50.24231
	-130.1993	221.4616	-50.23496
	-134.9698	232.2083	-58.96352
	-137.1392	236.5472	-59.97096
	-138.1942	239.6812	-61.24540
	-139.2009	241.2499	-62.14649

	Dim.1	Dim.2	Dim.3	Dim.4	Dim.5
completeobs.lnGDP		0.8834	.	.	.
completeobs.lnGDPPC	0.9521	.	.	.	.
completeobs.LNPop		0.6924	.	.	.
completeobs.STRI		0.6948	.	.	.
completeobs.FDIrestr		.	0.7315	.	.
completeobs.RiskC	-0.9064	.	.	.	.
completeobs.GI	0.8264	.	.	.	.
completeobs.lnSVA		0.8642	.	.	.
completeobs.LNCR		0.8697	.	.	.
completeobs.ES	0.8321	.	.	.	.
completeobs.lnFDIIn		0.7253	.	.	.
completeobs.PercentageInternet.User	0.7440	.	.	.	.
completeobs.AVT	-0.5620	.	.	-0.5469	.
completeobs.PAT		0.7946	.	.	.
completeobs.RD	0.7047	.	.	.	.
completeobs.EF	0.7873	.	.	.	.
completeobs.HDI	0.8444	.	.	.	.
completeobs.Corruption_Rate	0.9457	.	.	.	.
completeobs.GovernmentEffectivenessGovEf	0.9247	.	.	.	.

3.2.2. Confirmatory Factor Analysis

We found three really meaningful models. Tradepotential, Institutional Quality and Restrictiveness

```
Latent variables:
                    Estimate  Std.Err  z-value  P(>|z|)
  TRADEPOT =~
    lnGDP             1.000
    lnGDPPC           0.378    0.028    13.371    0.000
    lnSVA             1.052    0.005   230.447    0.000
    ComX              0.668    0.040    16.542    0.000
    lnFDIIn           0.597    0.048    12.356    0.000
    STRI              0.734    0.188     3.909    0.000
    CRiskC           -0.636    0.060   -10.521    0.000
  MDGDL =~
    RD                1.000
    EF               10.204    0.842    12.121    0.000
    HDI               0.063    0.006    10.986    0.000
    CR                1.505    0.095    15.763    0.000
    GOVEF             1.268    0.079    16.064    0.000
    PST               0.686    0.059    11.697    0.000
    RQ                0.931    0.061    15.360    0.000
  RSTRCTVNS =~
    FDIrestr          1.000
    AVT              30.251   14.689     2.059    0.039
    EF              -49.050   17.971    -2.729    0.006

Covariances:
                    Estimate  Std.Err  z-value  P(>|z|)
  TRADEPOT ~~
    MDGDL             0.422    0.075     5.620    0.000
    RSTRCTVNS        -0.005    0.004    -1.152    0.249
  MDGDL ~~
    RSTRCTVNS        -0.004    0.003    -1.794    0.073
```

3.2.3. Kmeans clustering

As the number of units must be bigger than variables, we applied Kmeans Clustering for countries, while Hierarchical Clustering (HC) for explanatory variables. In HC, 1st cluster: Gdp, GDP per capita, population,
2nd cluster: tariff rate, foreign trade restrictiveness, human development index, country risk level, government effectiveness and regulation quality

3rd cluster: Services Valueadded,Country export level, Foreign Direct Investment, Services Trade Restrictiveness

4th cluster:Globalization Index

5th cluster: Employment in Services and Economic Freedom Index

For countries, Iceland, Pakistan and 3 other groups.
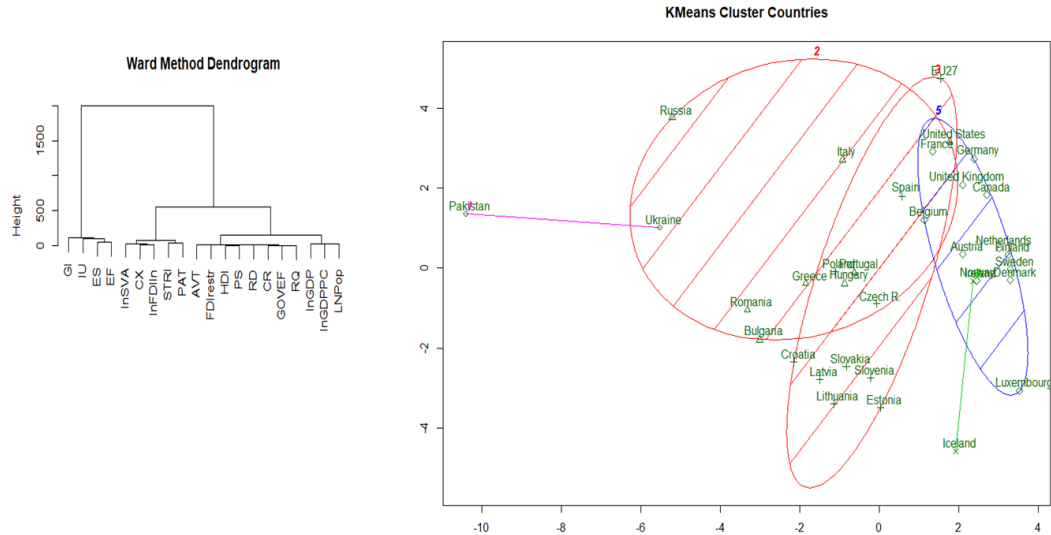
3.2.4. Canonical correlation

According to results of canonical correlation analysis, the number of canonical dimensions are 7. GDP, Services Value added, Country Export level, Foreign Direct Investment Restrictiveness have the highest coefficients for canonical variates. For other canonical dimension representing instituional quality, the variables with the highest coefficients are Regulation Quality, Research&Development, Human development Index and Country Risk Classification.

Variables with highest structural correlations for canonical dimensions are Economic Freedom, Services Value Added, Country Export level, Services Trade Restrictiveness Index and Average Tariff Rate.

  Aggregate Redundancy Coefficients (Total Variance Explained):

X | Y: 0.4236186   Y | X: 0.7353038

3.2.5. Comparison of univariate variance

According to Manova and one way Anova tests: Variables differ with regards to classes of countries.

3.2.6. Multinominal logistic regression

According to Coefficients, for every unit increase in Services Trade Restrictiveness Index, the odds of being in a low middle income level country is higher by a factor of 8.54832+01. For every unit increase in Country Risk Classification, the odds of being in a low middle income level country is higher by a factor of 6.481451e+136 Predictive power of the model is almost 73.7

3.2.7. K-Nearest Neighbour

Do high GDP, GDPpercapita, employment in services and good institutional indicators really put the country in the group which has services value added higher than average? As there is 11/49 wrong predictions, the prediction power of the model is 77,55%

3.2.8. Neural network
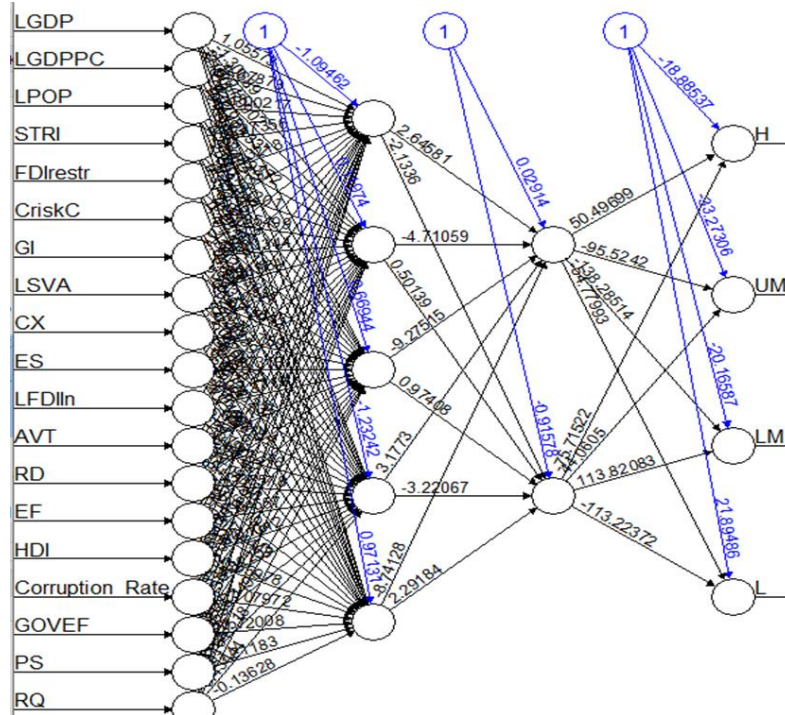
3.2.9. Decision tree

4. As a regression tree/ "anova" for a regression tree, the explanatory power of decision tree is %10.37 higher than regular regression model.


```
Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)    20.4425993  0.1380009 148.134  < 2e-16 ***
LGDP            1.0550041  0.0075582 139.583  < 2e-16 ***
FDIrestr       -0.4131257  0.0538393  -7.673 4.73e-13 ***
CriskC         -0.0122532  0.0064838  -1.890 0.060041 .
GI              0.0049141  0.0012882   3.815 0.000175 ***
CX             -0.0409664  0.0066028  -6.204 2.53e-09 ***
ES              0.0064032  0.0006233  10.273  < 2e-16 ***
LFDIIn         -0.0098087  0.0038993  -2.516 0.012569 *
AVT            -0.0075891  0.0035887  -2.115 0.035532 *
EF             -0.0024955  0.0007707  -3.238 0.001381 **
Corruption_Rate -0.0409150 0.0081280  -5.034 9.70e-07 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.05744 on 230 degrees of freedom
Multiple R-squared:  0.9987,    Adjusted R-squared:  0.9987
F-statistic: 1.811e+04 on 10 and 230 DF,  p-value: < 2.2e-16
```

4.1.1. Panel Data Estimation (Balanced panel wih cross sections and time series)

Future Research

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Decision Making - Abstracts

Analysis of Station Capacities for BlueBikes - Metro Boston's Bike Share System

Decision Making

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BlueBikes, formerly Hubway, is a bike-sharing system in greater Boston area, operating since 2011. They regularly organize a data challenge competition for public since 2012. The data includes the number of available bikes and empty docks per station. The aim of this study is to obtain optimum capacity levels in the selected stations to decrease the shortage duration by using queuing model analysis. Two different cases were examined: the shortage of racks and the shortage of bikes. Here, only a few stations were considered, which are the most frequently used ones. The simulation model is built and solved in ARENA.

ANALYZING THE MAJOR FACTORS OF DISASTER REDUCTION AND RECOVERY BY AHP AND BUILDING AN EVALUATION MODEL FOR RESILIENT COMMUNITIES

Decision Making

Ms . Li-hsiang Chien [1] , *Prof . Ja-Shen Chen* [2]

1. *change88887@yahoo.com.tw* , **2.** *jchen@saturn.yzu.edu.tw*

In this study, we proposed an evaluation model and analyzed the main factors of building resilient communities. More than two hundred literature were studied and summarized. A questionnaire was designed based on the literature and the interview with six domain experts in Taiwan. Thirty questionnaires were collected. Using the AHP method, the main factors of disaster reduction and recovery capability were examined. The results showed among the factors that "protect ecological environment" had a global weight of 0.560 and "maintain infrastructure" had a global weight of 0.440. Thus, we concluded that "protect ecological environment" was the most important evaluating factor.

Improved group decisions for hotel selection in the Analytic hierarchy process

Decision Making

Ms . Jin Fang [1], *Dr . Fariborz Partovi* [1]

1. *Drexel University*

This paper is about identifying the important criteria for hotel selection. We will use topic modeling to discover the important criteria and their corresponding weights in the multi-criteria decision-making setting. The real-world data set were scrapped from a famous travel website for detailed analysis.

Leadership during Crises: Navigating Complexity and Uncertainty

Decision Making

Dr . Kedir Assefa Tessema [1]*, Ms . Jacki Eovitch* [1]*, Ms . Paige Gallagher* [1]

1. *Wilkes University*

Organizations face different kinds of challenges. No challenge is as existential as when a natural disaster decimates the property and other forms of assess the organization is based on for its operation. Some organizations survive such challenges and others do not. Although there are several factors that contribute to organizations' ability to navigate complexity and uncertainty during crises, leadership is widely believed to be pivotal.

In this research, we provide a historical case study of one organization that successfully navigated a crisis that posed an existential challenge. We rely on eulogies, archival documents and interviews for our data.

Nudging, Digital Nudging and Hypernudging

Decision Making

Ms . Ja-Nae Duane [1]

1. *Ben*

Nudges are small changes designed to guide individuals towards a preferred choice option (Thaler and Sunstein, 2009). As decision-making moves into the digital landscape, the literature shows that individuals are making irrational decisions and are bombarded with nudges (Acquisti & Grossklags, 2007). Digital nudges utilize digital information systems. A powerful driver of digital nudges are "hypernudges" (Yeung, 2016), which are personalized choice environments guided by algorithmic outputs. However, where is the line between the algorithm being the choice architect and the decision-maker becoming one? This workshop explores the background and evolution of nudging, as well as ethical considerations for decision-makers.

Performance in small and medium enterprises considering human resource practices: A case of Ghana

Decision Making

Dr . Emelia Ohene Afriyie [1]**, Dr . Mariama Yakubu** [2]**, Dr . Iddrisu Awudu** [3]

1. *Accra Technical University ,* **2.** *University of New Haven ,* **3.** *Quinnipiac University*

In this paper, we investigate human resource practices on organizational performance in small and medium scale enterprise (SMEs). Our objective is to identify the extent to which human resource management practices positively affect organizational performance. We develop a conceptual framework based on the human resource practices with hypothesis and used structural equation model (SEM) to investigate the extent of the relationship. We find that regardless of the significant impact on HRM practices and organizational performance, motivation and job satisfaction serve as an intermediary in improving the performance of the microfinance institutions.

SIMON'S DECISION-MAKING PHASES: AN EXPLORATORY FIELD EXPERIMENT

Decision Making

Dr . Matthew Liberatore [1] **,** ***Dr . William Wagner*** [1]

1. *Villanova University*

Herbert Simon organized the decision-making process into three identifiable phases: *intelligence, design,* and *choice.* The present research seeks to explore the nature of Simon's decision phases by conducting a field experiment. The 239 subjects performed a variety of BI tasks of differing complexity. They were further separated into three different computing scenarios: laptops seated, tablets seated, and tablets walking. Their activities while solving these problems were recorded and later coded to distinguish between Simon's decision phases. This study addresses time spent by phase, its relationship to task performance, and whether task complexity or computing scenario influences the results.

THE APPLICATION OF A RESOURCE ALLOCATION METHODOLOGY IN A MULTI-CHANNEL COMPANY

Decision Making

Dr . Yasamin Salmani [1] **_, Dr . Fariborz Partovi_** [2]

1. *Bryant University , * **2.** *Drexel University*

The goal of this study is to discuss the application procedure of a channel-based resource allocation methodology in the context of a real-world case study. The model proposes a channel-level benefit-to-cost ratio and uses this notion in the integer linear model for allocations of the limited budgetary resource across the sales channels. The response from the managers who participated in the allocation procedure confirmed the effectiveness of the proposed model.

What drives business success or failure in emerging markets?

Decision Making

Mr . Prince Gyimah [1], Prof . Robert Lussier [2], Mr . Etse Nkukpornu [3]

1. *University of Education, Winneba, Kumasi-Campus ,* **2.** *Springfield College ,* **3.** *Christain Service University College*

This study examines the factors that drive the success or failure of businesses in an emerging market. The study is a survey research using logistic regression model to test the Lussier success vs failure prediction model of 120 successful and 110 failed businesses in the developing economy of Ghana. The result supports the validity of Lussier model (p = 0.000) with a high accurate rate of 71.18% in predicting the success or failure of businesses. Capital, industry experience, staffing, and marketing skills are the most significant factors (t-values < 0.05) that contribute to success. Practical and theoretical implications are discussed.

Decision Making - Papers

ANALYZING THE MAJOR FACTORS OF DISASTER REDUCTION AND RECOVERY BY AHP AND BUILDING AN EVALUATION MODEL FOR RESILIENT COMMUNITIES

Abstract

Over the past two decades, nearly two billion people have been affected by adverse climates, resulting in massive destruction of buildings, evacuation of tens of thousands of people, and billions of dollars in economic loss worldwide. In this study, we proposed an evaluation model and analyzed the main factors of resilient communities. More than two hundred literature mainly relating to resilient communities, resilient governance, disaster management, post-disaster recovery and reconstruction for resilient communities were studied and summarized. A questionnaire was designed based on the literature and the interview with six domain experts in Taiwan. Thirty questionnaires were collected from village chiefs of resilient communities in northern Taiwan, undertakers of resilient community planning, experts and scholars who guided the construction of resilient communities, and undertakers or section managers of district offices and returned after completion.

Using the AHP method, the main factors of disaster reduction and recovery capability were examined. The results showed among the factors that "protect ecological environment" had a global weight of 0.560 and "maintain infrastructure" had a global weight of 0.440. Thus, we concluded "protect ecological environment" was the most important evaluated solution. In this aspect, the 12 indices of "protect ecological environment" were identified. Using an efficiency evaluation diagram, sensitivity analysis was used to determine the sensitivity of each factor for decision-making. The evaluation model for resilient communities is intended to create priority vectors of performance indices of important factors of the community disaster reduction and recovery capability. The evaluation model is of practical value. Specifically, it can be used for reference by the National Fire Agency of Ministry of the Interior and village chiefs, who are willing to participate in the construction of resilient communities.

Keywords: Resilient Community, Disaster Management, Evaluation Model for Resilient Communities

1. Introduction

Over the past two decades, at least two billion people worldwide have been affected by adverse climates. Taiwan is plagued with a variety of natural disasters (e.g., floods, earthquakes, typhoons, seawater intrusion, mudslides, landslide, earthslides and rockslides, ground subsidence, beach erosion, and widely distributed fault zones). Natural disasters cause not only direct losses of human life, buildings, property, industries, and public facilities, but also indirect losses arising from the interruption of social lives, economic activities, social relations, and infrastructure. Over the years, Taiwan's natural disasters have caused a total loss of at least NT$2 trillion (30 NT$≒ 1 USD).

To cope with diverse natural disasters (e.g., climate change, rainstorms, typhoons, and earthquakes), Taiwan must be well prepared at all times, and have rapid response and recovery capabilities in the event of natural disasters. Climate risks comprise hazard, system vulnerability, and exposure (Field et al., 2014). The hazards faced by communities include climate hazards and non-climate hazards, which have direct and indirect impacts on various systems (e.g., ecological, agricultural, coastal, and human health systems). In addition, typhoons have a direct impact on infrastructure, thus causing property losses. Moreover, climates may cause non-climate disasters, for example, biological hazards, extinction of insects and animals, insect attacks, technological hazards, industrial pollution, traffic accidents, fire, and hazards to human health (e.g., diseases transmitted by water) (Parry et al., 2012).

Related studies over the past five years evaluate the anti-disaster capability of communities using the Delphi and analytical hierarchy process (AHP) approaches, and emphasize the importance of diverse factors (e.g., health, governance and environment, economy, information and communication, and social contact). Evaluating the anti-disaster capability of communities, physical conditions, and environment (i.e., good infrastructure) are essential indices, and AHP is used to evaluate communities' economic development and sustainability. Economy-oriented urban revival projects should be evaluated in terms of local economic revival and employment, as well as other economy-related indices. It is recommended that future studies highlight qualitative indices and environmental factors. To evaluate community resilience, Community Risk Assessment (CRA) tools must be strictly reviewed. Communities' institutional, social, architectural, economic, and environmental aspects should be evaluated. Environment is the minimum dimension that can harm community resilience, but is given little attention. The three studies above all argue that ecological environment is an important index of community resilience. Hence, ecological environment is used as an evaluation criterion in this study. Resilience means that people learn lessons from destructive events and take

adaptive and innovative methods to allow a long-term gradual evolution of the system (Elmqvist, 2014; Sharifi & Yamagata, 2016). The three documents above all argue that ecological environment is an important aspect. In practice, ecological environment is not considered by the related studies, so it is impossible to know whether and to what degree ecological environment affects communities' disaster reduction and recovery capability. Therefore, ecological environment is used as an evaluation criterion when this study discusses the evaluation model for resilient communities in terms of "maintain infrastructure" and "protect ecological environment."

Resilient communities highlight a coexistence with risks, and can reduce the impacts of disasters and recover from such impacts quickly. To quantify the degree of community resilience, many scholars have conducted a number of studies. For example, they measured the performance of post-disaster reconstruction in five aspects, i.e., social mentality of individuals and families, degree of organizational and institutional recovery, recovery degree of economic and commercial activities and productivity, completeness of infrastructure recovery, and recovery degree of public order and governmental operation. Considering that social infrastructure construction helps communities of public facility reconstruction restore economic lives quickly, scholars argued that community and local trust networks are beneficial to post-disaster reconstruction. Most studies argued that community residents will, if losing social trust, take a passive attitude toward climate change and undergo a social maladjustment. Therefore, it is necessary to pay close attention to disadvantaged people with high vulnerability and low adjustability. Some scholars argue that social media can be used to help the disaster-stricken develop an anti-disaster capability and reduce disaster losses, but their lives, work, and placement may be ignored, and that most of disaster relief funds are inputted into ineligible infrastructure construction. Therefore, they emphasize that pre-disaster social capital is beneficial to the post-disaster reconstruction of communities, and post-disaster placement requires an accumulation of social capital to enhance community resilience. Resilient communities are mainly evaluated in environmental, social, economic, and psychological aspects in terms of anti-disaster capability. Ecological environment is an important aspect. Resilient communities are able to enhance the adaptive capacity and reduce disaster impacts. Previous studies show that community resilience involves diverse aspects and indices that interact with each other. Through expert interviews and questionnaire surveys, this study discusses the evaluation model for resilient communities suited to the actual needs of community residents.

2. Literature Review

2.1 Resilient Community

In 1973, Holling initially introduced the term "resilience" and proposed the concept "ecosystem resilience," namely, the persistency of ecosystem changes due to natural or human-made reasons associated with the natural system. Therefore, it is of great significance to observe dynamic ecosystems and pay close attention to their self-renewal capacity after they undergo an external disturbance. Disasters are unpredictable and due to an overexposure to uncertainties, planners and policy makers are encouraged to understand local development through the concept of "resilience" (Cutter et al., 2008; Brown & Westaway, 2011; Mitchell, 2013; Saunders & Becker, 2015). The community resilience is implemented by local communities in the process of social survival to address the negative social and economic impacts during a crisis; theoretical and practical limitations preclude people from deep understanding of crises (Gaillard, 2010; Manyena, 2014; Matyas & Pelling, 2014). Davoudi (2012, p. 299) implies that the recovery capacity is not yet clear, and many expressions of resilience are not sufficient to address social issues, and do not mention some progressive interpretations and stereotyped expressions (O'Hare & White, 2013; McEvoy et al., 2013). Existing interpretations of resilience are usually very weak and fail to provide practical solutions, as well as the tools and methods required for community participation and reinforcement (Mitchell, 2013; Hutter & Kuhlicke, 2013). For lack of clarity, acceptance, participation, enhanced social process, and dynamic flexibility at a practical level, communities may take the traditional management pattern. Under the command and control of policy makers, resilience of local communities is transformed into social resilience (Adger, 2000; Davidson, 2010; Alexander, 2013a; Brown, 2014). Resilience refers to the restoration of the system to the prespecified state. For this method, resilience can be measured in terms of the anti-disturbance capacity of the system and speed of balance restoration (Davoudi, 2012). In case of notable fluctuations, the system restores itself to an old or new stable state (Davoudi, 2012, p. 301). Resilient communities allow the sharing of resources and collectively develop their knowledge and capacity to meet changes. The sharing strategy serves to enhance the sense of social responsibility, create a favorable atmosphere full of unity, cooperation, mutual assistance, care, sharing, frankness, and pleasure, and to develop people's community consciousness and increase social cohesion and social capital (Wang et al., 2013). Resilience refers to the adaptability of the system and serves to accomplish goals, ensures service continuity, and absorbs or restricts interruptions (Sauser et al., 2011).

Resilient communities can accomplish sustainability in living (social), ecological

(environmental), and productive (economic) aspects. Specifically, resilient communities serve to improve the quality of people's life, protect ecological environment, reduce pollution, recycle resources, promote public participation and autonomous management of communities, and comply with the principle of fairness. Identifying vulnerable places may help communities develop an anti-disaster capacity and share lessons and experiences, community composition (Chang et al., 2015), economic information, infrastructure, and community governance (Alshehri et al., 2015b). Seventy-three percent of Taiwanese land is simultaneously exposed to natural disasters such as earthquakes, typhoons, floods, and landslides, and 73% of Taiwanese people are faced with threats from natural disasters, ranking first globally. To build resilient communities, it is necessary to consider the four stages of disaster management, to conduct environmental, social and economic improvements, and to create sustainable living environments.

2.2 Resilient Governance

As defined by A Framework for Assessing the Resilience of infrastructures and Economic Systems (Vugrin et al., 2010), system resilience refers to the capability of the system to effectively control the magnitude of unexpected accidents and deviation from the prespecified performance objectives. It is of vital importance to apply resilience analysis, implement an effective post-disaster reconstruction strategy, and assess the cost and reliability of the risk mitigation strategy. Through appropriate knowledge, timely methods, social cooperation, and flexible originalities, resilient governance can reduce the cost of the risk mitigation strategy. To shorten the disaster handling time, it is necessary to provide a service system for post-disaster reconstruction, plan a standardized operation procedure for disaster reduction beforehand, and establish an all-round and multi-functional recovery mechanism.

2.3 Disaster Management

Disaster management refers to a series of activities implemented against natural and human-made disasters, including disaster reduction, preparedness, response, and recovery. In response to global impacts of climate change, the adaptation to global climate change can be categorized under emergency management in recent years (Freitag, 2007). Related studies emphasize the interaction between environmental management, climate change, disaster reduction, and adaptation (Labadie, 2011). Hazard and disaster studies involve three theories, including social system theory, vulnerability analysis theory, and social constructivism. Disaster vulnerability is ascribed to political, economic, and cultural factors, and exposes individuals and groups to various disaster risks. Social

constructivism relates to the definition of disasters, and capability of social systems and institutions to control disaster risks. The theory can be used to develop an integrated emergency management mode, and emphasizes a reduction in natural environments to minimize losses, as well as the management of ecological environments. Newman contends that resilient cities should highlight the self-sufficiency capacity, develop renewable energy actively, reduce reliance on fossil fuels, recycle resources, and take continuous carbon reduction as goals. Most ecologists argue that the resilient city strategy should extensively discuss how to reduce disaster risks, and highlight the issues such as waterfront area management, urban landscape design, construction of green and blue belt infrastructure, and conservation of environmental buffer areas (The World Bank, 2013). An urban system consists of various networks. An urban system comprises ecological, social, and technological elements. The studies of cities and sustainability emphasize the interaction between social and technological systems, usually known as socio-technological networks (Graham & Marvin, 2001; Guy, Marvin, & Moss, 2001; Romero-Lankao & Gnatz, 2013). Namely, a city is regarded as a complex socio-ecological system that comprises socio-ecological and socio-technological networks. Considering that the spatiotemporal scale determines the characteristics of urban resilience, the studies of urban resilience differ in this regard (Alberti et al., 2003; Brown et al., 2012; Desouza & Flanery, 2013; Ernstson et al., 2010). In the process of globalization, cities are interlinked with different places and spaces through system interaction, involving an exchange of materials, water, energy, and capital (Armitage & Johnson, 2006; Elmqvist, Barnett, & Wilkinson, 2014).

U.S. scholars Godschalk et al. (1999) contend that disaster reduction is a pro-active action and is intended to reduce or eliminate long-term threats of disasters to people's lives and property. To accomplish the objective of disaster reduction, it is necessary to formulate a cooperation strategy and action plan centered on the use of land. It is necessary to formulate a standardized operation procedure according to the characteristics of population distribution, conduct disaster prevention education, indicate evacuation routes in the case of natural disasters, and implement an autonomous management and quick recovery mechanism after natural disasters.

2.4 Vulnerability

In a broad sense, vulnerability refers to the likelihood of a specific system, subsystem, or system component to be damaged because of its exposure to the disaster pressure or disturbance (Turner et al., 2003). Vulnerability can be classified into two types: 1) physical environment vulnerability, focusing on traditional disasters and impacts; 2)

social vulnerability (regional existing status prior to the occurrence of disasters), focusing on the structural factors of impacts of disasters on human societies or regions (Adger et al., 2004). Vulnerability analysis includes hazard identification and hazard evaluation. Sociological scholars are inclined to determine whether people are able to cope with pressure or change socioeconomic factors; climatologic scholars argue that vulnerability is the possibility of occurrence and impacts of weather and climate-related events. It is of great importance to identify the natural environmental hazards of a region and intensity and occurrence frequency of such hazards, and to analyze the casualties or property loss arising from the interaction of human environments and human-made environments.

2.5 Fragility Analysis

Disaster reduction of communities and residential environments should focus on local socioeconomic fragility and planning of disaster prevention (Chatterjee & Mukhopadhyay, 2015; Johnson et al., 2015). In the study of challenges faced by the development of Asian cities, governance and development of mega cities should concentrate on risks and resilience, but not merely consider the importance of economic development and critical infrastructure to spatial development (Singh, 2015; Miller & Douglass, 2016). In the field of disaster studies, fragility is the core concept of studies and policies concerning climate change (Hinkel, 2011).

Considering the overall interaction of natural environment and socioeconomic environment, some studies focus on climate change and disaster impacts, and discuss how to improve adaptability (Dessai et al., 2005; Engle, 2011; Hung & Chen, 2013) through adaptation planning. Adaptation planning should consider different aspects of climate change or disaster impacts from the perspectives of overall environment and social benefits (Kirshen et al., 2008; Intergovernmental Panel on Climate Change, 2012). Appropriate adaptation strategies can be proposed for regions of high exposure, fragility, and risk through fragility and risk evaluation oriented to starting points and integrated analysis of climate change or disaster impacts (Kwadik et al., 2010; Ranger et al., 2010; Hung et al., 2013; Hung & Chen., 2013). Particularly, it is advisable to develop win-win and no-regrets or low-regrets comprehensive adaptation strategies and reduce the risk and fragility of regions or social groups through diverse ways (e.g., early warning system, risk communication, land use planning, improvement in living conditions of disadvantaged groups, and ecosystem maintenance) (Heltberg et al., 2009; Intergovernmental Panel on Climate Change, 2012; Lloyd et al., 2013). To this end, experts must comprehensively analyze disaster potentials and fragility, and determine the core of an adaptation strategy. There are many uncertainties that may affect the results of disaster evaluation and

adaptation policy implementation (Vincent, 2007; Auld, 2008; Kwadijket et al., 2010). The study of autonomous adaptive behaviors emphasize that adaptive behaviors of residents are not primarily affected by the external physical environment, but result from the interaction between environments and individual psychology, daily life, disaster experience, and information acquisition (Adger et al., 2009; Kuruppu & Liverman, 2011). Whether residents take responsive or adaptive behaviors actively is primarily determined by the psychological cognition of climate change and disasters (Hisali et al., 2011). Social capital usually plays a mediating role between community collectives, governments' adaptation policies, and residents' adaptation strategies. Therefore, the completeness of social capital affects disaster resilience, adaptability, and capability to reduce disaster risks and losses (Adger, 2003; Wolf et al., 2010). Social capital and participation include social trust, assistance, and participation; these factors involve climate change and disaster management systems, as well as collective behaviors—usually, those with complete social capital may perform positive collective behaviors. Most studies argue that if losing social trust, residents will take a passive attitude to climate change, thus causing a maladaptation phenomenon (Niemeyer et al., 2005). Participation in community disaster prevention or accession to related public institutions serves to know community environments better, and to increase the capacity of resource acquisition and willingness of autonomous adaptation (Krishnamurthy et al., 2011). In addition, it is noteworthy that social disadvantaged groups are not good at pre-disaster and post-disaster adaptation. Social disadvantaged groups are of high fragility and low adaptability (Brouwer et al., 2007; Hung & Chen, 2013). From the perspectives of disaster preparedness and disaster response, governments may provide appropriate incentives to encourage residents to engage in related adaptation and response, and encourage residents and communities—through intensive social capital like workshops and community organizations—to participate in the design of disaster warning mechanisms and drawing of disaster maps. This helps residents know and trust governments' disaster information, and facilitates effective application of information (Cadag & Gaillard, 2012; Hung & Chen, 2013).

2.6 Risk Cognition

Risk cognition alone is not sufficient to guide the behaviors of risk reduction (Lindell & Whitney, 2000). Some scholars contend that risks are a subjective concept. Subjective risks are susceptible to factors such as individual traits, culture, and socioeconomic status. Studies show that various risks can be covered by characteristics such as sense of fear, controllability, degree of knowledge, and range of influence. The

judgment of natural disasters is not significantly correlated with the behaviors of disaster preparedness, but correlated with the severity of disaster results. If no behaviors of disaster preparedness are available, the damage from disasters will intensify the sense of fear and anxiety, and make a notable psychological impact; for example, it will be more time-consuming to recover from psychological trauma, regain confidence, reconstruct communities, or go back to work.

2.7 Community Resilience

The International Strategy for Disaster Reduction (ISDR) defines resilience as a system capability, or to be more specific, a capability of a community or society to resist or change functions and structures to an acceptable extent. Resilience covers the self-organizing capability, as well as the capability to learn from previous disasters or upgrade to a better state in the future and reduce disaster risks (Djordjevic et al., 2011).

Disaster studies highlight community resilience, and use each community as a unit of analysis to discuss the vulnerability, economic development, environmental health, and social demand in a community, and how to improve overall benefits through coordination and cooperation (Frankenberger et al., 2013; Kech & Sakdaplorak, 2013). In the process of post-disaster reconstruction, communities and local organizations apply their acquired resistance, adaptation, response and recovery abilities, and adapt themselves to environmental change in a real-time and effective manner; this is a presentation of community resilience (Frankenberger et al., 2013). Communities need to be accompanied deeply for a long period, and organizations that are established temporally due to the allocation of coping resources will usually not exist for long. This implies the importance of capability accumulation of local organizations; otherwise, local organizations will fail in the long-term reconstruction after the departure of non-local organizations—this also represents a major disaster preparedness mechanism for communities (Hung et al., 2016). Social resilience comprises three capacities which includes coping capacity, adaptive capacity, and transformative capacity (Kech & Sakdaplorak, 2013); there is a considerable correlation between the three capacities. Specifically, the coping capacity aims to acquire a stable state after coping with impacts, the adaptive capacity expects a flexible response from individuals, groups, communities, or the society, and the transformative capacity highlights change or pursues a better state (Frankenberger et al., 2013). It is necessary to possess and develop the adaptive and transformative capacities, learn from previous experiences, and adjust and change existing lifestyles. Figure 2-1 shows the correlation between critical factors of resilience.

Figure 2-1 Correlation between critical factors of resilience
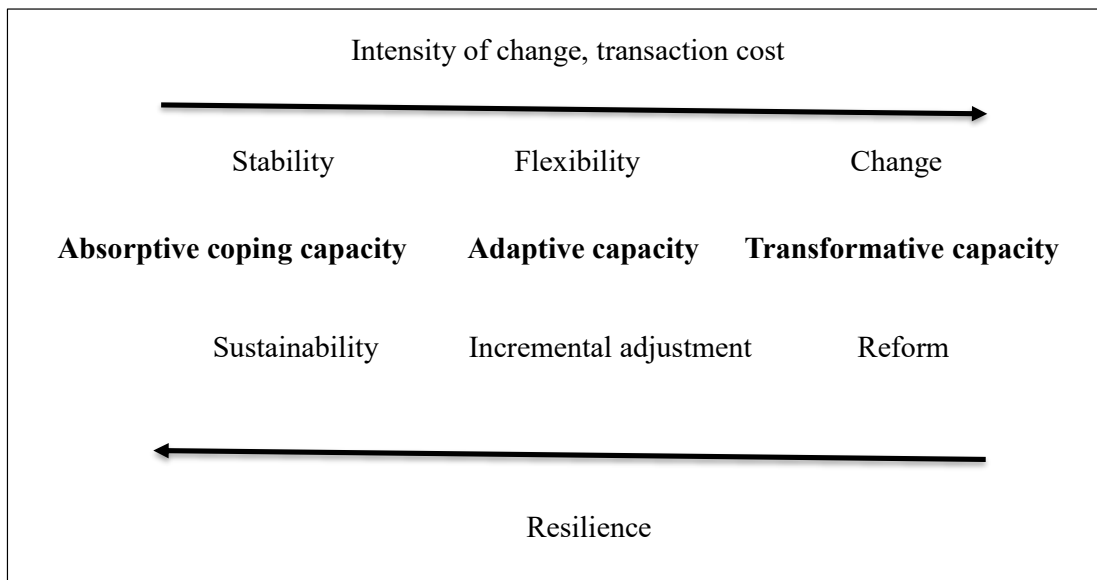
Data source: Frankenberger et. al., 2013

The performance of post-disaster reconstruction can be measured in five aspects, including: 1) social mentality of individuals and families; 2) degree of organizational and institutional recovery; 3) recovery degree of economic and commercial activities and productivity; 4) completeness of infrastructure recovery; and 5) recovery degree of public order and governmental operation. Disaster sociology covers two aspects, including social vulnerability and social resilience. Resilience is an instinct of specific groups for reconstruction or adaptation to new life after a disaster. In addition to certain factors (e.g., disaster severity, population density, economic capital, and human capital), some scholars try to interpret the difference of post-disaster recovery speed in terms of social infrastructure construction in disaster-stricken areas. The state-dominated and top-down disaster management and relief cannot completely account for the difference of post-disaster recovery; by contrast, communities and local networks play a more important role. The act of depredation is supervised and punished by capitalizing on the mutual benefit and trust between people, as well as their sense of honor. Such mutual benefit and trust are usually based on previous social networks, which are referred to as trust networks by Tilly. Wide coverage and high cohesiveness of trust networks are more beneficial to post-disaster reconstruction, whereas narrow coverage and low cohesiveness of trust networks are less beneficial to post-disaster reconstruction.

2.8 Post-disaster Recovery and Reconstruction

As defined by the ISDR, post-disaster recovery and reconstruction refer to the

recovery and improvement of public facilities, living conditions, and livelihood in disaster-stricken areas. In the process of post-disaster recovery and reconstruction, it is necessary to consider how to reduce future disaster risks and build better communities (Jha et al., 2010). According to the U.S. Department of Homeland Security (2011), core capabilities of post-disaster recovery and reconstruction comprise five aspects, including prevention, protection, mitigation, response, and recovery; furthermore, recovery comprises economic recovery, health and social services, housing, infrastructure systems, and natural and cultural resources. The five aspects are of vital importance to post-disaster recovery and reconstruction. In addition to the construction of housing, it is also necessary to construct and secure essential facilities such as water, electric power, and gas, and restore economic activities closely associated with people's livelihoods. Community resilience is the main objective of disaster management (Yoon et al., 2016).

In the study of challenges faced by the development of Asian cities, governance and development of mega cities should concentrate on risks and resilience, and not merely consider the importance of economic development and critical infrastructure to spatial development (Singh, 2015; Miller & Douglass, 2016). In recent years, the Internet and social media have had far-reaching influence on disaster communication (Haddow, 2014). It has become a trend that disaster information is communicated through social media. In particular, Twitter and Facebook along with other social media play an increasingly important role in disaster prevention and relief, which can help disaster-stricken people establish an anti-disaster capability and reduce the losses from disasters (Cohen, 2013). Governmental organizations and non-governmental organizations (NGOs) worldwide now use such social networks with higher frequency than before, thus facilitating disaster preparedness, disaster response, and post-disaster recovery (Haddow, 2014). Disadvantaged groups are subjected to environmental or technological limitations (Velev & Zlateva, 2012). Barrios (2014) investigated post-disaster community reconstruction and resilience from an anthropological perspective and found that after a disaster, it is a matter of great importance to make disaster-stricken people feel the sentiment of recovery from spatial, social, and infrastructural creation. Cox and Perry (2011) emphasize the role of social capital in the process of recovery; specifically, the pre-disaster social capital of community residents is beneficial to post-disaster reconstruction, and the accumulation of social capital in post-disaster placement is beneficial to enhancing community resilience.

In summary, resilient communities are mainly sustainable in living (social), ecological (environmental), and productive (economic) aspects, or to be more specific, in improving the quality of life, protecting the ecological environment, reducing pollution, recycling resources as much as possible, promoting autonomous community management

by community residents, and complying with the principle of fairness. Community resilience involves tools and community-related information, considers future uncertainties, and makes people understand the complexity of a community ecosystem more deeply (Levine, 2014; Sellberg et al., 2015). With the evolution of the concept of "community resilience," people are increasingly aware of the importance of its evaluation methods and tools (Cohen et al., 2016; Cutter, 2016). The development of evaluation tools includes a few steps, for example: 1) determine a community; 2) standardize the evaluation indices; and 3) assign a weight to each index (Peacock et al., 2010). Evaluation tools are determined according to literature review and expert opinions, and they are used to determine the criteria for community resilience, to create a comparison matrix, and to check the degree of inclusion of criteria for resilience. In the comparison matrix, the flexibility criteria comprise five critical dimensions, including environmental, social, economic, infrastructure and architectural environment, and institutional dimensions; most evaluation tools for community resilience involve multiple dimensions of flexibility, but the environmental dimension is not fully incorporated into evaluation tools; environmental damage affects community resilience significantly (Burton, 2014; Cutter et al., 2008; Hughes et al., 2013). Flexibility is a multifaceted structure and is attained through all dimensions; it is necessary to give more attention to environmental factors. The development of evaluation tools should not be separated from each other, but promoted mutually; various criteria for flexibility do not work in isolation, but interact with each other in a complex interrelationship network (Sharifi & Yamagata, 2014; Sharifi & Yamagata, 2016).

2.9 Evaluation Model for Resilient Communities

A highly representative and reliable evaluation method comprises the following steps: 1) experts review the preliminary evaluation hierarchy for resilient communities, disaster prevention, and relief items combined with various factors; 2) expert opinions are solicited and returned; 3) the overall opinion and prediction problem are respectively fed back to experts to solicit their opinions again; 4) experts amend their original opinions according to the overall opinion; 5) experts reach a consensus on prediction results through a repetition of previous steps. Under the condition of uncertainty, a complex problem is systemized and hierarchized through AHP, and then quantitatively calculated for the purpose of comprehensive evaluation. Experts assign different weights to reduce the risk of decision-making errors. The evaluation results are used for reference when regional disaster managers formulate strategies of disaster reduction and recovery.

3. Methodology

Using the AHP approach, major factors of the disaster reduction and recovery capability were classified into four aspects, including ecological (environmental) factors, living (social) factors, productive (economic) factors, and psychological (cultural) factors. Through questionnaire surveys or expert interviews, expert opinions were solicited. A complex problem was hierarchized to build a two-layer evaluation framework. Evaluation criteria for the factors of disaster risks were established, and weights were assigned to such factors to make evaluation results more objective. Finally, an overall consistency test was conducted so that decision makers could select an evaluation model for resilient communities.

As described below in Table 3-1, there are a total of 216 research documents concerning ecological (environmental), living (social), productive (economic), and psychological (cultural) factors. Prediction questionnaires were distributed to ten experts with different experience and expertise to solicit their opinions. Then, questionnaire contents were amended according to expert opinions. After the questionnaire survey was completed, the following steps were performed: 1) determine the relative importance of decision attributes of each level; 2) create pairwise comparison matrices to calculate eigenvalues and eigenvectors; 3) through a consistency test, calculate the relative importance (or weight) of relative factor of each index; 4) analyze the priority weights; and 5) decide on the optimal solution.

Table 3-1 Document statistics on study objectives and strategies of the evaluation model for resilient communities

Objective	Evaluation model for resilient communities	
Sub-objective	Strategy	Literature summary
Ecological (environmental) factor	Ecological protection	10
	Pollution reduction	8
	Resource recycling	18
Living (social) factor	Organization and institution	33
	Community participation	30
	Trust network	32
Productive (economic) factor	Infrastructure	19
	Commercial activity	14
	Productivity	12
Psychological (cultural) factor	Mental state	12
	Collaboration and cooperation	22
	Cultural capital	6
Total number of research documents:		216

Data source: processed in this study

The evaluation framework for resilient communities comprises four levels. The first layer is the objective layer, the second layer is the object layer, and the third layer is the strategy layer. Resilient communities are evaluated in terms of the disaster reduction and recovery capability. Expert opinions are solicited, and then questionnaire contents are amended according to expert opinions.
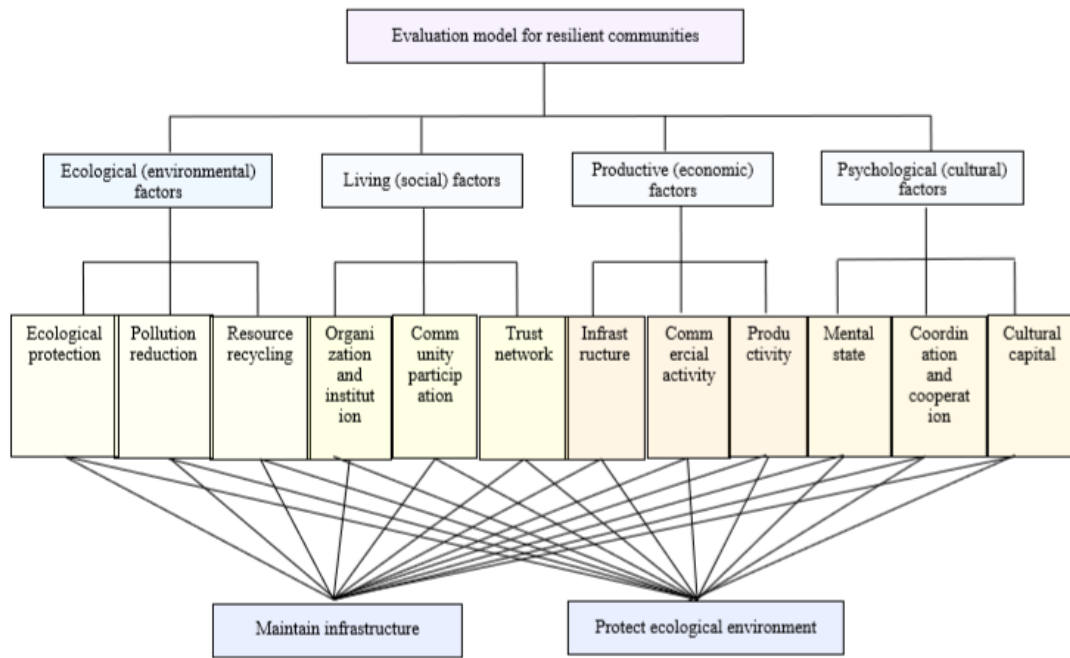
Figure 3-1 Study framework

The respondents included village chiefs who were responsible for construction of resilient communities, undertakers of resilient community projects, experts and scholars who provided guidance or advice for construction of resilient communities, undertakers or section managers of district offices. They give opinions or suggestions on expert surveys or interviews. In this study, 30 questionnaires were distributed and returned (including 10 questionnaires addressed to interviewed experts, 10 questionnaires addressed to 10 disaster prevention individuals, and 10 questionnaires addressed to village chiefs).

4. Study Results

(1) Pairwise comparison matrix and priority vector of the objective aspect of performance indices of evaluation model for resilient communities

As described below in Table 4-1, the maximum eigenvalue (λmax) is 4.03, the consistency index (C.I.) is 0.01, and the consistency ratio (C.R.) is 0.01; these values are all below 0.1, meeting the requirements specified by Saaty. In terms of priority vector, ecological (environmental) factors (priority vector: 0.301) are the most important

objective aspects, followed by living (social) factors (priority vector: 0.292), productive (economic) factors (priority vector: 0.231), and psychological (cultural) factors (priority vector: 0.176).

Table 4-1 Pairwise comparison matrix and priority vector of the objective aspect of performance indices of evaluation model for resilient communities

Evaluation model for resilient communities	Weight	Rank
Ecological (environmental) factor	0.301	1
Living (social) factor	0.292	2
Productive (economic) factor	0.231	3
Psychological (cultural) factor	0.176	4
λmax=4.03 C.I.=0.01 C.R.= 0.01 RI=0.90		

Data source: data processed in this study

(2) Weight analysis for performance indices of evaluation model for resilient communities

 a. Using a single objective aspect as the unit of analysis

Among the ecological (environmental) factors, the most important influencing factor is ecological protection (priority vector: 0.425), followed by pollution reduction (priority vector: 0.306), and resource recycling (priority vector: 0.269).

Among the living (social) factors, the most important influencing factor is community participation (priority vector: 0.509), followed by trust networks (priority vector: 0.285), and organization and institution (priority vector: 0.206).

Among the productive (economic) factors, the most important influencing factor is infrastructure (priority vector: 0.524), followed by productivity (priority vector: 0.274), and commercial activity (priority vector: 0.202).

Among the psychological (cultural) factors, the most important influencing factor is coordination and cooperation (priority vector: 0.577), followed by mental state (priority vector: 0.234), and cultural capital (priority vector: 0.189).

Table 4-2 Analysis of performance indices in a single objective aspect

Ecological (environmental) factor	Weight	Rank
Ecological protection	0.425	1
Pollution reduction	0.306	2
Resource recycling	0.269	3
λmax=4.03 C.I.=0.01 C.R.= 0.017 RI=0.58		
Living (social) factor	Weight	Rank
Organization and institution	0.206	3
Community participation	0.509	1

Trust network	0.285	2
λmax=4.02 C.I.=0.008 C.R.= 0.015 RI=0.58		
Productive (economic) factor	**Weight**	**Rank**
Infrastructure	0.524	1
Commercial activity	0.202	3
Productivity	0.274	2
λmax=4.02 C.I.=0.009 C.R.= 0.016 RI=0.58		
Psychological (cultural) factor	**Weight**	**Rank**
Mental state	0.234	2
Collaboration and cooperation	0.577	1
Cultural capital	0.189	3
λmax=4.002 C.I.=0.0008 C.R.= 0.017 RI=0.58		

Data source: data processed in this study

b. Analysis of global weight based on all evaluation indices

In terms of priority vector, the 12 evaluation indices are ranked in descending order. 1) community participation (priority vector: 0.149); 2) ecological protection (priority vector: 0.128); 3) infrastructure (priority vector: 0.121); 4) coordination and cooperation (priority vector: 0.102); 5) pollution reduction (priority vector: 0.092); 6) trust network (priority vector: 0.083); 7) resource recycling (priority vector: 0.081); 8) productivity (priority vector: 0.063); 9) organization and institution (priority vector: 0.060); 10) commercial activity (priority vector: 0.047); 11) mental state (priority vector: 0.041); 12) cultural capital (priority vector: 0.033).

Table 4-3 Analysis of overall performance of the evaluation model for resilient communities based on all evaluation indices

Aspect	Weight of Aspect	Index	Weight of Index	Hierarchical Weight	Hierarchical Rank
Ecological (environmental) factor	0.301	Ecological protection	0.425	0.128	2
		Pollution reduction	0.306	0.092	5
		Resource recycling	0.269	0.081	7
Living (social) factor	0.292	Organization and institution	0.206	0.060	9
		Community participation	0.509	0.149	1
		Trust network	0.285	0.083	6
Productive (economic) factor	0.231	Infrastructure	0.524	0.121	3
		Commercial activity	0.202	0.047	10
		Productivity	0.274	0.063	8
Psychological (cultural) factor	0.176	Mental state	0.234	0.041	11
		Collaboration and cooperation	0.577	0.102	4
		Cultural capital	0.189	0.033	12

Data source: data processed in this study

c. Weight analysis for performance indices of "maintain infrastructure" and "protect ecological environment" under a single objective aspect

As described below in Table 4-4, the 12 evaluation indices are ranked in terms of priority vector. In the aspect of ecological protection, "protect ecological environment" (priority vector: 0.701) is the most important influencing factor, followed by "maintain infrastructure" (priority vector: 0.299). In the aspect of pollution reduction, "protect ecological environment" (priority vector: 0.644) is the most important influencing factor, followed by "maintain infrastructure" (priority vector: 0.356). In the aspect of resource recycling, "protect ecological environment" (priority vector: 0.616) is the most important influencing factor, followed by "maintain infrastructure" (priority vector: 0.384). In the aspect of organization and institution, "protect ecological environment" (priority vector: 0.552) is the most important influencing factor, followed by "maintain infrastructure" (priority vector: 0.448). In the aspect of community participation, "protect ecological environment" (priority vector: 0.539) is the most important influencing factor, followed by "maintain infrastructure" (priority vector: 0.461). In the aspect of trust networks, "protect ecological environment" (priority vector: 0.525) is the most important influencing factor, followed by "maintain infrastructure" (priority vector: 0.475). In the aspect of infrastructure, "maintain infrastructure" (priority vector: 0.588) is the most important influencing factor, followed by "protect ecological environment" (priority vector: 0.412). In the aspect of commercial activity, "protect ecological environment" (priority vector: 0.546) is the most important influencing factor, followed by "maintain infrastructure" (priority vector: 0.454). In the aspect of productivity, "protect ecological environment" (priority vector: 0.516) is the most important influencing factor, followed by "maintain infrastructure" (priority vector: 0.484). In the aspect of mental state, "protect ecological environment" (priority vector: 0.602) is the most important influencing factor, followed by "maintain infrastructure" (priority vector: 0.398). In the aspect of coordination and cooperation, "protect ecological environment" (priority vector: 0.566) is the most important influencing factor, followed by "maintain infrastructure" (priority vector: 0.434). In the aspect of cultural capital, "protect ecological environment" (priority vector: 0.579) is the most important influencing factor, followed by "maintain infrastructure" (priority vector: 0.421).

Table 4-4 Performance indices of "maintain infrastructure" and "protect ecological environment" in single target aspect

Ecological protection	Weight	Rank
Maintain infrastructure	0.299	2
Protect ecological environment	0.701	1
Pollution reduction	Weight	Rank
Maintain infrastructure	0.356	2
Protect ecological environment	0.644	1
Resource recycling	Weight	Rank
Maintain infrastructure	0.384	2
Protect ecological environment	0.616	1
Organization and institution	Weight	Rank
Maintain infrastructure	0.448	2
Protect ecological environment	0.552	1
Community participation	Weight	Rank
Maintain infrastructure	0.461	2
Protect ecological environment	0.539	1
Trust networks	Weight	Rank
Maintain infrastructure	0.475	2
Protect ecological environment	0.525	1
Infrastructure	Weight	Rank
Maintain infrastructure	0.588	1
Protect ecological environment	0.412	2
Commercial activity	Weight	Rank
Maintain infrastructure	0.454	2
Protect ecological environment	0.546	1
Productivity	Weight	Rank
Maintain infrastructure	0.484	2
Protect ecological environment	0.516	1
Mental state	Weight	Rank
Maintain infrastructure	0.398	2
Protect ecological environment	0.602	1
Collaboration and cooperation	Weight	Rank
Maintain infrastructure	0.434	2
Protect ecological environment	0.566	1
Cultural capital	Weight	Rank
Maintain infrastructure	0.421	2
Protect ecological environment	0.579	1

Data source: data processed in this study

d. Global weight of comparison matrix between the performance index objective aspect and single objective aspect, and of priority vector

"Weight" is a relative concept. The weight of an index refers to the relative importance of the index in an overall evaluation. Weights include global weights and hierarchical weights. A global weight refers to the priority vector of the overall objective based on a consideration of all layers; a hierarchical weight refers to the relative importance of each solution at the lower layer to the upper layer. As described below in Table 4-5, the 12 evaluation indices are ranked in terms of priority vector. First, in the aspect of ecological protection, the global weight of "maintain infrastructure" is 0.0382, and the global weight of "protect ecological environment" is 0.0897; hence, "protect ecological environment" is the most important influencing factor. Second, in the aspect of community participation, the global weight of "maintain infrastructure" is 0.0685, and the global weight of "protect ecological environment" is 0.0801; hence, "protect ecological environment" is the second most important influencing factor. Third, in the aspect of infrastructure, the global weight of "maintain infrastructure" is 0.0712, and the global weight of "protect ecological environment" is 0.0499; hence, "maintain infrastructure" is the third most important influencing factor. Fourth, in the aspect of coordination and cooperation, the global weight of "maintain infrastructure" is 0.0441, and the global weight of "protect ecological environment" is 0.0575; hence, "protect ecological environment" is the fourth most important influencing factor.

e. Consistency test for overall hierarchy of performance indices

The degree of importance varies from layer to layer. It is necessary to test the consistency across the whole hierarchy. The consistency ratio of the hierarchy (C.R.H) is divided by the random index of the hierarchy (R.I.H). For the matrices with the same order, C.R.≤0.1 indicates a satisfactory degree of matrix consistency. C.R.H<0.1 indicates that the consistency of the hierarchy is acceptable. After the whole hierarchy passes the consistency test, global weights can be calculated to determine the priority vector of each alternative solution. The priority vector determines the priority of an alternative solution, and decision-makers select an appropriate solution accordingly.

For the performance indices of the evaluation model for resilient communities, the C.I.H is 0.0179, and the C.R.H is 1.4794, so 0.0179 ÷ 1.4794=0.0121 (less than 0.1). Therefore, the result passes the C.R.H test.

Table 4-5 Global weight of comparison matrix between the objective aspect and single objective aspect, and priority vector

Aspect	Weight of Aspect	Index	Weight	Name	Weight	Global Weight
Ecological (environmental) factor	0.301	Ecological protection	0.425	Maintain infrastructure	0.299	0.0382
				Protect ecological environment	0.701	0.0897
		Pollution reduction	0.306	Maintain infrastructure	0.356	0.0328
				Protect ecological environment	0.644	0.0593
		Resource recycling	0.269	Maintain infrastructure	0.384	0.0311
				Protect ecological environment	0.616	0.0499
Living (social) factor	0.292	Organization and institution	0.206	Maintain infrastructure	0.448	0.0269
				Protect ecological environment	0.552	0.0332
		Community participation	0.509	Maintain infrastructure	0.461	0.0685
				Protect ecological environment	0.539	0.0801
		Trust network	0.285	Maintain infrastructure	0.475	0.0395
				Protect ecological environment	0.525	0.0437
Productive (economic) factor	0.231	Infrastructure	0.524	Maintain infrastructure	0.588	0.0712
				Protect ecological environment	0.412	0.0499
		Commercial activity	0.202	Maintain infrastructure	0.454	0.0212
				Protect ecological environment	0.546	0.0255
		Productivity	0.274	Maintain infrastructure	0.484	0.0306
				Protect ecological environment	0.516	0.0327
Psychological (cultural) factor	0.176	Mental state	0.234	Maintain infrastructure	0.398	0.0164
				Protect ecological environment	0.602	0.0248
		Collaboration and cooperation	0.577	Maintain infrastructure	0.434	0.0441
				Protect ecological environment	0.566	0.0575
		Cultural capital	0.189	Maintain infrastructure	0.421	0.0140
				Protect ecological environment	0.579	0.0193

Data source: data processed in this study

5. Conclusion

The subject of this study included communities, fire stations, assistant teams, and experts and scholars with respect to the construction of resilient communities in Taipei City, New Taipei City, and Taoyuan City. The 30 respondents of the questionnaire survey included village chiefs or disaster prevention personnel who participated in the construction of resilient communities, along with assistant teams from National Taiwan University and Ming Chuan University who provided guidance or advice for practical construction of resilient communities. The AHP approach was used to analyze the evaluation model for resilient communities and determine the priority vectors of performance indicators of major influencing factors. The findings are of practical value.

Specifically, they can be used for reference by the National Fire Agency of Ministry of the Interior, organizations associated with the planning of resilient communities, or village chiefs who are willing to participate in the construction of resilient communities.

From the perspective of disaster reduction and recovery, this study first analyzed the four aspects of major factors of the evaluation model for resilient communities. Based on the 12 evaluation indices specified in the expert questionnaire, this study then proposed two evaluation solutions, including "maintain infrastructure" and "protect ecological environment." The results show that the global weight of "maintain infrastructure" is 0.440, and the global weight of "protect ecological environment" is 0.560. Therefore, "protect ecological environment" is the most important evaluation solution, followed by "maintain infrastructure." Table 5-1 describes the global weight of each overall evaluation solution.

Table 5-1 Global weight of overall evaluation solution

Overall Evaluation Solution	Weight	Rank
Maintain infrastructure	0.440	2
Protect ecological environment	0.560	1

Data source: data processed in this study

"Protect ecological environment" is the most important evaluation solution in this study. In this aspect, the 12 indices are ranked in terms of priority vector in the following descending order: 1) ecological protection (global weight: 0.090); 2) community participation (global weight: 0.080); 3) pollution reduction (global weight: 0.059); 4) coordination and cooperation (global weight: 0.057); 5) resource recycling (priority vector: 0.050) and infrastructure (global weight: 0.050); 6) trust network (priority vector: 0.044); 7) organization and institution (global weight: 0.033) and productivity (global weight: 0.033); 8) commercial activity (global weight: 0.025) and mental state (global weight: 0.025); 9) cultural capital (global weight: 0.019). Table 5-2 describes the priority of comparative indices in "protect ecological environment."

Table 5-2 Priority of comparative indices in "protect ecological environment"

Index	Protect Ecological Environment (Priority)	Rank
Ecological protection	0.090	1
Pollution reduction	0.059	3
Resource recycling	0.050	5
Organization and institution	0.033	8
Community participation	0.080	2
Trust networks	0.044	7
Infrastructure	0.050	5
Commercial activity	0.025	10
Productivity	0.033	8
Mental state	0.025	10
Collaboration and cooperation	0.057	4
Cultural capital	0.019	12

Data source: data processed in this study

Sensitivity analysis aims to present the sensitivity of each factor in decision-making through an efficiency evaluation diagram. The participating experts unanimously agreed that "protect ecological environment" was very important. Figure 5-1 shows the efficiency evaluation diagram for sensitivity analysis.
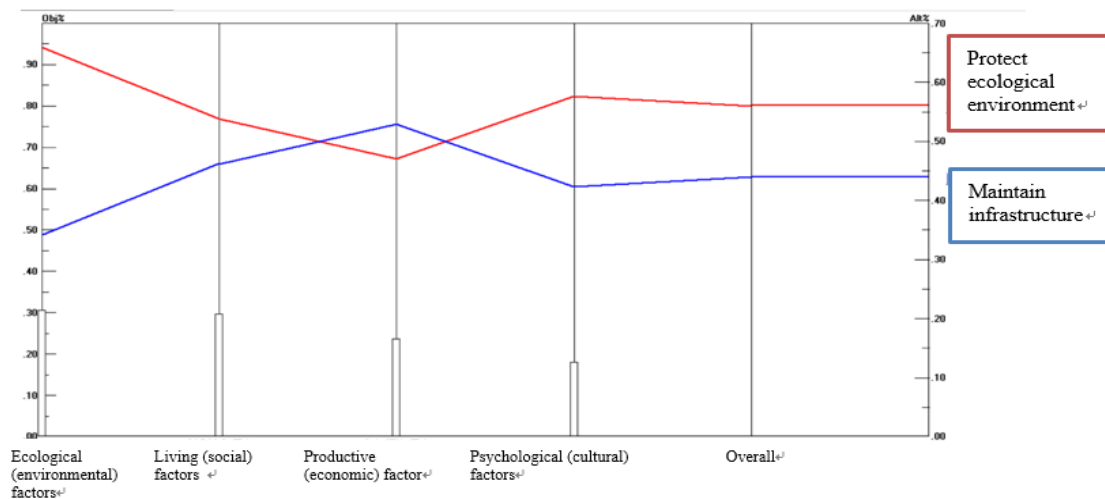
Figure 5-1 Efficiency evaluation diagram for sensitivity analysis

The dynamic evaluation diagram for sensitivity analysis comprised two parts: 1) weight values of conditional factors; and 2) comparison diagram of solution weights. The weights of conditional factors are ranked in descending order: 1) ecological (environmental) factors (30.1%); 2) living (social) factors (29.2%); 3) productive

(economic) factors (23.1%); and 4) psychological (cultural) factors (17.5%). As shown in Figure 5-2, the weight of "protect ecological environment" (56%) is higher than that of "maintain infrastructure" (44%). Evidently, "protect ecological environment" has the highest weight among the alternative solutions.
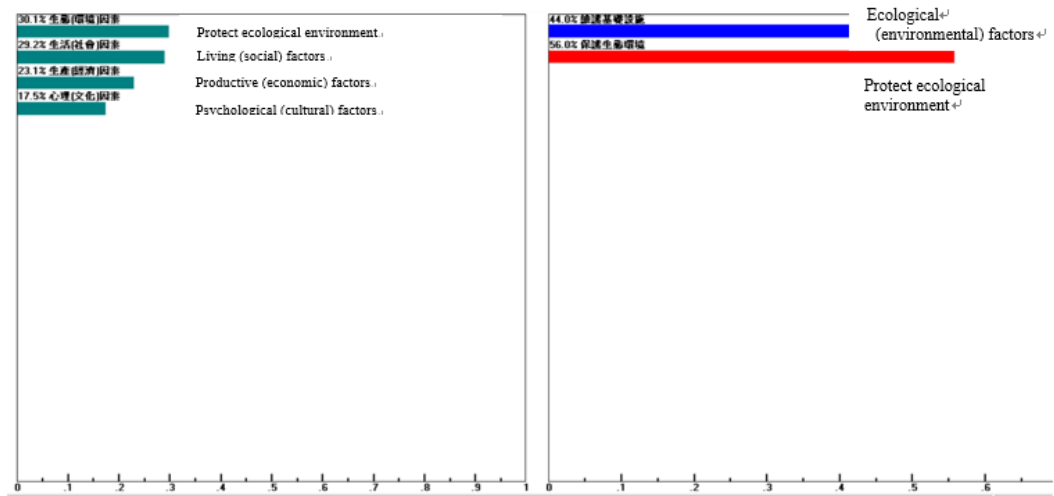
Figure 5-2 Dynamic evaluation diagram for sensitivity analysis

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Improved group decisions for hotel selection in the Analytic hierarchy process

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Abstract

This paper is about identifying the important criteria for hotel selection. We will use topic modeling to discover the important criteria and their corresponding weights in the multi-criteria decision making setting. The real-world data set were scrapped from a famous travel website for the detailed analysis.

Keywords: Analytic Hierarchy Process, Hotel Selection, Group decision.

1   Introduction

Analytic Hierarchy Process (AHP) (Saaty, 1988) is a useful method to assess the finite number of alternatives in multicriteria decision-making (MCDM) problems. The AHP provides judgements on both quantitative criteria and qualitative criteria (Badri, 2001). Since its initial development, AHP has been applied to a wide variety of decision areas in manufacturing and service (Partovi et al., 1990; Mikhailov & Tsvetinov, 2004; Ishizaka & Labib, 2011). There are three main steps in using AHP: (1) construction of the hierarchy of the problem; (2) obtaining pairwise matrices of the criteria and the alternatives to provide relative importances; and (3) revealing priorities.

In the first step, a hierarchy composed of decision elements is developed based on the problem. Albayrak & Erensal (2004) mentioned that a hierarchy has at least three levels: the overall objective of the decision problem at the top; multiple criteria, and sub-criteria that evaluate the alternatives in the middle; the decision options or alternatives at the bottom. The second step is obtaining pairwise comparison matrices of the criteria and the alternatives. Decision-makers assign the relative importance based on their opinions for each pair of criteria and alternatives, separately

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using Saaty scale (Saaty, 1980). In the final step, the composite weights of the decision alternatives are then determined by aggregating the weights throughout the hierarchy. The outcome of this aggregation, so-called priorities, is an overall weight for each alternative.

It has been forty years since the AHP was introduced by Saaty (1980). There has been many modifications and improvements to the original framework, such as rank reversal, ANP and fuzzy AHP. Belton & Gear (1983) introduced the rank reversal problem in the AHP and Barzilai & Golany (1994) showed this issue can be avoided when the output of the process is properly redefined as weight-ratio matrix rather than a normalized-weight vector. The ANP technique, also developed by Saaty (1996), is another multi-criteria decision tool which allows for the consideration of more complex interdependencies among levels of attributes and alternatives. ANP can include hierarchical relationships but does not require a strict hierarchical structure as does AHP. In traditional formulations of the AHP, human judgements are represented as exact numbers. However, decision makers may find it more confident to give interval judgements than fixed value judgements. Therefore, Van Laarhoven & Pedrycz (1983) proposed the fuzzy AHP, which introduced fuzzy ratios using triangular membership functions. Researchers also combined AHP with other tools like linear programming, data envelopment analysis, artificial neural network, quality function deployment (Partovi & Corredoira, 2002), genetic algorithms, SWOT-analysis (Ho, 2008).

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THE APPLICATION OF A RESOURCE ALLOCATION METHODOLOGY IN A MULTI-CHANNEL COMPANY

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Abstract

The goal of this study is to discuss the application procedure of a channel-based resource allocation methodology in the context of a real-world case study. The model proposes a channel-level benefit-to-cost ratio and uses this notion in the integer linear model for allocations of the limited budgetary resource across the sales channels. The response from the managers who participated in the allocation procedure confirmed the effectiveness of the proposed model.

Keywords: resource allocation, channel-level benefit-cost analysis, multi-channel optimization, integer linear programming, real company application

Introduction

To be competitive in the market, firms utilizing multiple sales channels should constantly update their knowledge of customer priorities (Hoppner & Griffith, 2015; Watson, Worm, & Ganesan, 2015) as well as operating costs associated to each specific channel to make effective investment decisions. The process of resource allocation across various established channels, is regarded as a major strategic decision for such firms (Salmani, Partovi, & Banerjee, 2018a). In practice, most of these decisions are made on an ad hoc basis.

This study contributes to the implementation procedure of the model to demonstrate business-world applicability of modeling framework. There is a dearth of tools to support supply chain managers in making optimal resource allocation decisions across the cooperative sales channels (Salmani, 2019).

The Case Study

The resource allocation model described in the research by (Salmani et al., 2018a) is applied in aiding management of a U.S manufacturing firm to allocate monetary resources to various sale channels. To preserve anonymity, the name of the firm is disguised, and for the sake of brevity, the particulars of the case is condensed.

The Company Background

The ABC Company is a pioneer in the biotechnology industry. It manufactures the scientific cameras that support bioresearch. ABC is the owner of numerous U.S. and international patents and trademarks.

ABC is a highly regarded leader in the global scientific community for producing high performance industrial cameras that are used in the biotechnology science for super-resolution imaging procedures. The products include type I, type II, and Type III cameras. ABC customers are universities and scientific research laboratories across the world. ABC distributes the products through two main sales channels, namely (i) a direct channel and (ii) an indirect channel via a third-party dealer. In the direct sales channel, the company takes the orders directly from the customers and ships the products through company-owned facilities. The company commences manufacturing the products after receiving an order from a customer. The company does not utilize

any land-based stores to stock the finished products. The orders are shipped directly to the final customers from the plant.

ABC Inc. is a provider of high-performance digital cameras for imaging in life science and industrial applications. The company achieves this goal by identifying the customers' expectations and satisfying customers by high quality products. The production process in the ABC Inc. is based on Make-To-Order (MTO) policy. Therefore, through any channel to make a purchase, the customer will never experience a stock-out situation.

The marketing communication director was asked to draw upon her knowledge of the customers' wants regarding channel selection. The criteria which are important for ABC's customers in the decision of how to make a purchase include customer's contact of interaction, delivery time, cost, and purchasing convenience.

ABC's Model

An Analytic Network Process (ANP) model is proposed for the ABC Company to measure the customer preference priorities. The ANP's Criteria cluster includes the ABC customers' factors. The Alternative cluster consists of the ABC's sales channel formats including the direct and the indirect channels.

Two top managers of the ABC company, the marketing communications director and the product manager, evaluated the ANP comparisons. They compared channel alternatives with respect to each criterion through a pairwise comparison process. Next, they conducted the pairwise comparisons between the channel selection criteria. The four criteria in a pairwise fashion, with respect to each channel structure, were compared. Finally, the results from pairwise comparison are obtained. The interested reader for detail calculations please refer to (Saaty, 2004).

The ANP results show that 58% of the customers prefer to purchase through the direct channel, and 42% of the customers would choose to order indirectly through a third-party dealer. The priorities obtained from the super matrix for the direct and indirect channels are associated with benefits to customer. In ABC resource allocation decision making, there are often opposing criteria, such as operating costs that cannot be integrated with benefits as we discussed before. In cases like this it is useful to construct a separate model for comparing the operating cost of each

channel. The important role of operating costs in resource allocation decisions are highlighted in the literature (Salmani, Partovi, & Banerjee, 2018b; Wang, Li, & Cheng, 2016).

In comparing the operating costs of the two channels since the company follows an MTO production strategy, the demand for products is certain. Consequently, the standard deviation of demand is zero and no safety stock is required for final products. The company ships the cameras to the customers as well as to the dealer directly. As a result, there is no holding cost or ordering cost in the distribution configurations.

Based on the analysis of ABC's data, we calculate the weights for direct and indirect sales channels in ABC's distribution portfolio. These weights are found applying a proposed benefit-to-cost ratio measure. The role of this measure in the ABC's resource allocation process is regarded as crucial. Because it includes customer preferences as well as the relevant costs of employed sales channel structures. Accounting for the company's limited monetary resource, we use this notion in an ILP framework, with the objective of enhancing overall distribution process.

Conclusion

The management in the ABC confirmed that the proposed measure plays a crucial role in the resource allocation problem, since it represents a channel-level benefit-cost analysis that has not been dealt with enough in the company.

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Information Systems and Decision Support - Abstracts

Artificial Intelligence Adoption: A Re-Examiniation of Technology Acceptance

Information Systems and Decision Support

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Technology acceptance models have been used to explore the consumer adoption of a variety of technologies, such as online banking, e-books and wearable health monitors. This research summarizes the examined and significant antecedents to consumer technology adoption. This insight is used to propose a model for examining the adoption of smart speakers, such as Amazon Alexa and Google Home. Examined variables include performance expectancy (usefulness), effort expectancy (ease of use), social influence (subjective norm/ influence), facilitating conditions (support/ knowledge), hedonic motivation (enjoyment), price value, habit and trust.

Building Effective IT Project Management Course

Information Systems and Decision Support

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The Project Management Institute reports that there is a dramatic increase in the number of jobs requiring project management skills, and over the next decade the demand for project managers will outstrip the demand for other professions. The educators strive to prepare graduates for the PM positions and their challenges should be aware of the perceptions of experienced working professionals about the necessary skills in successfully completing a project. They should also be aware of what students consider to be necessary PM skills and will be benefited by knowing what their colleagues teaching PM courses think of the necessary skills.

Does Blatant Benevolence Increase Social Capital Online?

Information Systems and Decision Support

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This study intends to explore the prosocial post on social media. We first explore people's opinions on the prosocial posts on social media. Based on the results, we develop a framework for prosocial posts and social capital. We next apply a lab experiment to empirically investigate the framework: 1). Whether posting prosocial behavior increases social capital; 2). What moderators affect the relationship between posting prosocial behavior and social capital. By establishing the relationship, we provide insights to charity organizations and social media companies to encourage their users to post prosocial behavior and thus indirectly increase their members.

Electronic community of cybersecurity: A network analysis of CVE disclosure on Twitter

Information Systems and Decision Support

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Effective vulnerability management requires collecting a variety of intelligence from both official sources like National Vulnerability Database (NVD) and unofficial sources such as from social media. This study contributes to vulnerability management literature by investigating the electronic community existing on social media platforms such as Twitter and focusing their cause to the exposure of cybersecurity vulnerabilities, specifically, Common Vulnerabilities and Exposures (CVE). Hence, we apply network analysis on related users and posts. Our objective is to characterize network behavior over time by detecting active users and subgroups through analyzing their interactions on the network across different time points.

INFORMATION PROCESSING TECHNIQUES FOR BETTER MANAGERIAL DECISIONS IN SMALL BUSINESSES

Information Systems and Decision Support

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Recent innovations in the field of information systems have revolutionized the way businesses operate. With the emergence of web services, the convergence of telecom and computing is finally reaching maturity in a unified platform for doing business in the 21st century. However there is still a dearth in the current literature that analyzes how this digital technology can help small businesses in such areas as business process reengineering and data analytics. This paper studies how information processing techniques based on the criticality of business processes can help in making better managerial decisions in the small business environment.

Network Structure & Coordination in Electronic Markets

Information Systems and Decision Support

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Studying the complex interactions of buyers and the role social structures play in purchasing can be accomplished using a collective buying market where coordination and communication are the keys to successful bidding. The objective of this research is to examine coordination based on the structure of the buying group, i.e. interactions between buyers in the group. We study the structure using Social Network Analysis techniques to determine if the structure plays a role in successful coordination. Using a quasi-experimental electronic market, we examine centralization measures of groups as a measure of structure using a simple group-buying platform.

RSM Audit Software

Information Systems and Decision Support

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The purpose of this paper is to discuss RSM US LLP's current audit software, CaseWare. The paper will outline some of the deficiencies in the program and it will outline possible solutions to the problems. The study will consider whether RSM should adopt a new information system entirely or if there are more efficient ways to overcome the challenges associated with using the software.

Synthetic Average Neighborhood Sampling Algorithm (SANSA): A Neighborhood Informed Synthetic Sample Placement Approach to Improve Learning from Imbalanced Data

Information Systems and Decision Support

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Machine-learning classification models are increasingly being used in both real-world applications as well as in academic literature. However, many real-world phenomenon happen much less often, and thus are more interesting and in many cases much more high-stakes to predict. In this work, we propose a new synthetic data generation algorithm that uses a novel "placement" parameter that can be tuned to adapt to the each datasets unique manifestation of the imbalance. SANSA also defines a novel modular framework to rank, generate and scale the new samples, which can be used in the future with other functions to propose better methods.

Information Systems and Decision Support - Papers

INFORMATION PROCESSING TECHNIQUES FOR BETTER MANAGERIAL DECISIONS IN SMALL BUSINESSES

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ABSTRACT

Recent innovations in the field of information systems have revolutionized the way businesses operate. With the emergence of web services, the convergence of telecom and computing is finally reaching maturity in a unified platform for doing business in the 21st century. However there is still a dearth in the current literature that analyzes how this digital technology can help small businesses in such areas as business process reengineering and data analytics. This paper studies how information processing techniques based on the criticality of business processes can help in making better managerial decisions in the small business environment.

Keywords: Information Systems, Business Data Analytics, Business Process Reengineering, Small Businesses

INTRODUCTION

Information Technology provides ready to use, end-to-end solutions and allow small businesses to focus on their core business. Recent innovations in digital technology can play a significant role in spurring the growth of small businesses. Small and medium scale enterprises account for more than 90 percent enterprises in most OECD (Organization for Economic Cooperation and Development) nations and provide about 80 percent of economic growth (Scupola, 2009). Significant research shows that these businesses contribute to economic growth in multiple ways. Their presence in an economy leads to more competitive large enterprises that can outsource some of their activities to smaller firms. Compared to their relatively small sizes, they create more jobs than large firms (Passerini, 2012). Smaller size is an advantage, particularly in terms

of the ability to anticipate and respond to changes and achieve a deeper and closer interaction with the customers.

Information is an important asset that gives small businesses a competitive advantage in the new economy. Information access plays a critical role in the informed decision making process, making it easy for these businesses to make good competitive decisions (Modimogale, 2011). The ability of small businesses to survive in an increasingly competitive global environment is largely predicated upon their capacity to leverage information as a resource. In today's fierce competitive environment, small businesses need to be highly responsive and adaptive to demands of customers, actions of competitors, and changes in economic conditions (Rashaniphon, 2011). Data analytics can be as useful to small businesses by identifying those business processes that are capable of exploiting the new innovations in that area.

This paper is organized as follows. First we briefly describe the current scenario pertaining to small businesses. IT Strategies and Business process reengineering as applied to small businesses are discussed next. This is followed by a discussion of how business data analytics can be used to help small businesses. The next section proposes a framework that will help adopt the appropriate IT strategy for small and medium scale enterprises. Concluding remarks form the last section.

SMALL BUSINESSES

Even though the economic importance of small and medium scale enterprises has been known, they were considered comparatively unimportant during the great Internet boom during the 1990s and early 2000s (Passerini, 2012). Use of broadband information technology required extensive investment in technological assets and a long term access to capital. Such capital requirements were not available to small businesses. Today small businesses can compete and excel due to continual improvements in Internet technology as well as breakthroughs in cloud computing and mobile connectivity.

Access to capital and an established brand name are the main advantages of large organizations. One of the greatest advantages small businesses have is flexibility. Many small businesses have a single owner who is free to change policies, and technologies (Sadowski, 2002). For example, the owner of a small grocery store can decide to use broadband to create an automatic reorder

system with suppliers. Small businesses can offer new services and change internal processes without having to clear a multitude of committees that would exist in a large organization. Cloud computing, and open source software have brought down the investment requirements and costs. This has resulted in the availability of broadband technologies to small businesses to streamline business processes, grow the customer base, and enlarge existing offerings.

According to Kirchoff's typology (Kim, 2004), small firms can be classified based on two dimensions: innovation and growth as shown in Appendix I. Core firms represent where innovation and growth are low, whereas Glamorous firms have innovation and growth at a high level. Constrained companies have low growth potential but high innovation potential. Ambitious firms have high growth potential but low innovation potential. This paper mostly focuses on Core firms. Mills (2015) classifies small businesses based on types of firms – whether they are sole proprietorships, B2B, etc. – as indicated in Appendix II. Most of the Core small businesses are either sole proprietorships, or local businesses serving consumers and other local businesses. Lower costs of Information Technology (IT) deployment, mobility advantages supported by broadband, and an IT services support system (now directly available as-a-service) can help the more IT conservative small firms (such as 'core' as indicated in Appendix I) to transition to the new mobile apps (Passerini, 2012).

There is a lack of knowledge about the potential benefits of information technology and strategies to support small businesses in achieving their business objectives. Small businesses face the challenge that generally they are owner managed and the owner makes all or most of the decisions about the business (Fillis, 2004; Spencer, 2006). Unfortunately, owner-manager's limitations become limitations of the business. Information technology needs to be considered a key player for the small business in reaching its goals. As information technology is perceived to be expensive by small businesses, they often do not budget for it. The other problem with regard to the cost of IT is that small businesses may invest in unnecessarily big solutions due to sales pitches, hype of specific products or market patterns without considering their real need [Grandon, 2004]. Technology is constantly evolving which raises two issues. On the one hand the small businesses need to monitor the kind of technologies that their clients are using and try to make sure that they are ready to serve them. On the other hand, the small businesses s do not

need to change every time there is a change in technology as this depends upon the focus area of the small businesses. The competitiveness of a small business depends on the way in which IT is used to support business processes.

EMERGING INFORMATION TECHNOLOGIES

Emerging information technologies provide ready to use, end-to-end solutions and allow small businesses to focus on their core business. Some of these emerging information technologies are:

● Software-as-a-Service (SaaS),

● Infrastructure-as-a-Service (IaaS),

● Platform-as-a-Service (PaaS),

● Everything-Else-as-a-Service.

Software as a service (SaaS) provides a service that is directly consumable by the end user. SaaS is a model in which the customer licenses applications and provides them to users on demand. The services run on the provider's infrastructure and are accessed through a public network connection. Applications may be made available through the Internet as browser applications, or may be downloaded and synchronized with user devices. SaaS services are centrally managed and updated (Rhoton, 2013). The most common pricing model is based on the number of users, but there may be additional fees based on bandwidth, storage, and usage. There are many similarities between SaaS and the services offered a few years ago by application service providers (ASPs). However, there are also some important differences in the approaches to multi-tenancy, the pay-as-you-go model and the ability to provision on demand. SaaS offers several compelling benefits. It simplifies licensing. In fact, the customer doesn't need to acquire (or directly pay for) a software license at all. This is a task of the provider. There is also no need to calculate maximum capacity. It outsources the tedious task of application maintenance and upgrades and ties customer costs to usage, which lowers fixed costs and capital investment.

Infrastructure-as-a-Service (IaaS) provides flexibility for small businesses to install their own applications in a shared environment quickly and easily. The technology that makes IaaS offerings possible is virtualization. Virtualization is the ability to create a virtual representation

of an otherwise physical hardware platform. In an IaaS model, virtualization apples to servers, the computing hardware. IaaS gives small businesses the ability to have their business applications hosted on a centralized platform with a utilitarian billing model and virtually unlimited capacity. This will be very valuable for start-up companies.

Platform-as-a-Service (PaaS) is targeted towards small businesses that create their own applications. PaaS provides a middle ground between SaaS and IaaS. PaaS provides application service enterprises a central platform to host their applications. PaaS provider manages all backend components of the infrastructure for application hosting such as load balancing, hardware, operating systems, scaling, and infrastructure monitoring. PaaS is better than traditional web platforms in terms of geographically distributed collaboration, reduced cost of infrastructure through the pay-as-you-go model and cost reduction through higher level programming abstractions. PaaS is simpler to manage than IaaS and represents a smaller platform to distribute and can leverage more functionality and services from the provider.

SaaS and IaaS have paved the way for a multitude of other services that can be grouped as "Everything-Else-as-a-Service". Database-as-a-Service provides database instances through the Internet for customers. Amazon's Relational Database Service (RDS) provides various MySQL and Oracle database instances for use. Another example of this is Xeround. Security-as-a-Service leverages on the SaaS model. Security companies provide a SaaS offering which meets various security needs of businesses. Small businesses can obtain significant security advantages by acquiring email security services, Web protection services, vulnerability assessments, and certification services all using an as-a-service model. As storage costs are lowering and broadband speeds are increasing, Storage-as-a-Service offerings are available. As a result of fast data transfer speeds, users can choose cloud-based storage services. Some Storage-as-a-Service offerings provide desktop integrations for automatic synchronization of files (Passerini, 2012).

Monitoring-as-a-Service offerings provide small businesses managed and hosted monitoring capabilities. Through an external monitoring service, service enterprises can ensure round-the-clock managed monitoring across various locations. Some monitoring services perform profiling of an enterprise's applications. Profiling is the ability to perform deeper diagnostics of an

application. For small businesses, this means that they can quickly identify bottlenecks, inefficiencies, or other exceptions in their applications. Analytics-as-a-Service is very useful for Web-based enterprises. Small businesses using e-commerce channels can understand their customers better by identifying traffic patterns which can lead to other metrics such as shopping patterns and frequently viewed products. Analytics can also track user activity and how users were referred to the site.

Automation-as-a-Service provides automation services such as event driven execution of tasks. Some automation services are provided through deployment of agents in the customer environment. The agents regularly check for changes in schedule from a centralized server managed by the service provider. Tokenization-as-a-Service is used for data security. Tokenization is the process of abstracting sensitive data into a series of tokens. This amounts to virtual replacement of sensitive data with a unique identifier that cannot be mathematically reversed. By offloading the receipt and storage of sensitive information such as credit card information, small businesses can be relieved of the burden of maintaining security and compliance. Logging-as-a-Service reduces the burden of analyzing log files by providing consolidation and analysis services.

SMALL BUSINESSES AND INFORMATION TECHNOLOGY

Small businesses can leverage information technology (IT) in two different ways. One way is to enhance operational support and transaction processing activities. Small businesses adopt and use simple IT innovations without any form of planned strategy to integrate other aspects of business (Qureshil, 2009). In this approach, any form of IT-based competitive advantage is accidental rather than planned. The second way is typically taken to use IT to improve interaction and relationship with customers. A majority of small businesses depend on a small number of customers who purchase large amounts of goods and services. These major customers influence the price of goods and services provided by small businesses. Close relationships among small businesses and customers enable these businesses to respond quickly to any change in customer requirements.

Levy (2001) has proposed an analytical framework that incorporates both forms of strategic focus. In this Focus-Dominance Model (Appendix III), customer dominance is compared with strategic focus. This framework provides four different strategies to IT adoption. The "Efficiency" quadrant consists of small businesses that exploit simple systems such as word processing and spreadsheets. The "Coordination" quadrant consists of small businesses that have a need to increases market share and their customer base. The "Collaboration" quadrant indicates those small businesses that attempt to incorporate emerging technologies to manage relationships with major customers. The "Innovation:" quadrant consists of those businesses that actively seek to adopt new IT innovations to achieve competitive advantage.

In a follow-up study, Levy (2002) investigated 43 small businesses to observe their positions in the Focus-Dominance Model. The results revealed that most of the small businesses make only one move, from "efficiency" to "coordination" or from "efficiency' to "collaboration." Small businesses taking either one of these paths tend to avoid losing control and stay within their current markets. It was also observed that only 17 out of the 43 small businesses wanted to move to the "innovation" quadrant perhaps due to environment scan that indicated possible business growth.

BUSINESS PROCESS REENGINEERING

Business process reengineering (BPR) involves changes in structures and in processes within the business environment. A key stimulus for reengineering has been the continuing development and deployment of sophisticated information systems and networks. Redesign, retooling, and re-orchestrating form the key components of BPR that are essential for an organization to focus on the outcome that it needs to achieve. The entire technological, human, and organizational dimensions may be changed in BPR. Information technology plays a major role in business process reengineering as it provides office automation, it allows the business to be conducted in different locations, provides flexibility in manufacturing, permits quicker delivery to customers and supports rapid and paperless transactions (Wu, 2005).

The BPR technique implements organizational change based on rapid change, employee empowerment, and training and support by information technology. In order to implement BPR to an enterprise, the following key actions need to take place:

● Selection of the strategic processes for redesign,

● Simplify new processes – minimize steps – optimize efficiency – modeling,

● Organize a team of employees for each process,

● Organize the workflow – document transfer and control,

● Assign responsibilities and roles for each process,

● Automate processes using information technology,

● Train the process team to efficiently operate the new process,

● Introduce the redesigned process into the new organizational structure.

Applying BPR techniques to small businesses differ substantially from the way large enterprises deal with this issue. BPR concept requires an organization to have a strategy and then set business objective to achieve that strategy. In order to achieve the objective effectively, organization can apply BPR concepts to put the right processes in place (Rashaniphon, 2011; Wailgum, 2009). However, in the case of many small businesses, this classical approach may not be workable. Most of the successful people in small businesses are hands on persons and most likely they do not even bother about the word 'strategy', especially in the business environment of developing countries. It is more effective to try out hands on approach to make changes quickly. They are only looking for short term objectives.

Here are some guidelines that are especially relevant to small businesses (Mansar, 2007):

● Read the market for your business clearly by SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis,

● Develop a strategy that optimizes cost, quality, time, and flexibility,

● Execute the developed strategy by strengthening the processes identified for reengineering and without interfering unnecessarily.

Small businesses can leverage techniques and tools that have become increasingly available as open source software such as 'Alfresco' software for content management (Passerini, 2012).

Along with the traditional knowledge management processes that include acquisition/creation, storage and retrieval, dissemination and application, SMEs benefit from various size based advantages. For example, in the area of knowledge storage and retrieval, the proximity of project teams to the company owner enables quicker and more frequent transactions compared to large organizations.

BUSINESS DATA ANALYTICS

Small businesses are often intimidated by the cost and complexity of handling large amounts of digital information. In the past, companies seeking to tap into big data needed to purchase expensive hardware and software, hire consultants and invest huge amounts of time in analytics. But trends such as cloud computing, open source software, and software as a service have changed all that (Simon, 2013). Data analytical strategies can help small businesses, whose marketing budgets are limited; employ better web design and marketing concepts. Today, web designers and marketers have access to a wealth of information which makes for useful intelligence with proper application. It is important to focus on critical data required for the analytics process. In the first stage, data is filtered to keep only what is relevant for the business (Davenport, 2006; Davenport, 2007). Next, the particular metrics which will draw out people from the general pool who are likely to become customers is identified. In the third stage, web and data analytical tools are used to track Internet marketing campaigns and measure results. Lastly, the available data is analyzed to derive meaningful interpretations and structures that can inform both online marketing campaigns and design strategies to result in better customer management.

Data intelligence can be applied to strengthen search engine optimization (SEO) strategies and to raise customer engagement with the business, which is also important for effective web design (Smith, 2010). It gives small business more cost efficient and effective tools and information to track online marketing achievements and give more consumer targeted strategies. The online environment gives small businesses boundless room for expansion for their reach and visibility. Big data can be used to draw out customer intelligence for more optimal design and marketing strategies (Howso, 2008). Some of the ways through which small businesses can concentrate on

strategies which will enable them to reach a bigger audience without sacrificing the quality of engagement are listed below:

- Building a website to leverage the Internet's ability to broadcast your business to a geographically limitless audience,

- Leverage the knowledge and skills of web design/development experts to ensure your business website is able to offer the best user experience including better online viewing and navigation for site visitors,

- Apply data analytics to take stock of different mobile devices used by your potential audiences and ensure that your website design effectively renders on all these devices. It should fit their viewing behavior and be optimized for as many mobile platforms as possible,

- Use social media data and search engine optimization (SEO) metrics to grow your social media assets which will increase your business exposure in organic search and social media networks (Davenport, 2007; Wailgum, 2009).

Customer preferences are constantly changing, and data analytics provides a reliable tool to collect and process this information on consumer behavior and buying habits. Big data gives small businesses measurable metrics and intelligence which can improve the relevance of your site and content to your target audience. This is done through the use of predictive models like audience segmentation which can monitor your customers' buying habits to separate old customers from new, repeat customers from single-purchase ones, among others. Listed below ae some of the techniques that can be adopted:

- Customers are grouped as per their buying behavior and preferences, and the new segments are used to create more targeted messages

- Social data intelligence can be used to understand how and how much consumers are engaging with the business/brand on social platforms

- Intelligent algorithms and tools are applied to big data to give better customer insights and deliver targeted ads to every consumer

Customer data intelligence empowers small business owners by giving them more meaningful data to analyze customer behavior and business performance. Objective and valuable data thus

collected from internal and external resources can then help drive business growth, and help small businesses direct their limited marketing resources towards strategies that will result in the highest conversions, engagement and sales. Passerini (2012) in her case study of "Transport Designs" analyzes how a firm that used computers only for payroll and scheduling done on subjective guesswork evolved into a company that uses wireless Ethernet to transfer draft drawings from the design office's computer to the factory floor's computer.

FRAMEWORK FOR ADOPTION OF APPROPRIATE IT STRATEGY

Although technology can create new or modified business practices at a rapid rate, successful adoption of new best practices must stand up to market forces. Technology and the marketplace are continually reshaping business activities and as a consequence, business strategies. An organization must continually work towards an alignment that fits into the organization's business strategy and IT strategy. This alignment should improve the likelihood that new initiatives are explicitly linked to areas that are critical to successful business performance, provide a source of competitive advantage. The role of IT should be that of a strategic enabler for competitive success, rather than just an operational supporter.

In the first stage, existing business processes are examined. The number of processes is indeed very large as these pertain to upstream and downstream of the supply chain as well as operations related to the specific business. The gamut of these processes/interactions is also very diverse. The analysis is conducted along the three dimensions of complexity, criticality and cost. Socio-technical factors are considered in the second stage. Not only will this help towards transparency, but it will also make acceptance by constituents easier, Socio-technical factors pertain to exacerbated accountability dysfunctions that can occur as a consequence of automation. According to Bovens (2005) the major categories of dysfunctions are: Rule-obsession, and Proceduralism. Before manual procedures are automated, it has to be ensured that there are no problems due to such dysfunctions.

Rule-obsession or Output-obsession refers to the focus on outcomes over process. 'Proceduralism' refers to increased emphasis on procedures to avoid responsibility and

accountability. Strict adherence to procedures cam render the bureaucracy to lose the ability to balance procedures with corporate values. Relying heavily on encoded computer procedures can undermine the effectiveness of organizations.

Processes are restructured in the third stage. Automating legacy procedures that afforded plenty of opportunities for inefficiency will not yield results. At this stage, the results of data analytics are used to modify processes (Mills, 2015; Passerini, 2012). The main objective of restructuring various processes before transforming them into digital interactions is to improve the effectiveness as a system. When automated processes result in disintermediation, it is necessary that the relevant entities are on board with new procedures. After completion of the restructuring stage, we are ready for implementing in the fourth and final stage.

The degree of automation can vary across a wide range. Smith (2010) states a scale of nine degrees of automation starting from the first level where the computer offers no assistance to the ninth level where the computer decides everything. In between these extremes, there are several levels where a varying degree human-computer interaction occurs. The appropriate level of IT intervention depends on the particular interaction that has to be automated.

This framework also provides a means of evaluating extensive (if not comprehensive) series of business process transactions. Depending upon the value of the parameters of the given transaction, we are able to make inferences on the potential of that transaction for potential of IT intervention. This naturally opens up a wide arena of analysis, particularly for others who wish to specialize and focus specifically on the dynamics and characteristics of specific interactions where IT intervention is useful. This approach is effective since it focuses on specific critical processes of small businesses and renders overall improvement.

RESEARCH FINDINGS

In this section, we summarize the results of two business surveys conducted by the U.S. Chamber of Commerce in January 2018. The first survey consisted of a national poll of 1,000 small businesses and 50 state-level polls of 100 small businesses. The second survey was a

national consumer poll of more than 5,000 adults on the perceived benefits of digital platforms. Examining the use of digital platforms as a whole in the United States, the national survey finds that the use of digital platforms by small enterprises is ubiquitous:

● 84% of small enterprises are using at least one major digital platform to provide information to customers;

● 80% are using at least one major platform to show products and services, as well as to advertise;

● 79% are using digital tools to communicate with customers and suppliers, and

● 75% are using tech platforms for sales.

The national survey also revealed the importance of digital skills to managers in small businesses when hiring:

● 62% of small businesses surveyed stated that digital and social media skills are an important factor when hiring; a higher proportion reported this as a more important consideration than where a candidate attended school.

Even in a country with nearly universal Internet access, American businesses still view the cost of Internet services as a constraint to building an online presence: 55% reported that the cost of Internet and connectivity is a challenge. On the skills side, 57% of small businesses surveyed said that lack of familiarity with the digital tools available is a challenge. This finding suggests that even if a business obtains Internet access, it can be hard to know which tools to use. Recruiting skilled employees is a challenge for 61% of small businesses surveyed by the U.S. Chamber of Commerce in January 2018. Even when owners are able to successfully launch their businesses, they still have difficulty finding employees to expand operations.

One advantage to digitization is the ability to buy and sell across borders at a low cost. Of the small businesses surveyed, 27% reported selling goods or services to another country, a substantially higher proportion than the national proportion of U.S. firms that export. Yet, many small businesses are reluctant to trade internationally. When asked whether they think export activity is an important business activity, less than half of respondents stated that they believe that it is important to sell to other countries. Looking only at businesses that do not report

exports, 43% said that they do not think there is demand for their goods and services in other countries, and 40% said that international exporting is too expensive.

CONCLUSION

Small businesses can benefit from using techniques made available by emerging information technologies. New technologies are paving the way for new market creation. As a direct result of this, we have seen new small businesses emerging to cater niche markets as an alternative to impersonal commercial companies. Business process engineering and business data analytics have been used successfully in the corporate world. However, using these techniques for small businesses poses some problems. The basic building blocks of IT implementation consist of digitized versions of interactions among various business processes. In this paper, we have presented a framework that can identify and categorize the different types of business processes/transactions. Restructuring these processes and then automating them in a systematic way as suggested in this paper affords a practical approach to leverage information technology. Monitoring the critical success factors will help in evaluating the success of these measures. Future work in this area focuses on developing a comprehensive framework that will enable entrepreneurs and researchers to point out the potential priority areas that need to be automated first and also yield a realistic estimate of resources needed to achieve such transformation. In addition, such an approach will also help in giving a better insight into process restructuring.

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Appendix I. Kirchoff's Typology of Small Firms [Adapted from (Passerini, 2012)]

CONSTRAINED **High Innovation** **Low Growth**	**GLAMOROUS** **High Innovation** **High Growth**
CORE **Low Innovation** **Low Growth**	**AMBITIOUS** **Low Innovation** **High Growth**

Appendix II. Types of Small Businesses [Adapted from (Mills, 2015)]

The Four Main Types of Small Businesses

TYPES OF FIRMS	NUMBER OF FIRMS*	DESCRIPTION
Non-Employee Businesses	23 million	Sole proprietorships
Main Street	4 million	Local businesses serving consumers and other local businesses
Suppliers	1 million	Suppliers to other businesses (B2B) in the traded sector
High-Growth	200,000	Fast-growing, innovation-driven businesses

*ESTIMATED. **NOTE** AN ESTIMATED 500,000 SMALL BUSINESSES ARE NON-SUPPLIERS
IN THE TRADED SECTOR AND DO NOT FALL INTO ANY OF THE ABOVE CATEGORIES.
SOURCE ANALYSIS OF DATA FROM THE CENSUS BUREAU BY KAREN MILLS AND MERCEDES DELGADO   © HBR.ORG

Appendix III. Focus-Dominance Model [Adapted from (Qureshi, 2009)]

	Cost	Value Added
Low	Coordination	Innovation
High	Efficiency	Collaboration

Customer Dominance

Strategic Focus
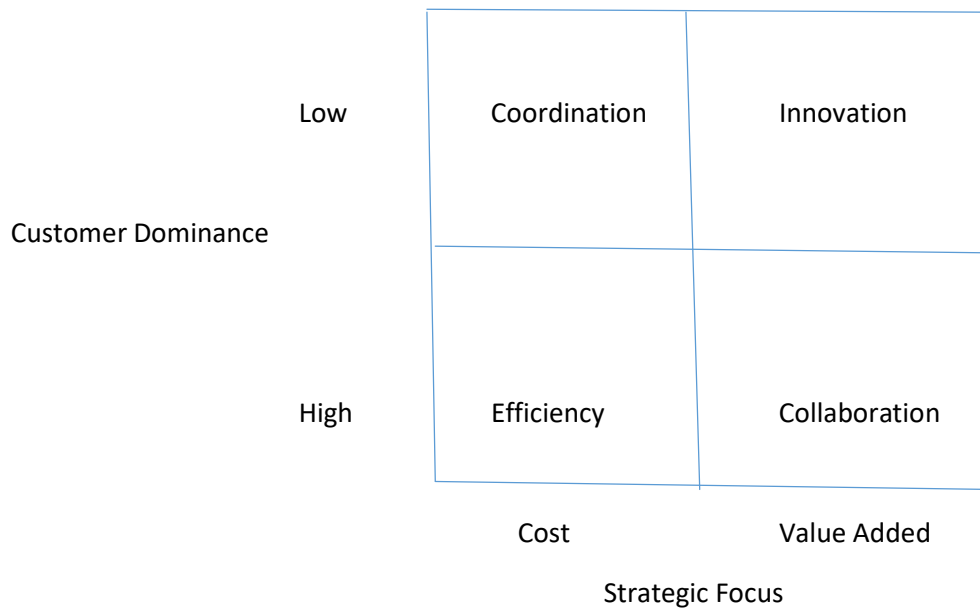
NETWORK STRUCTURE & COORDINATION IN ELECTRONIC MARKETS

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Introduction

Electronic markets provide researchers in economics and information systems a rich method for studying a number of economic theories. The social aspect of buying continues to be an intriguing area of study for researchers (Liang and Turban, 2012; Kaufmann and Wang 2001). Studying the complex interactions of buyers and the role social structures play in purchasing can be accomplished using a collective buying market where coordination and communication are the keys to successful bidding. While much of the research in collective markets has been focused on the buyer's behavior, such as the influence of communication and speed of bidding, little work has been done to explore the structure of buying groups.

Prior research in economic markets has focused on price, information exchange and coordination as driving factors (Hayek, 1945; Galbraith, 1952). Individual buyer and seller markets do not require coordination between buyers, but group buying, or collaborative markets, are highly dependent on coordination between the buyers in order to generate larger buyer surplus'. Coordination should allow buyers to get lower prices (Galbraith, 1952), however, coordination can occur in a number of ways. Coordination can occur through direct means such as verbal communication or electronic communication, or it can occur through indirect means such as price (Hayek, 1945). A group buying market facilitates coordination between consumers and, thus, represents a reasonable method to understand the effects of coordination in markets.

The objective of this research is to examine coordination based on the structure of the buying group, i.e. interactions between buyers in the group. We study the structure using Social Network Analysis techniques to determine if structure plays a role in the successful coordination measured by faster successful bids, and more buyer surplus, i.e. buyer profit. Using a

quasi-experimental electronic market, we will examine centralization measures of groups as a measure of structure. Previous pilots have shown that more centralized networks are slower to form groups and generate less buyer surplus (Pelaez et al., 2013). In this study, we limit group structuring mechanism, by controlling the group formation. Using SNA terminology groups are limited to a star, circle structure and all-wheel/channel structure (Freeman, 1978). In this manner, we are able to directly see how different structures affect performance. We implement a simple group-buying platform, using standard methods of experimental economics, and conduct a repeated-measure controlled experiment controlling for the structure manipulation on group performance.

Literature Review

Collective Buying Markets

Economists have used various electronic markets to study a number of different effects such as trust in online firms, purchase risk, loyalty, and flow (Battacherjee, 2002; Gupta et al., 2004; Wu et al., 2014; Koufaris and Hampton-Sosa, 2004). In specific electronic markets, such as auctions, consumer behavior plays an important role, especially considering the interaction between buyers and sellers or the interactions between buyers (Tai et al., 2012). The group buying process is different from traditional auctions in which bids are made and a seller accepts the highest bid. In a group buying market, buyers must agree on a collective bid, which is then presented to a seller for acceptance or rejection (Kauffman et al., 2010). This interaction between buyers to form a bid is considered a heterogeneous buying group and provides a richer set of data for the study of coordination, buying attributes, and interdependencies (Chen et al.,2007).

Previous studies in group buying have focused on customer value (Lee, et al., 2016), incentives and pricing mechanisms (Kaufmann et al., 2010) and social interaction (Lim, 2014). Factors such as trust and satisfaction increase intention to participate which can in turn increase levels of coordination (Shiau and Chau, 2015). Some studies have shown that due to the increased coordination, the group buying market can outperform traditional fixed-price

mechanisms (Chen et al., 2009). Coordination in these markets have usually been manipulated by buying group size, e.g. buying groups of 2 or 4, or by manipulating the method of coordination such as the introduction of communication channel (Pelaez et al., 2013)

However, to the best of our knowledge, there has been no research conducted specifically examining coordination on group performance in the context of economic experiments. Understanding coordination from a social network structure can provide more insight into factors leading to more coordination, identifying how different levels of coordination impact buyer surplus, and how different coordination structures affect the speed of successful bids.

Coordination Theory

Group buying auctions by their nature are very interdependent. The interdependence between each buyer requires a coordinated effort between buyers to reach an agreement on a bid to be sent to the seller. Coordination can be viewed as "the act of working together harmoniously" (Malone and Crowston, 1990). Even though there is a competitive nature in the group buying auction, the actions between buyers require coordination which can occur through price signals or direct communication. According to Malone and Crowston (1990) coordination theory refers to "a set of principles of how activities are coordinated and actors work harmoniously".

In group buying, it is clear that the primary activity is the group formation and submission of a successful bid; however, measuring the term 'harmoniously' can be a bit more elusive. A review of the literature finds that when discussing harmony within groups or economic societies, the term social cohesion or social harmony becomes relevant. Maxwell (1996) defines social cohesion in terms of shared values, where actors are engaged in a common activity with shared challenges. In economic markets, each individual should maximize their own value, however, in group buying the maximization of one's own value is dependent upon others. Therefore, since effective coordination is essential for successful bids, the feelings of cohesion between the buyers becomes an important factor.

Social cohesion and coordination are more process than outcomes (Markus and Kirpchenko, 2007). Malone and Crowston (1990) provide a framework for coordination theory, and identify four process levels. In the group buying market, the first process level is coordination, which refers to the goal of making a successful bid and the mechanism in the market by which the bids are made. The next level refers to group decision-making, in which buyers evaluate bids and determine which bid to join and submit to the seller. The third process level is communication in which the buyers use different means to communicate including price signals or direct communication. Finally, the last process level refers to perception of common objects, i.e. all buyers view objects such as actors, bids, seller equally. Coordination theory, therefore, provides a unique way to view the market, and, thus, explore ways in which coordination occurs, as well as identify the buyers perceptions of the process, products and other buyers within the market.

Social Network Analysis

Social network analysis is used to investigate social structures and the interaction between multiple actors through some form of connection (Otte and Rousseau, 2002). It is used across a variety of domains because of its usefulness in analyzing the interactions of groups. Since social network analysis measures the degree of dependence or interdependence among actors, it can provide useful information about the interdependence between actors. Increasingly, the social sciences are using SNA for a variety of analyses, especially when reviewing the influence of a single actor in the network or when reviewing the nodes together (Yang and Xie, 2016). Centrality measures are the key metrics for individual actors provided from Social Network Analysis (Freeman, 1978), and from these measures we can determine the level of influence of each actor.

In the economic literature, social network analysis has been used to study aspects of electronic markets such as the effects of price dynamics in online auctions (Dass et al., 2014), online reputation fraud (Wang and Chiu, 2005), and diffusion of information in auctions (Hinz

and Spann, 2008). Further, studies have used the technique to examine group performance. For instance, Shaw (1964) found that decentralized communication increased the performance of groups. Sparrowe et al. (2001), showed that decentralized groups are more interdependent because their outcomes are joined together. Group buying is considered a highly interdependent activity with joint outcomes, thus, decentralized groups should perform better (Chen et al.,2007). Other studies confirm the benefit of lower centralization leading to better performance including (Molm, 1994; Grund, 2012). However, Lee et al., (2013), did not find any performance difference between centralized and decentralized groups in an online gaming scenario.

Centralization measures are used to determine the characteristics of the network. There are three measures of centralization, degree, betweenness and closeness, each range from 0 to 1. Numbers closer to zero indicate a more balanced network while numbers closer to one indicate a more centralized network. Since balanced, decentralized, networks should increase the coordination and interdependence and thus lead to better overall performance. Balanced networks do not have any single actor controlling the bidding activity and thus should lead to more dynamic bidding.

There are three clear network structures which can offer comparative measures of performance. The wheel/All channel network in which all actors can bid with each other. The Circle network in which bids will only be engaged with neighbors. Finally, the star network in which one actor will be central to the network and be involved in all bids Freeman (1978), shown in Figure 1. The low centralization measures of the wheel and circle networks should enable all buyers to coordinate bids effectively and result in a more balanced network.
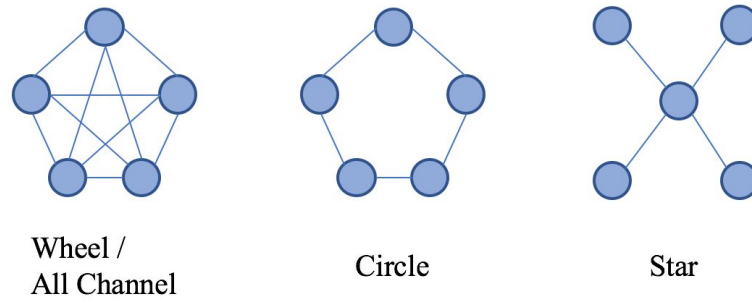
Network	Degree	Betweenness	Closeness
1) Wheel or All Channel	0	0	0
2) Circle	0	0	0
3) Star	1	1	1

Figure 1: Centralization measures of different types of networks (Freeman, 1979).

Research Question

We aim to add to the literature of electronic markets by understanding the effects of various structures on group performance. We measure successful coordination by specific performance measures, buyer profit and time to task completion. Galbraith (1952) suggested lower prices will come from more enhanced coordination among buyers. The group buying market enables buyers to obtain lower prices by increasing their coordination enabling aggregation of purchases (Anand and Aaron, 2003). Examining the structure could be an interesting research point since the coordination , in this experiment, is limited by the predefined structures from a social network analysis approach. Our goal is to identify the specific effects of specific network constraints and posit its direct effect on performance measured by buyer surplus and the time to successful bid. Thus, our first research question:

RQ1: Do more centralized group-buying structures impact the performance of buyers in the group as measured by time to task completion and buyer surplus?

Based on RQ1 we propose the following hypothesis:

H1a: A star structure will have a negative impact on time to task completion.
H1b: A star structure will have a negative impact on buyer surplus.

H2a: A circle structure will have a positive impact on time to task completion.
H2b: A circle structure will have a positive impact on buyer surplus.

H3a: An all-wheel structure will have a positive impact on time to task completion.
H3b: An all-wheel structure will have a positive impact on buyer surplus.

Methodology

We create a variant of a buyer initiated intra-auction group-buying economic model (Chen et al., 2009), in which the participants will attempt to coordinate their purchase of a single product from an automated seller. The experimental market is designed using the oTree software (Chen et al., 2016). The interface we created is a revision of a previously designed experiment using the zTree software for Economic Experiments (Fishbacher, 2007). Each buyer in the market is provided a unique willingness to pay value, in order to simulate heterogeneous demand among buyers. Each buyer in the market is asked to form a bid group but either creating a bid or joining existing bids.

Participants for the experiment will be recruited from a university in the Mid-Atlantic region of the United States. Each participant will receive a performance payout based on the outcome of their position in the market. Compensation increases the external validity, based on induced value theory (Smith, 1976), thereby enhancing more participation and engagement in the

market game. While the compensation may vary based on performance, each participant is guaranteed $5 to participate. Additional payments based on performance will be determined after pilot runs are completed in order to ensure a reasonable payout and remain within a stated budget. The manipulation for these sessions will consist of a particular network structure, i.e. internal rules will be developed to ensure that buyers can only join bids with certain buyers, thereby enabling the game to enforce a particular structure.

Procedure

Participants are brought into the experiment in groups of 5. Bid group formation is accomplished when three participants agree to place a bid with the seller. The study provides an element of competitive arousal by limiting the actual group bid formation to 3 people, i.e. 3 people must collectively agree on a bid price to be submitted to the automated seller. Since this experiment focuses on structure, buyers will be limited as to which bids they can join based on the structure manipulation. For example, if the manipulation is a "star structure", i.e. a central actor, chosen at random in each round, coordinates all bidding activities, then every buyer will only be allowed to see bids if created by the central actor or if the central actor is in a bid.

The automated seller will select a random number from a uniform distribution (50, 75). This value represents the "acceptable selling price", i.e. the amount at which the automated seller is willing to accept a group bid price (S_g). When 3 buyers form a bid, the bid is sent to the seller, which is then either accepted or rejected, if it matches or is above the "acceptable selling price". If the bid price is below the "acceptable selling price", the automated seller waits a random time (1-10 seconds) before rejecting the bid.

Buyers can create bids or join existing bids. Buyers will only see bids based on the manipulation being tested. Bids are sent to the seller when the minimum number of buyers have joined the group, in this case, three. Future studies may change this number to 5 or 7. If the offer is rejected by the seller, the buyers are notified and the buyers once again must regroup and

create a new bid. The process continues until the seller accepts the bid or the round terminates after a set amount of time 210 seconds.

The experiment for each buying group consists of one training/ pilot round to ensure the participants know the rules of the game and allow them to become familiar with the interface. Once the pilot round is complete, the game consists of 10 rounds, each round lasts 210 seconds, or terminates when a bid is accepted by a seller. Below in Figure 2, we show an example of the primary buyer screen.

Market

Buyer Screen					Time Left: 3:09
Last Offer Rejected					Buy Now
					36
					Buy Now

Open Offers				
In	Price	People Joined	People Needed	You Save
No	20	2	1	30
Yes	19	1	2	31

Rejected Offers		
In	Price	Savings
No	19	32

Your Limit	You Save	Your Last Bid	Your Bid
27	27	27	Submit Bid

Cumulative Profit: $39
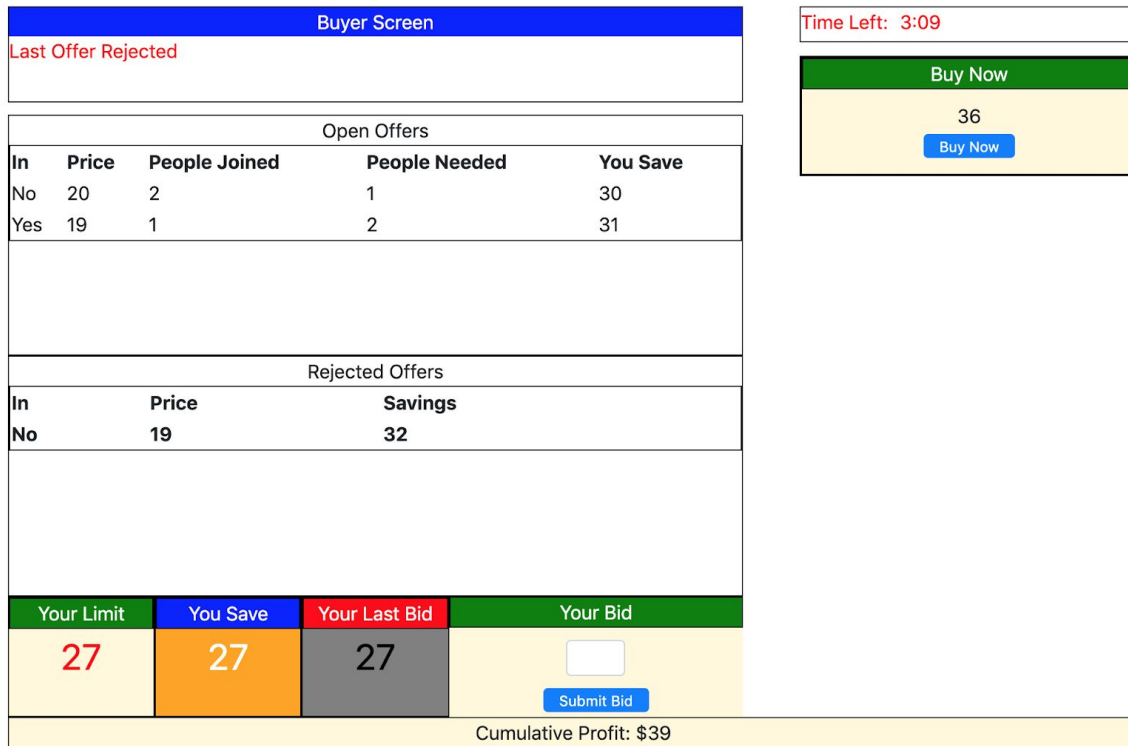
Figure 2: View of the Buyer Screen in oTree.

Discussion

This research provides methods and analysis for future research on the impact of structures in networked buying. The study suffers from external validity as markets generally do

not restrict who can buy or coordinate with each other; however, there may be some interesting findings as well as useful information. First, if the structure is found to be a significant factor in coordination, it could explain some discrepancies in economic literature between the price coordination debate from Hayek (1945) and Galbraith (1952). Second, by examining the different structures and their impact future economic experiments can use the information as a means of controlling for other effects, which may occur during economic experimental studies. Finally, practitioners could benefit from these outcomes by monitoring group buying behavior and identifying structural changes over time in bidding groups and possibly provide alternatives to buyers to mitigate any structural effects.

Conclusion

Economic experiments help provide support for existing economic theories, or provide counterarguments (Smith, 1976). Group buying experiments add to the literature in a specific variant of auction-style experiments. Group buying experimental studies have shown the effect of price, group size and communication effect on buyer surplus and time to task completion in an attempt to study the Hayek Hypothesis and Countervailing Power (Pelaez et al., 2013). This experiment seeks to contribute to the literature by designing an economic experiment specifically focused on the structural effect of coordination.

Specifically, we aim to explore the effects on buyer surplus and time to task completion given the constraint of network structure. It is believed that more restricted structures will reduce buyer surplus and increase the time to task completion. While more open structures buyers should be able to coordinate more freely and faster, thereby receiving higher buyer surplus

Finally, upon the conclusion of the experiment, we aim to determine the attitudes toward the market and toward the other buyers. It is hoped that we can identify how the structures impacted the overall attitudes and how these structures affect the bidding process. It is hoped that by studying the structure and coordination effect, we will have a strong contribution to the literature on group buying electronic markets.

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RSM AUDIT SOFTWARE

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Abstract

The purpose of this paper is to discuss RSM US LLP's current audit software, CaseWare. The paper will outline some of the deficiencies in the program and it will outline possible solutions to the problems. The study will consider whether RSM should adopt a new information system entirely or if there are more efficient ways to overcome the challenges associated with using the software.

I.   Introduction

The purpose of this paper is to discuss RSM US LLP's audit software. It will discuss the purpose and importance of the information system and will identify current problems and challenges the company faces in relation to its audit software. Moreover, the paper will discuss both the benefits and the deficiencies of the software to make an informed decision about the effectiveness of the information system and the overall purpose and significance of audit software.

II.   Company History

RSM US LLP (RSM) is a limited liability partnership and the U.S. member firm of RSM International, a global network of independent audit, tax and consulting firms. RSM is the fifth largest audit, tax and consulting firm in the United States, generating more than $1.9 billion in revenue. RSM owns and operates ninety offices in the U.S. for which they manage over nine thousand employees. The firm has a presence in more than 120 countries and generates roughly $5.1 billion (U.S.) in worldwide revenue with more than 43,000 people in over 800 offices globally.

In 1926, I.B. McGladgrey Co. was founded in Cedar Rapids, Iowa. Some of the most significant milestones in the firm's history include the initiation of offering consulting services in 1934 and the firm helping lead the American Institute of Certified Public Accountant's (AICPA's) adoption of Statement 23 in 1949 which outlined standards for accounting and review

services. The firm has undergone many name and brand changes throughout its history as a result of several acquisitions and mergers. In 1978, the firm merged with Broeker Hendrickson, becoming the Midwest's largest accounting firm. They then merged with A.M. Pullen and Co. in 1984, expanding to the Southwest region and surpassing $100 million in revenue. In 2005, the firm acquired tax and business services (AMEX) and became the first firm outside of The Big Four to pass $1 billion in revenue. In 1999, they sold non-attest to HRB but retained their affiliation with ASA and, by 2010, they launched the new McGladrey "master brand." In November 2011, McGladrey and Pullen acquired RSM McGladrey and by May 2012, the firm became McGladrey LLP. Most recently, in October 2015, the firm adopted the RSM global brand and became RSM US LLP (rsmus.com, n.d.).

III.   Company Overview

RSM is in the business of public accounting, offering audit, tax, and consulting services. RSM focuses on serving clients in the middle market which they define as a collection of companies that generate between 50 and 500 million dollars in revenue. While many of RSM's clients generate more than 500 million dollars in revenue, RSM recognizes the potential of their smaller clients and seeks to help them grow in the middle market. In terms of their audit services, they perform financial statement audits for private and public companies, governments, not-for-profits, and financial services including hedge funds, 401k's, banks, and employee benefit plans. They also perform audits of internal control over financial reporting and compliance audits. In addition, they perform reviews and compilations, offer preparation services, and offer attestation services, including service organization controls reporting. RSM also offers services in lead tax, international tax, state and local tax, corporate tax, private client services, wealth management, credits incentives and methods, as well as mergers and acquisitions/ private equities. Their consulting services include financial advisory, risk advisory, and technology management and consulting. RSM handles financial investigation and disputes, transaction advisory, valuation, health care advisory, real estate consulting, national gaming and hospitality consulting, and financial institutions advisory. Their risk advisory services relate to internal audits and Sarbanes Oxley, IT risk, security and privacy, enterprise governance and risk regulatory compliance, anti-money laundering and regulatory compliance, and service organization assurance. Their technology and management consulting services involve

management consulting, business applications (ERP and CRM), infrastructure, application development and integration, finance and accounting outsourcing, business intelligence, and health care IT (rsmus.com, n.d.).

IV.   Auditor's Duties and Responsibilities

Auditors are expected to develop strong working relationships with clients built on an understanding their businesses and challenges. They are also expected to understand clients' needs and expectations, their business and industry, accounting and control systems, employees, company values and industry-related Generally Accepted Accounting Principles (GAAP) and Generally Accepted Auditing Standards (GAAS) issues. Auditor's duties and responsibilities include assessing risks and evaluating client's internal control structures, performing substantive tests and tests of internal controls to identify and resolve accounting or reporting issues, and drafting financial statements under prescribed formats.

Growing awareness of Certified Public Accountant's (CPA's) responsibilities, increased efforts by the Securities and Exchange Commission (SEC) to protect investors, and increased complexity of accounting increase the number of lawsuits involving CPAs each year, especially in the audit profession. Auditors are subject to significant legal liability and, because we live in an increasingly litigious society, CPAs are more vulnerable than ever to lawsuits. The Sarbanes-Oxley Act of 2002 greatly contributed to the increased legal liability auditors are subject to as it requires them to express to an opinion on the effectiveness of internal controls for large public clients, which could expose CPAs to legal liability solely based on their opinion. Recession resulting in business failure and business failure in general make it difficult for both financial statement users and the public to differentiate between business failure and audit failure. CPAs will be subjected to more legal liability in the coming years, a product of new auditing standards, federal laws, the increased complexity of accounting, and the culture around litigation.

When performing an audit, the auditor must obtain appropriate and sufficient evidence to support the audit opinion that the firm issues. There are four primary types of audit opinions that RSM, like every public accounting firm, can produce. An unqualified audit opinion indicates that there are no material misstatements in the company's financial records to the auditor's knowledge. An auditor may issue a qualified opinion if there is no evidence of material misstatement; however, something is preventing the auditor from issuing an unqualified opinion.

An auditor may issue a qualified opinion, for example, if the financial records are not produced in accordance with a necessary accounting standard such as GAAP. A disclaimer may be issued if the auditor is unable to express an opinion at all. For example, an auditor may not be able to express an opinion on the presentation and disclosure of a company's financial statements if appropriate testing could not be performed for any reason. Lastly, an adverse opinion indicates that there is a significant misstatement in the company's financial records.

To support the auditor's opinion, the audit team must have a comprehensive trail of audit evidence in their workpapers. Audit evidence is the documentation collected by an auditor when reviewing financial accounts, internal controls, and other materials that confirm a client's financial statements ("Audit Evidence," 2018). There are seven primary types of audit evidence: observation, inspection, inquiry, recalculation, confirmation, analytical procedures, and reperformance. An engagement team must document all of the evidence obtained in one location, especially because the files can be subpoenaed if the client were to sue RSM for issuing an incorrect opinion. Each individual piece of data must be linked to a verifiable source to prove the accuracy, completeness, and origin of the information. Essentially, auditors must document how they obtained the information, how they can prove that it is correct, and if the data is reflected accurately on the financial statements. Auditors use workpapers to document the evidence they obtained throughout the audit. The workpapers the engagement team used to document their findings is stored in one central location called audit software. In the program, you can find the audit plan, the procedures the team intends to use, the client's financial statements, a risk assessment, and the testing the team conducted. Most, if not all, of the testing the team conducts will be done using the audit software.

V.   RSM's Audit Software

RSM's current audit software is CaseWare which was especially designed for conducting assurance and reporting engagements. The program allows different members of the engagement team to collaborate in real time in the same file. It also includes a special feature called CaseView that allows the auditors to create financial statements and other intelligent documents based on the project. The program seeks to provide an easy way to link source documents to reported information and allows the auditor to easily import crucial audit documents, including trial balances and general ledgers, into the software. If a member of the engagement team has an

outstanding item or a problem they would like someone else to review, he or she can create an "issue." That individual can then track the progression of the issue and review other team member's notes until the issue is resolved. When a task is completed, a team member will "sign-off," indicating that the task is ready to be review by a manager or a partner. When a team member signs off on a task, their initials are shown next to the file name so other members know not to continue working on that specific task. Moreover, if a task is in progress, a team member can mark the task as "in progress" with their initials so other team members know not to work on that specific task. RSM frequently audits the same clients over several years. Rather than creating a new file, CaseWare allows the team to roll their workpapers forward to the following year. The program also has an add-on that allows the team to automatically synchronize the data they input into the program with Microsoft Word and Excel templates. Their technology also allows files to be synced and saved automatically. If a team member is not connected to a wireless network, the file will be synchronized the next time the device is connected (CaseWare, n.d.). While the program's synchronization technology is intended to be easy and seamless, plenty of synchronizing issues and conflicts arise.

VI.   Current Problems and Challenges

We will exemplify Miss Lisa Smith's experience to discuss the current problems and challenges of using CaseWare at RSM.

After conducting an internship with RSM, Miss Lisa Smith accepted a full-time position as an auditor. During Lisa's internship, she was assigned to a client that entered into chapter 11 bankruptcy in early 2018 and was acquired by a private equity group (PEG). This specific PEG is the largest in terms of revenues RSM generates from clients. While they are a 3/31 filer, because of their recent bankruptcy and acquisition, Lisa's engagement team was performing two audits. One Wednesday afternoon, Lisa was working at the client site with her engagement team. After traveling about thirty minutes to Jersey City, New Jersey, Lisa walked into the conference room, placed her company issued computer on the table, opened CaseWare, and begin writing the payroll narrative in the audit software. The objective of the payroll narrative is to identify the procedures and relevant control activities (including management oversight controls) integral to the achievement of the relevant control objectives or that addresses the risk of material misstatement that the engagement team noted on the payroll APS (Audit Procedures Sheet) in the

audit software. In the narrative, Lisa, first, outlined the client's hiring process by discussing how a search for a candidate occurs, who interviews a candidate, who is involved in compensation determination, where candidate and new hire files are kept and who has access to them, what type of information they have on file for new hires (such as applications, I9's, W2's, direct deposit forms, and union paperwork), and who approves wages once they are calculated. Lisa then discussed salaries and pay increases by summarizing when pay raises are determined and are effective, who determines an employee's salary increase, if salaries are merit or performance based, if there is a tracking file to show a list of all employees who received a pay rate change and how it was determined, who approves pay rate changes, and if the pay rate change is reflected by their payroll provider and ultimately the general ledger. Lisa also discussed who is responsible for terminations, who approves terminations, and if exit interviews are conducted. Lisa went on to discuss bonuses- specifically, how they are determined, who approves them, when they are paid, and where the compensation amounts are kept. Lisa then described how the company ensures that payroll transactions are properly initiated and recorded within the general ledger, when payroll is processed and paid, how often employees are paid, who approves timesheets, how employees are paid (direct deposit or check), how CAD payroll is reconciled to USD, and what type of reports are generated from their payroll provider. Lisa continued writing the payroll narrative until it was completed. Lisa then uploaded the narrative into the payroll APS under the "Internal Control Understanding and Evaluation" section in CaseWare. Lisa was hopeful that the narrative would help the engagement team plan audit procedures around payroll and determine whether control activities relevant to the audit were implemented. After writing this extensive narrative and submitting it on CaseWare, Lisa moved on to operating expense testing. Soon after, however, Lisa received a notification on the bottom right hand corner of the application that said "sync conflict." This was the first time Lisa had seen a message like this as Lisa had only been working for RSM a few weeks and this was the first client Lisa was assigned to. Lisa soon realized that the other members of her engagement team received the same message. Matt, the manager of the engagement, worked closely with Lisa and was sure to review her work often. After realizing that there was a sync conflict, they worked together to try to understand why. They ultimately realized that both of them were working in the same APS at the same time and when Lisa saved her work, it deleted his version of the APS and replaced it with Lisa's. They spent several minutes discussing what Lisa had in her version and what they had in

his to decide which version they wanted to keep. They did have the option to delete Lisa's version and replace it with Matt's to resolve the sync conflict; however, Lisa included the entire payroll narrative in her version which took several hours to complete. They ultimately decided to override Matt's version with Lisa's. Matt then had to go back into the payroll APS and redo all the work that he completed prior. The same issue occurred several times throughout the coming months and Lisa quickly realized that sync conflicts were a huge issue for this program. Because sync conflicts are so common, multiple people cannot work on the same file at once. Moreover, having multiple people using the audit software in general, even if they are working on different tasks, can slow the program down. Additionally, CaseWare allows engagement team members to work in a file when their device is not connected to a wireless network and, once the device is connected, the file is uploaded to the cloud. However, the file is not uploaded in real time if a member of the engagement team is working in the file and not connected to a wireless network which can set the team back, waiting for a file to be uploaded. CaseWare also provides what seems to be an excessive number of features that are not necessary for every level, department, or industry. As an intern, it was difficult to learn how to use the software when Lisa had access to a large number of programs that Lisa did not need. For example, Lisa had access to programs specific to government and not-for-profit clients despite the fact that Lisa did not specialize in that industry. Lisa also had access to files that were only relevant to the manager and the partner on the audit.

VII.   Interview with Management

In an interview with Mike, a senior manager at RSM, Lisa and Mike discussed some of the deficiencies in the company's current audit software. Lisa began the interview by asking Mike what problems or challenges he has encountered when using CaseWare. Mike responded, "In my opinion, the biggest issue with CaseWare is the sync issues when someone is offline or when two people are working on the same workpaper without knowing it." Mike explained that on several occasions throughout his career with RSM, his version of the file was deleted or he had to override someone else's version with his. Lisa continued the interview by asking if, given his extensive experience with the software, he had any possible solutions to the problem. Mike explained that he did not think it would be feasible to change to a new audit system entirely for a few reasons. "For starters," he explained, "it would severely impact the consistency in past audits

and availability of data for future years when continuing to audit the same clients." He also explained that the cost of upgrading or implementing a new system would not be effective. Mike also expressed concerns about the amount of time it would take to update and implement a new system and how that could negatively impact ongoing audits. "CaseWare files are in use throughout the entire year. Changing the system could really impact audits and tax preparations that are in progress because there would be no down time to upgrade all systems," Mike explained. RSM also trains new hires internally with CaseWare and Mike explained that it would be far too difficult to continue having training in house if we were to implement a new software. It would take a significant amount of time to train management who would then need to train the lower level employees. In terms of sync conflicts, Mike says, "I personally think that the most obvious solution for someone being offline is for CaseWare to not allow any work to be conducted when someone is offline so that any sync updates are done in real time. Similarly, there should be alerts to anyone trying to access a file that is already in use by someone else."

VIII.   Conclusion and Recommendation

Ultimately, the senior manager at the firm made great recommendations about how to resolve sync conflicts. Logistically, it is not reasonable to adopt a new information system entirely mainly because audits are occurring year-round and the auditors would need to access previous years' files in future years. Instead, RSM should consider ways to alert engagement team members when they open a file that is already in use. Whether it is as simple as requiring team members to communicate with the group what file they are working in verbally or via instant message, or whether RSM finds a way to create alerts via CaseWare to let them know that a sync conflict may occur. As discussed, when team members are working remotely and do not have wireless internet access, their work is not uploaded in real time; instead, they must wait until they are connected to a network for the file to be uploaded to the cloud. Lisa suggest that RSM provide personal hotspots to their employees so they are able to have their work uploaded in real time. Of course, RSM must weigh the cost-benefit of paying for the use of personal hotspots. However, if it will eliminate such a pervasive issue, it may be worth the capital outlay. RSM should first try to understand the pervasiveness of the problem by conducting an employee survey and then determine if the issue is wide-spread enough to invest in personal hotspots. RSM should also consider limiting the number of features it provides their new and lower level

employees to eliminate confusion and only provide them with what is necessary for their respective position. While RSM has an information technology department, Lisa would also recommend that RSM create a position specifically for information system management. An information system specialist would streamline questions and concerns about the software itself and think of new and innovative solutions to current problems. This person, for example, would spearhead efforts to creating an alert system that minimizes sync conflicts.

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Synthetic Average Neighborhood Sampling Algorithm (SANSA): A Neighborhood Informed Synthetic Sample Placement Approach to Improve Learning from Imbalanced Data

Machine-learning classification models are increasingly being used in both real-world applications as well as in academic literature. However, many real-world phenomenon happen much less often, and thus are more interesting and in many cases much more high-stakes to predict. In this work, we propose a new synthetic data generation algorithm that uses a novel "placement" parameter that can be tuned to adapt to the each datasets unique manifestation of the imbalance. SANSA also defines a novel modular framework to rank, generate and scale the new samples, which can be used in the future with other functions to propose better methods.

Innovation and Creativity - Abstracts

Cybersecurity Policy: Is it worth the risk?

Innovation and Creativity

Dr . Carolyn LaMacchia [1]

1. *Bloomsburg University of Pennsylvania*

Responding to a sophisticated threat environment, innovative cybersecurity solutions protect an organization's financial assets, reputation, and stock value. Creative solutions may include the exchange of unquantifiable cybersecurity risk for a known cybersecurity policy premium. Another approach is to mitigate the exposure through the incorporation of an analytic-driven security information and event management (SIEM) system within the cybersecurity policy. This study analyzes the emerging innovative solutions in the management of cybersecurity policies. To investigate the impact of these solutions, the study considers a collection of Fortune 1000 companies with cybersecurity breaches that occurred from 2015 through 2019.

Development and Testing of a Creative Strengths Instrument

Innovation and Creativity

Dr . Eric W. Stein [1] **_, Dr . Denise Potosky_** [1]

1. *Penn State*

Successful business organizations must innovate in order to remain competitive and innovation requires creative people. Identifying those people is non-trivial.

The purpose of this work was to develop, refine, and test an instrument to measure creative strengths in four key areas: improvisation, design thinking, experimentation, and aesthetic awareness.

The presentation will describe conceptualization of the measure, the measurement model, how the instrument was developed, how scales were refined and purified using factor analysis, validation procedures and normative values for scales.

We will briefly discuss applications of the instrument and how instructors may use the online instrument for teaching or research.

The impact of organizational 'mindset' on innovation

Innovation and Creativity

Prof . Heidi Hughes [1] *, Dr . Hyoun-Sook Lim* [1] *, Dr . Caleb Bragg* [1]

1. Central Connecticut State University

To remain competitive and relevant to the marketplace, organizations need employees to engage in innovative practice. Many studies have made an attempt at understanding what leads to innovation. This study builds on existing knowledge by using Dweck's motivation self-theories or 'mindsets'. While much of Dweck's theories are used in pedagogical studies, there is scope for using the theories in organizational behavior studies. This study will a) extend existing knowledge regarding the relationship between organizational 'mindset' and innovation across organizational levels, and b) develop new knowledge by demonstrating that 'mindsets' can be used to describe an organizational culture of thinking.

Legal, Ethical, and Social Issues - Abstracts

Leading Human Resource Strategy for Diverse Cultures

Legal, Ethical, and Social Issues

Prof . Glen Vogel [1]

1. _Hofsta University_

Properly managing diversity and inclusion helps enable companies to reduce the costs associated with employee absences, high-turnover, legal expenses, and decreased productivity because companies that respect and value diversity and inclusion are able to attract and retain the best employees in their field. Effective diversity management and inclusion is achieved when they are valued by all levels of management there is a culture within the organization that supports diversity and inclusion initiatives. HR managers play an important role and as catalysts to help define an organization's approach to these issues, which, ultimately, will positively impact individual, team, and organizational performance.

MELDING ETHICAL BEHAVIORS INTO LEADERSHIP EXPECTATIONS. SEEKING TO MAKE THE PHRASE, 'ETHICAL LEADERSHIP' NO LONGER NECESSARY.

Legal, Ethical, and Social Issues

Dr . Maureen Mackenzie-Ruppel [1]

1. _Molloy College_

Remember 'E-Commerce'? It was a distinct and emerging discipline. Now E-Commerce concepts are easily integrated into traditional business courses. The term 'e-commerce,' seems redundant. YET, we as scholars still maintain a distance between '_Leadership'_ and '_Ethical Leadership'_. When will the phrase, '_Ethical Leadership_,' fade from the business vernacular as redundant? As scholars, we can study the distinction and seek to meld them so fully that the terms become synonymous. This paper presents an educational path to help leaders see the overlap so that each can develop a personal roadmap to tightly integrate the concepts into their business practices.

Recruiting For Success. Does Board Diversity Matter?

Legal, Ethical, and Social Issues

Ms . Meg E. Cotter Mazzola [1] , **Mr . Joseph L. Pontacoloni** [1] , **Mr . Angel Claudio** [1] , **Mr . Javier A. Salguero** [1] , **Mr . Marcelles James** [1] , **Prof . Robert Yawson** [1]

1. *Quinnipiac University*

Nonprofits are obligated to have an active board of directors to operate. This reliance places the organization in a vulnerable position where they must recruit and engage with external stakeholders and identify individuals with the combination of talent needed to succeed as well as the passion for supporting the organization's vision. We explore motivation as it relates to governance boards and the value of diverse board composition and whether certain criteria of diversity carry more weight in terms of impact than others.

The 2013 AACSB standards – Has there been Continuous Improvement in terms of Ethics?

Legal, Ethical, and Social Issues

Dr . Lori Koste [1]

1. *Grand Valley State University*

While ethics has always been recognized by the AACSB, the 2013 accreditation standards increased the emphasis on this discipline. Ethics is now a required general skill area and general business knowledge area. These standards have been in place for more than five years, and given the timing cycle of AACSB maintenance and (re-)accreditation visits, may now be more prevalent within business school curriculums. Did this change to AACSB requirements bring about greater ethics inclusion within those accredited programs? This study explores the presence of stand-alone ethics courses across the pool of US undergraduate AACSB accredited business programs.

The Legal and Ethical Considerations of Using Social Media in the Recruiting and Hiring Stages of Employment

Legal, Ethical, and Social Issues

Prof. Bruce Haller [1], *Prof. Daniel Ball* [1]

1. *Molloy College*

The use of social media in the recruiting and hiring process raises both legal and ethical considerations for employers. The obvious potential for abuse has generated legislative action, ethical debate, and an extensive search for best practices.

This paper will examine the current legal parameters of the use of social media at the recruitment and selection process stages of employment. The ethics and appropriate ethical considerations of social media as a component of the hiring process will be examined using the DB Weighted Scoring Model. Finally, recommendations for best practices will be recommended.

Legal, Ethical, and Social Issues - Papers

Leading Human Resource Strategy for Diverse Cultures

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Synonyms
Inclusion; Affirmative Action; Diversity Education and Training; Recruitment and Retention; Professional Development; Performance Appraisal; Compensation Equity; Diversity; and Diversity Audit

Cross References to other Chapters
Harassment in the Workplace
Workplace Bullying
Affirmative Action in Business
Racial & Ethnic Diversity in Business
Managing Diversity

INTRODUCTION:

While the concept of diversity, as an issue for U.S. businesses to focus on, really only gained traction in the late 1980's, in the past two decades, the realization that there is a strong connection between diversity and having a competitive business advantage has increased as businesses have expanded their activities into the global marketplace. Workplace diversity acknowledges the reality that people differ in many ways, visible or invisible, including races, ethnicities, genders, ages, religions, disabilities, and sexual orientations, and these same people may also have differences in education, personality, skill sets, experiences, and knowledge bases that all need to be understood, accepted and valued (Shen, Chanda, D'Netto & Monga 2009). It is no surprise then, that the increase in internationalization and globalization of businesses has exacerbated the importance of workplace diversity. Diversity itself, however, is neither meaningful nor beneficial if it does include the creation of an environment of inclusion. Inclusion means going beyond compliance-based, minimum requirements-set-forth-by-law prerequisites to create a place of business that actually harnesses and maximizes the talent of the company's greatest asset: its people (Danna). One study found that companies more often gave more weight to diversity than inclusion when it has been shown that diversity plus inclusion is what leads to improved business performance (Deloitte 2013). As such, diversity and inclusion

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together are essential components of a healthy and successful organizational culture. In fact, this same study found that when employees think that their company is highly committed to, and supportive of diversity, **and** they feel highly included, then they are 80% more likely to agree that they work in a high performing company (Deloitte 2013).

One of the more critical aspects of a Human Resource professional's job is to create and cultivate an environment supportive of the different experiences and perspectives among their particular organization's workforce to ensure that it attracts and retains talent, which is one of the many ways a business can remain competitive in the marketplace. Moreover, effective HR professionals must develop strategies that focus on improving the organization's flexibility and knowledge base to foster and cultivate a work environment that is conducive to diversity and inclusion management. After all, diversity and inclusion management are not just a part of what human resources managers do, they should be critical components of their company's practices and policies. A workplace that supports diversity and inclusion attracts top talent because talented people naturally gravitate towards organizations that embrace diversity in such a way that it can yield meaningful career paths for these engaged and motivated employees.

Diversity and inclusion are no longer simply compliance-based, meet the minimum requirements of the Equal Employment Opportunity Commission (EEOC) or Affirmative Action (AA) expectations; rather, they are now considered important aspects of successful businesses. They are also the natural result of what science tells us is people's deep-seated need to belong and to be noticed and appreciated.

DIVERSITY AND INCLUSION MANAGEMENT

Managing diversity refers to a proactive approach intended to manage a heterogenous workforce in such a way that potential advantages of diversity are maximized while its potential disadvantages are minimized (Kundu, Bansal & Chawla 2015). That means, enabling a diverse workforce to perform to its full potential in an equitable work environment where their individual differences are deeply valued to build a more effective and profitable organization (Kundu, Bansal & Chawla 2015). Inclusion can be described as an active process of change or integration, as well an outcome, such as a feeling of belonging. Inclusion means that the

employees feel that they work in a place of fairness, respect, value and belonging and that their unique value is known and appreciated (Deloitte 2013).

In the past, the efforts to diversify a workforce were driven by a need or desire to insulate a company against claims of discrimination. Concepts of Equal Employment Opportunity (EEO) and Affirmative Action (AA) were largely born out of the civil rights movement of the 1960s (Shen, Chanda, D'Netto & Monga 2009). The modern, twenty-first century concept of diversity management and inclusion is a departure from the negative connotation of the past, rather, it is focused on the positive attributes that accompany a diverse and inclusive workplace. In a nutshell, diversity management "takes advantage of the growing cultural pluralism that results from the internationalization of business, development of world markets, growing workforce mobility, and the increasing awareness of individual differences" (Shen, Chanda, D'Netto & Monga 2009).

OBJECTIVES AND PRACTICES OF DIVERSITY MANAGEMENT AND INCLUSION
While one of the obvious objectives of human resources diversity management is to be compliant with EEO and AA requirements, human resources managers also need to realize that additional objectives include assembling a workforce/workplace that is creative, flexible, attractive to future employees, and aides in retaining the current workforce. In order to achieve these objectives, human resources managers need to incorporate the mindset of diversity and inclusion into every aspect of their role as people managers. They need to develop a culture that unifies diverse employees under a common value set which will, in turn, help the company embrace diversity as a tool for augmenting organizational effectiveness and performance (Kundu, Bansal & Chawla 2015). Because the effects of diversity can be positive, negative, or neutral, depending on how well it is managed, as well as if the environment is one of inclusion, it is imperative that a company's diversity management strategy address organizational cultural change to insure that diversity is both valued and encouraged (Kundu, Bansal & Chawla 2015). Achieving a diverse and inclusive workplace is not something that can be achieved overnight or without significant effort. In the constantly changing and evolving landscape of business it can be difficult to find new ways to connect diversity and inclusion to business value and, in turn, shape a workplace culture that thrives even in the most unpredictable business climates.

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BUILDING A FOUNDATION OF DIVERSITY AND INCLUSION

HR professionals should lead the charge to create a business environment that fosters inclusion. Unfortunately, when it comes to issues of diversity and inclusion, most organizations tend to take knee-jerk or "band-aid" type actions without incorporating both into the foundation and culture of the business itself. Some of the barriers that HR professionals must overcome when taking a leadership role in implementing systematic and comprehensive diversity and inclusion education programs are: (1) to many educational programs are stand-alone or piecemeal programs that lack a connection to a cohesive organizational diversity management framework; (2) the absence of an auditing or process for measuring the acquisition and application of learning to the workplace; (3) lack of diversity in the facilitators of the diversity education programs; and (4) failure to include all levels of employees in the diversity development process (Chun 2018).

Inclusion can only be successful if it starts with building a solid business culture foundation that supports its goals and objectives. That means that businesses first need to define what kind of culture they would like to exist in their workplace. While this is often accomplished from a top-down perspective (senior management dictating to the masses), it is essential to realize that many of the most effective ideas for inclusion can come from below. Next, the business needs to self-assess the existing cultural strengths and weaknesses with the organization. This will also help identify assets that already exists that can support and reinforce the diversity and inclusion mission as well as identify areas that need improvement. After that, the organization can reach out and form focus or identity groups to bring people together to solicit ideas. This would be followed up by collecting those ideas, along with any data that is mined in the process, and then develop strategies, policies, and education programs to implement whatever ideas the organization feels best support its diversity and inclusion mission. In a nutshell, HR managers should be the researchers that gather the data needed to develop the most effective diversity and inclusion initiatives and they can also act as the advocates for the program since they have the ability to communicate across the different departments and focus groups. HR managers, in effect, are both facilitators and influencers, all the while aware of the various political nuances that exist within a particular business to help protect and nurture the diversity programs, support

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all of the various participants, and to think strategically while being mindful of the long-term and short-term goals to support the diversity and inclusion mission (Gutmacher 1998).

HR'S ROLE IN DIVERSITY MANAGEMENT AND INCLUSION

Diversity management and inclusion are not separate activities that HR professionals engage in; rather, they are integrated into the various practices and policies of the core functions of their practice: recruiting talent, performance management, benefits, pay issues, education and development. Throughout an employee's lifecycle there exists critical points where the employee is more vulnerable to decision-making bias or behaviors that can unconsciously create an advantage for some and a disadvantage for others that undermine aspirations of diversity and inclusion (Deloitte 2013). Diversity management and inclusion should be integrated not only into these vulnerable moments, but into the fabric of equality of opportunity, flexible working hours, work-family balance, meaningful and participative performance assessment, and inter-cultural education (Kundu, Bansal & Chawla 2015). In the end, all businesses would prefer to recruit, retain, reward, and promote a heterogeneous mix of talented employees. Moreover, employees would prefer to work for a company where promotion and development opportunities were based on merit, recruitment processes supported the selection of the best person for the job, and performance management/appraisal processes enabled employees to demonstrate their particular and unique skill set (Deloitte 2013).

1. **Diversity as Part of Recruitment**

    Many companies have been successful in hiring a more diverse workforce that includes women, minorities, disabled persons, and other socially disadvantaged persons in a way that resembles the more diverse environment within which they are situated. To support an effective policy of diversity and inclusion HR managers need to help managers make hiring and promotion decisions based on diversity sensitive criteria. That includes having visible diversity in hiring committees as well as hiring and promotional decisions based on specific job-related qualifications, competencies, and experience (Kundu, Bansal & Chawla 2015). In order to attract a diverse array of candidates, HR managers need to also ensure that the company has a work-life balance and benefits package that has flexibility built-in and considers the diverse needs of today's workers. Benefits such as flexible work schedules, work-from-home, child-care options, parenting leave, and an array of

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other work-life balance issues all need to be a regular part of how the company does business. This supports the concept of inclusion; that is, that these benefits are not available to select employees/managers or are even in existence to solely to satisfy a legal requirement, rather, they are part of the culture of the organization and are available to all employees.

2. **Education and Development**

It is important to distinguish between the term "education" and "training." People are educated while animals are trained. While this may seem like semantics, it is important to stress that the language and terminology used in this area are critical because unfortunately, most diversity education programs used by businesses employ language that has the negative and unintended impact of reinforcing existing norms, values and perspectives of the dominant segment of the organization. Initially, US companies developed "diversity training courses" that could last from an hour to more than a day as a way of wiping out biases against women and minorities in the workplace (Lipman 2018). In the past, diversity education sessions were treated like all other information disseminating exercises; that is, they were one-time events or something that was rolled out after a violation was experienced. To be effective, diversity and inclusion education needs to be a systematic process where the entire workforce – top management down to the lowest-ranked employees – is educated about the cultural, socio-economic, racial, identity, and religious differences among employees (Kundu, Bansal & Chawla 2015). Recently, studies have found that, in many instances, diversity training has actually had the unintended consequence of making things worse in the workplace because many of the participants have interpreted the key learning point as having to walk on eggshells around women and minorities and having to choose their words carefully so as not to offend (Lipman 2018). In some instances, women and minorities leave the training with a belief that their coworkers are even more biased than originally believed and that learning about others' biases can actually heighten one's own (Lipman 2018). Because so many companies improperly handle the issue of diversity education, many employees claim to suffer from "diversity fatigue" (Lipman 2018). When diversity education is made mandatory, focuses primarily on the legal aspects of discrimination, and is specific to only certain categories of employees (i.e., managers), then it is most likely going to be

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unsuccessful. Rather, when diversity and inclusion education focus on perception and awareness, including everyone at all levels of the organization, and recognizes that everyone can engage in unconscious biases, it has a higher likelihood of success.

3. **Performance Assessment**

Discrimination in performance appraisal is one of the root causes of job dissatisfaction and demotivation for a diverse workforce and, as a result, women and minorities often feel neglected and do not believe they have an upward career path (Kundu, Bansal & Chawla 2015). Because of this, women and minorities often do not feel like valued employees and, instead, feel like they are "diversity props" or tokens of diversity without actual inclusion (Jackson 2019). It is part of an HR managers' responsibility to create an environment where all employees feel valued and included. It is incumbent on HR managers to make sure that a company's performance appraisal practices are objective and not subjective, that they are directly related to the job and company and are fair to all employees while avoiding special treatment. As part of diversity management, HR managers should review performance appraisal processes to excise any language or consideration of the employee's race, gender, or other diversity characteristics. In addition, one of the reasons that many diverse workers feel that their upward trajectory has been stunted is because of a lack of effective mentoring. It is imperative that HR managers examine both formal and informal mentoring arrangements and identify situations where a successful senior member of the workforce can be paired with an under-represented junior employee with the objective of guiding them and to help remove any invisible barriers that may impede the advance of their career.

4. **Compensation and Flexible Schedules**

Pay equality is part of effective diversity management. Compensation structure, wage determinants, and benefits schemes should be designed around objective factors relating to the individual and position at issue and should be free from discriminatory factors. It should not be a surprise that a diverse workforce will have different priorities when it comes to their families and their work-life balance. As such, an individual-driven compensation system can support individual lifestyles and will further promote diversity (Shen, Chanda, D'Netto, & Monga 2009). It is not uncommon for big companies to adopt an array of policies/benefits relating to work schedule flexibility to accommodate varying

lifestyle needs such as: day care, work-from home needs, flex schedules, and even accounting for employee's desires to use time for charitable or health related endeavors. Not every employee has the same family situation or expectations and HR managers, as part of their diversity management efforts, need to make sure that the company is open to supporting these diverse needs and expectations.

5. **Workplace Environment**

HR managers are also charged with making sure that the day-to-day work environment is one that embraces diversity and provides for inclusion. That means also being mindful and aware of the changing landscape of diversity. The most recent change to the area of diversity in the workplace is the subject of identity. Gender identity and transgender issues have become the focus of considerable attention in recent years, as both famous and ordinary people have shared their experiences and stories. Greater public awareness has followed. Even so, many employers find themselves unsure of how to navigate the shifting landscape (Hayes 2017). HR Managers can start by making sure that gender identity is included in all of the company's discrimination policies, dress code policies, and any other policy that may create a feeling of exclusion or discrimination, as well as be prepared to respond and provide guidance to all employees should the issue of a transitioning employee arise. Ensure that the workplace is one that insists on civility and respect, which includes making sure that proper use of pronouns is enforced and that employees feel that their identity requests are being honored in all aspects of their employment. Workplace civility and respect are not limited to gender identity, rather the same policies need to be reviewed and modified, if necessary, to cover issues of race, disability, sexual orientation, national origin, traditional gender issues, and all other areas of diversity present in the workplace.

6. **Auditing Effectiveness**

A diversity audit can help eliminate hidden biases, overcome conscious and unconscious unfairness and remove glass (or other) ceilings that may contribute to the decline in worker satisfaction and prevent the creation of an atmosphere that does not support inclusion. In addition, once the above strategies and policies are put in place it is important for the HR manager to audit their success. This is one of the biggest failures on the part of most companies. Companies are quick to recognize the need to adopt a

strategy to address diversity and inclusion issues but most fail in the follow-through or neglect to circle back and measure the effectiveness of those strategies. This should be a box-checking scheme that looks solely at data and outcomes; rather it must be an interactive and inclusive process that requires engaging with all members of the workforce to ensure that the diversity management and inclusion policies are effective and working. Periodic audits of diversity and inclusion are necessary to identify the areas that requirement improvement, as well as, companies can use this data to benchmark their position in the industry or region.

CONCLUSION

Even today, among an array of global organizations that promote the diversity of their workforce, inclusion is not achieved. While most, if not all, companies are aware and conscious of equal opportunity issues, largely because of the legal jeopardy associated with non-compliance, very few go beyond the minimal requirements of the law and still suffer from different internal perceptions of what diversity management means and requires. It is true that successfully managed diversity will lead to a competitive business advantage, particularly in areas such as problem-solving, global understanding, creativity, innovation, and flexibility (Kundu, Bansal & Chawla 2015). Properly managing diversity and inclusion helps enable companies to reduce the costs associated with employee absences, high-turnover, legal expenses, and decreased productivity. That is because companies that respect and value diversity and inclusion are able to attract and retain the best employees in their field. Effective diversity management and inclusion can only be achieved when they are valued by all levels of management there is a culture within the organization that supports diversity and inclusion initiatives. HR managers play an important role here and can be the catalyst to help define an organization's approach to these issues, which, in the end, will positively impact individual, team, and organizational performance.

Some scholars have suggested that HR managers can take the lead on these issues by: (1) working to develop an organizational diversity learning plan that includes areas of weakness, outcomes assessment (i.e., audits) and accountability; (2) promoting a data or research driven approach to these initiatives based on the particulars of their specific organization in lieu of using a generic diversity plan; (3) taking the lead in structuring and scheduling educational initiatives,

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specifically with respect to content and objectives, to make sure diversity and inclusion efforts are coordinated across the entire company; (4) creating an incentive structure that recognizes contributions to diversity and inclusiveness; and (5) examining both conscious and unconscious barriers in the company's hiring, promotion, compensation, and benefits policies and practices to eradicate subjective factors that affect outcomes. (Kundu, Bansal & Chawla 2015).

Finally, HR managers need to consider and treat diversity management and inclusion as an ongoing and positive process and not as a problem to be solved. In the end, it doesn't matter how emphatically a company claims it embraces diversity and inclusion if its own policies and practices scream otherwise. With the leadership of HR managers, and the sincere investment of the entire workforce, a company can create a workplace that is simultaneously equitable and free from hostility as well as healthy and competitive.

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MELDING ETHICAL BEHAVIORS INTO LEADERSHIP EXPECTATIONS. SEEKING TO MAKE THE PHRASE, *'ETHICAL LEADERSHIP'* NO LONGER NECESSARY

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ABSTRACT

Remember 'E-Commerce'? It was a distinct and emerging discipline. Now E-Commerce concepts are easily integrated into traditional business courses. The term 'e-commerce,' seems redundant. YET, we as scholars still maintain a distance between '*Leadership'* and '*Ethical Leadership'*. When will the phrase, '*Ethical Leadership*,' fade from the business vernacular as redundant? As scholars, we can study the distinction and seek to meld them so fully that the terms become synonymous. This paper presents an educational path to help leaders see the overlap so that each can develop a personal roadmap to tightly integrate the concepts in to their business practices.

Keywords:

Leadership, Ethical leadership, ethical values, educating future leaders, leadership values.

1 INTRODUCTION

Recall the days of the emerging and stand-alone educational path called, E-Commerce? It was futuristic. It offered insight into a very different world of business processing, for which we were starting to understand. Now, E-Commerce concepts are fully integrated into traditional business courses and conferred degrees. The world of business now recognizes that both traditional and online business practices have melded together. Yet, business professionals still have a clear distinction between the concepts of '*Leadership'* and '*Ethical Leadership*.' When will the phrase, 'Ethical Leadership,' fade from the business vernacular as redundant and therefore be no longer necessary? How can we, as business scholars, study the distinction between these concepts, and seek to integrate them so *fully* that the terms will become synonymous? This paper

proposes an educational path to help managers see the differences *so* clearly, that each may develop a personal roadmap and commitment to integrate the concepts so tightly in to their professional language and practices, that they can no longer be considered distinct concepts.

2 BACKGROUND: WHAT CORPORATE SENIOR LEADERS EXPECT FROM THE NEXT GENERATION OF DEVELOPING FUTURE BUSINESS LEADERS

In past corporate life, a substantial amount of developmental leadership and management training was funded. Ethics and ethical decision-making was a tangible part of that corporate training; but, that is *not* always the case today. There is more discipline-specific training and preparation that supports business specialization as compared to the past, when leaders and managers were more generalists. There are less training dollars dedicated to the foundational development of the leader candidate; the work belongs to the colleges and to the individual.

Responsibility of Business Education

What *do* senior leaders expect from the Business Colleges and Schools in the preparation of the next generation of ethical leaders? (Mackenzie). To explore this question, senior leaders, leaders of corporate ethics programs, and ethics' scholars were interviewed. The results revealed four insights as to what is expected from the Business Schools:

- Teach the student to develop courage. It is scary to be faced with a situation which you do not know how to handle. It is easy to fear retaliation.
- Teach students persuasive communication skills. Teach them how to say, "No." Students should learn how to have a difficult conversation, without damaging their long term careers.
- Teach the student about the slippery slope. If a young leader *does* take a step down the wrong path, it desensitizes the person to take another step. Each becomes less difficult. The slippery slope has started.
- Teach students to see the dilemma! Mackenzie's research reveals that individuals may not even SEE that a dilemma lies before them. Corporate leaders and scholars have reported that young future leaders need to "…understand where the grey is within the

grey." The young leader must understand that the world is not black and white – but, you must see where the lines are.

Responsibility of the Individual

More is expected of the individual to accept responsibility for his or her *own* education and professional development. Recruitment into entry-level positions may rely on evidence of demonstrated skills and knowledge within a college discipline. Entry-level financial analyst candidates are often recruited from the Ivy League Universities. The Big Four accounting firms expect a certain discipline-specific college-level success pattern before an invitation to a coveted internship is offered. Yet, as these candidates enter into corporate life, they need to continuously develop their own leadership style and disposition, especially as relates to ethics, ethical maturity, and ethical decision-making. This responsibility exists whether or or not these candidates are explicitly advised of this accountability. How will these young candidates develop these skills?

Often senior leaders will passively observe the behaviors and interactions of young candidates in varying workplace scenarios; as a result of these random observations, senior leaders may select certain young candidates for tracks that lead to increasing opportunity and responsibility. If ethical decision-making is *not* an explicit component of this testing ground, then these leadership characteristics may not be rewarded with promotion and elevated responsibility. Remember the well-tested management concept, "what gets measured, gets managed." (Drucker). If ethics education is not *measured* and ethical behavior is not *measured* and *rewarded* as an expected part of the leadership development journey, then the young candidate has a lower chance of getting it right. A young manager may find him or herself facing a significant dilemma without the proper experience, preparation, or awareness. If self-development is expected of leadership candidates, then these candidates need to understand what is *expected*. These expectations are not limited solely to newly graduating business students, but also pertain to mid-level and senior leaders as they progress in accountability and authority.

3 LITERATURE REVIEW DEFINING LEADERSHIP VS ETHICS

How has the concept of leadership been defined? Twenty years ago it was suggested that "corporate leadership stands as one of the most significant roles in need of reevaluation and redefinition" emphasizing that "corporate leadership affects all aspects of corporate life" (Miranda, et al.). Defining leadership ranged from a view of domination to a more socially focused, or pro-group, perspective. Within this range the *individual benefit* is at one end and the *group's benefit* is at the other. A leader's influence over a group was an ingredient that suggested that subordinates *share*, therefore should pursue, the *corporate*-related goals (Rost). Another definition related to this evaluation suggests that leaders exercise their influence through *persuasion*, which was a positive move away from the militaristic pattern of old-world leadership.

Transactional vs. transformational are essential concepts in the transition of a leader's role as his or her influence increases. The transactional focus allows the supervisor to be more directive as the employee is exchanging time for salary. The transformational leader will *persuade* employees to work collectively toward achieving the *group* goals; transcending individual self-interests and working toward the greater good. A clear expression of this leadership definition is "persuading other people to set aside for a period of time their individual concerns and to pursue a common goal that is important to the responsibility and welfare of the group." (Hogan, Curphy, Hogan, 493). Other leadership terms driving a pro-group philosophy include: charismatic, inspirational, and visionary. Charismatic leadership "is a broadly applied term that does not distinguish between good or moral and evil or immoral." (House & Howell, 83). Both Gandhi and Hitler are charismatic leaders. Though these terms can appear to be aligned with an ethical social interest, "…it is surprising to note that theoretical and empirical links between these concepts are [mostly] absent in the professional literature." (Miranda et al, 264). It can be in the best interest of the company to express an interest in social interest in order to keep the perception of ''goodness" surrounding the corporate image. The concept of ethics is not an explicit link to the concept of Leadership.

The terms *ethical* and *ethics* link more easily to decisions and behaviors, rather than to an organizational culture or to the concept as powerful as *leadership*. If individuals are consider

then traits and characteristics will most likely will be described, which could, hopefully, include the descriptor of *ethical*. Leadership, by definition has followers (Drucker) with the goal of moving the followers' toward the achievement of some goal. The *HOW* we move the subordinates forward is where the concept of ethics, may emerge. Duarte went directly to the developing leaders and found that 95% of students reported that they benefited from studying ethics, but that they perceived a "gap between the ideal and the practice of ethics" (Duarte, 120). The gap was described as putting ethics *outside* of the leader's primary role. These developing managers suggested that "there is a clear fissure between the ideal of ethics and the perceived difficulty, and for some, the impossibility of achieving it in professional practice" (Duarte, 125).

4 AN EDUCATIONAL PATH FOR LEADERS

This paper proposes an educational and self-reflective path for leaders. The education path explores why the concepts of 'leadership' and 'ethical leadership' remain in separate spheres and establishes five stepping stones that allow leaders to take responsibility for integrating ethical *thought* and *behavior* into day-to-day business practice.

Stepping Stone #1 to Inviting Ethical Practice into Day-to-Day Business Practice: Understanding Ethics at its Foundation

Consider the philosophical foundation of ethical theory; allow it to prepare a path toward an intentional professional life of ethical thought, behavior, and leadership. The larger theories directly relate to why ethics must be intimately integrated into the automatic thinking and decision-making of those who influence others, whether as civic or corporate leaders.

Kohlberg's model of "moral development" of the individual illustrate that change occurs over time. The individual develops moral reasoning as he or she matures from a child to an adult as experiences are endured. Children learn what is right and wrong through reprimand and punishment with a single-focus on self-interest. In this Pre-conventional Stage the individual avoids punishment. As the individual matures, he or she understands the value of complying with social norms; wanting to fit in. Being told that you are a 'good girl or boy' brings a level of peace and may raise self-esteem and confidence. This conventional stage is where the individual

understands authority as a system of maintaining social order. Utilitarianism focus on ethics which is *outcome-driven* and serves the greater good with less focus on the actual ethical decision. As corporate leaders, the outcome-driven goal coupled with the Conventional Stage of moral develop may interfere with the leader's motivation to apply ethical reasoning to a developing ethical dilemma. Some individuals mature to the Post-Conventional Stage, where the individual can see him or herself as *separate* from the societal group. The individual's moral principles will drive behavior, even when it is in conflict with the corporate goal or even the rules of law. Some people get stuck in the Pre-conventional Stage and live to avoid punishment, but many people thrive in the Conventional Stage where they want to know and understand the rules and to safely and comfortably fit in (Kohlberg).

Stepping Stone #2 to Inviting Ethical Practice into Day-to-Day Business Practice: Understanding How our Mind Works

In understanding and reflecting on the moral development of the individual, our next stepping stone considers the cognitive processes that may allow leaders to miss an opportunity to *see* the developing dilemma. If we wish to develop the awareness and flawless decision skills that will allow us to discern what is ethical behavior and to notice when are we slipping a bit, we need to be diligent and to not allow assumptions to flow over us and prevent us from *seeing* what is before us.

Tversky and Kahneman provide the empirical evidence and foundation for this stepping stone. The work of these theorists provide explicit evidence for leaders to consider in how the mind processes information. Relevant to this discussion of inviting ethical practice into the day-to-day practices of leaders, is the understanding of the System 1 and System 2 minds (Kahneman). The System 1 mind allows an individual to make automatic judgments; little or no effort is required. The individual simply knows the answer and believes it to be accurate. Depth perception is a simple example as an individual will automatically know whether one object on table is closer or further. Kahneman (2011) explains that the system 1 mind allows the individual to function with ease, avoid danger, and *multi-task*. The System 2 mind requires the individual to allocate mental attention to the problem or question; to concentrate. An example of the system 2 mind interacting

with the system 1 mind is when two individuals are in a car. When the road is clear, the destination is simple, and there are no distractions, then system 1 allows the individual to drive and speak to the passenger, answering questions and having a coherent conversation. When traffic develops or an engine light appears, system 2 takes over and the easy conversation is interrupted as the individual must now concentrate. As individuals become expert at some task that muscle memory moves those tasks from system 2 to system 1. A well trained pianist can continue to play even if major distractions take place in the room, where a novice will be derailed. There are other cognitive biases that help individuals navigate the variables that swirl as decisions are made. If leaders' minds had to give attention to every step they made and every task they complete while multi-tasking, these leaders would be paralyzed.

If leaders allow essential information to flow over them that *should be* perceived as red flags related to developing dilemmas, these leaders will miss their chance to change direction or stop an unethical process from derailing the company. These cognitive biases are very present, especially in the lives of corporate leaders, whose days are packed and time is limited. These biases cause leaders to make decisions without the attention that may be needed. Cognitive processes allow information to fit easily into what is already known and accepted. This stepping stone educates leaders on how the mind works so that they can slow down and invite practices that avoid missing the red flag.

Stepping Stone #3 to Inviting Ethical Practice into Day-to-Day Business Practice: Consider Senior Leaderships Expectation for the Preparation of Future Leaders

The original research results related to what senior leadership expect from colleges in the preparation of future leaders, was discussed earlier in this paper (Mackenzie). As a stepping stone, it is worthy to be gently reviewed. As the understanding of how ethical reasoning develops and how the mind processes information when faced with a problem or question, these expectations become a more relevant set of ingredients in the quest to invite ethical practices into day-to-day business practices. The four expectations are: (1) teach students to develop courage; (2) Teach students persuasive communication skills and how they may say 'No.' Teaching students how to have a difficult conversation, yet not destroy their long-term career aspirations,

is necessary. (3) Teach students out the slippery slope and the ease by which the slippery-ness can take place, and (4) teach students to see the dilemma!

Stepping Stone #4 to Inviting Ethical Practice into Day-to-Day Business Practice: Consider an Old World Eight-fold Path for Observing Self and Guiding Choices

Stepping stone #4 requires a shift from *gaining* knowledge related to defining leadership, developing ethical reasoning, understanding cognitive biases, and recognizing leadership expectations (stepping stones 1-3), *to* making an individual commitment to a behavioral shift in how self-observation can influence professional development and daily choices.

The *Noble Eightfold Path* (Jagaro 2007) begins with the individual selecting the Right View (step 1). As an adult an individual will recognize that there is responsibility for his or her life and the outcomes that emerge from that life. When fear, jealousy, and anger emerge, the individual should realize that they emerge from his or her own choices and reactions. That sparks the Right View where the individual learns to notice and observe one's own behavior. As leaders, we must ask, do we have the Right View – related to our role? The Right View leads to the Right Intention (step 2). As business people we learned in Marketing 101 that intention precedes behavior, except in the cases of impulse buying! Intention is powerful. With experience and reflection the individual learns that selfishness and hubris does not bring clear and ethical decisions. Actively establishing the Right Intention and pushing away self-serving thoughts will allow an ethical intention to thrive. The Right View and the Right Intention are tightly related. If they are kept in the forethought, the result is the Right Speech (step 3). Leaders must never forget that what they say shapes life, creates hope, and can cause harm. Mastering the Right Speech is essential and the outcome of speech has consequences. It leads to the Right Action (step 4). Leaders control their physical body and their ability over physical actions take place. Leaders' actions are visible and send important messages into the organization. Every individual who is able needs to earn a living; how an individual makes his or her living can define how ethics is integrated into the day-to-day practices and decisions. This next step on the path is the choice of the Right Livelihood (step 5). Does the leader gain success at the expense of another or does the leader pull up his or her colleagues. This path guides the individual to train the mind

with the last three steps being the Right Effort (step 6), the Right Concentration (step 7), and the Right Mindfulness (step 8). When an individual does not make an effort, bad decisions are made. The Right Effort leads to the Right Concentration, which brings us back the system 1 mind, which is effortless and automatic vs. the system 2 mind which requires our concentration and effort to make the right choices. And finally, the Right Mindfulness provides the leader clarity of mind. If a leader is to tight integrate ethical decision-making into all he or she does, the individual must be mindful.

The Noble Eightfold Path makes each person responsible for him or herself. If an individual has the Right View, the Right Intention, with the Right Speech, and the Right Actions, then the outcome will be the Right livelihood. Then commitment is made to put forth the Right Effort, give time for the Right Concentration, and ultimately the Right Mindfulness, which closes the path and feedback to the Right View.

Stepping Stone #5 to Inviting Ethical Practice into Day-to-Day Business Practice: Consider if and how these Corporate Leadership Expectations can be explicitly integrated into Leadership Development

This last stepping stone is for the reader. Reflect on whether your organization's leadership, coupled with its management development program and/or corporate training initiatives, have explicitly articulated expectations and measures within its leadership development process. Does your organization provide ongoing training as leaders elevate to higher levels of influence? Are ethical practices valued within your organization? And last, what are YOU willing to do on a day-to-day basis to invite increased awareness and ethical practice so that it becomes fully integrated?

5 CONCLUSION

An essential component of this proposed educational path is that each leader take the explicit opportunity to reflect, at each step, how he or she will integrate the *learning* into his or her day-to-day business practice. Reflective leaders are encouraged to articulate expectations of active learning and heightened awareness among subordinates, especially young and developing

leaders. Senior leaders must consider how these concepts can be integrated into the workplace training and into the annual employee evaluation. Scholars and educators need to consider how these concepts can be integrated into the college curriculum, and into the High School experience. As each generation of leadership assumes responsibility for integrating the awareness of '*seeing the dilemma'*, valuing the '*courage'* to say '*no,'* and becoming more aware of the '*slippery slope,'* into its onboarding and leadership measurement matrices, then we as scholars may see the melding of the terms 'ethical leadership,' and 'leadership,' so they become redundant. Only with *commitment* and *practice* can the world of business heal thyself.

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RECRUITING FOR SUCCESS. DOES BOARD DIVERSITY MATTER?

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ABSTRACT

Nonprofits play an essential role in society. To realize their important missions, nonprofits rely on strong and committed leaders at both the organization level as well as the governance level. Nonprofits are obligated to have an active board of directors to operate. This reliance places the organization in a vulnerable position where they must recruit and engage with external stakeholders and identify individuals with the combination of talent needed to succeed as well as the passion for supporting the organization's vision. Knowing that board members have a long-lasting impact on their organizations, this paper looks at the varying models of governance and the implications for choosing one model over another. Determining the best structure for a governance model represents one component to setting an organization up for success. Equally, if not more important, is ensuring that the board of directors is composed of motivated and committed individuals who are steadfast in their efforts to support the mission of the organization. In order to find the best people for the role, an organization must understand what drives and motivates an individual to serve on a board. The topic of motivation as it relates to governance boards, and how existing boards can use the motivating factors to recruit and retain board members is explored. Finally, we explore the value of diverse board composition and whether certain criteria of diversity carry more weight in terms of impact than others.

Keywords: Recruitment, Diversity, Governing Boards, Nonprofits, Motivation

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MODELS OF GOVERNANCE

A board of directors is typically a formal construct that provides governance for the company or organization. Members of the governing board are directors of the corporation under the law (Worth, 2019). Because nonprofit governing boards are not all the same, they have different implications for how they operate and bring forth organizational affairs to their governing boards and their CEOs. Governance practices are measures of board effectiveness as these practices reflect the board's capacity to perform various functions and competencies (Buse, Bernstein & Bilimoria, 2016). There are several and important responsibilities the governing board must achieve. First, they appoint, support, and evaluate the CEO of the organization. Governing boards establish a clear institutional mission and purpose, approve the organization's programs, ensure sound fiscal management and the organization's financial stability, and create standards for organizational performance to hold the organization accountable (Yawson, 2019).

There are different board governance model's nonprofit organizations use to implement internally. We examined these models and their purposes. Worth (2019) provides examples of the models of governing boards that are common to find in nonprofit organizations; they are elected governing boards, self-perpetuating governing boards, hybrid governing boards, and advisory councils. Furthermore, we examine the patron model, which its focus is on fundraising activities. Each of these models has compelling advantages and disadvantages. In the following sections we discuss the various models.

Elected Boards

A nominating committee of the existing board introduces and recommends nominees who will often be approved by the board of directors to obtain membership via a formal vote. Existing board members can vote via mail, email, and often in annual meetings. An advantage of this type of board is that the CEO may serve as a strong advocate for the nominee and be reactive to the members' needs and concerns (Worth, 2019). A disadvantage of this board is the fast turnover it can implicate on the governing board, which can hinder long-term goals and plans of the organization.

The American Red Cross is an example of the elected board model. A Governance and Board Development Committee is responsible for assessing the Board's skill set requirements and needs against a pre-determined set of criteria. The Committee then follows a six-step process to identify candidates, interview candidates, and nominate candidates. The final step is a

recommendation by the Committee to the full Board for a vote. If approved, the candidates will be presented to the delegates of the American Red Cross at the annual meeting. (www.redcross.org)

Self-perpetuating Boards

This structure is prevalent among the 501(c)(3) charitable nonprofit boards. This governing board is similar to the elected boards in which members are elected by existing members of the board (Worth, 2019). However, self-perpetuating boards create stable situations for the nonprofit organization (NPO) and its CEO. They tend to have longer terms than elected boards, and the board's membership often changes slowly. In contrast to corporations with boards elected by voting members, charities are governed by self-perpetuating boards. In other words, in this type of board, members vote for their successor. An advantage of this type of board is the continuity of culture and priorities and organizational strategic goals. It also allows the recruitment of new members with needed skill sets that may benefit the board of directors. One crucial disadvantage, however, is that in this structure, the governing board may stay complacent in terms of responding to new changes in the revolving environment and yield too much authority to the CEO.

Hybrid Governing Boards

This type of board is emerging in leading-edge nonprofits. It addresses the weaknesses identified in other approaches through judicious use of committees structured around the board, rather than management, responsibilities (Gill, 2007). In this type of model, the governing board members seek the appointment of individuals externally. This model is typically used in public organizations; for example, the governor of the state often appoints the board of a state university. Another example of this board can be found in religious congregations and health care organizations such as Medicaid and Medicare (Worth, 2019). In hybrid governing boards, members can be elected, and some can be appointed or serve ex-officio. Worth (2019) proposes that ex-officio "is designated to be held by the individual who holds a certain office or position" (p. 85).

Advisory Councils

These councils do not have the legal authority nor the responsibility for governance in the organization. Instead, they provide guidance and advice to the board of directors in expertise in finance [fundraising], operations orientation and strategic goal transparency, and law or the industry with which the organization is affiliated. There are several reasons why these advisory councils are created within the governing board. Advisory councils of experts can provide

substantive advice on the organization's programs as well as advice on current clients and stakeholders who provide feedback on the effectiveness of programs from a different perspective (Worth, 2019). When situations raise questions, the board can turn to the advisory council for advice and seek assistance and guidance through organizational issues. Thus, the importance of a diverse council ensures the success of the organization overall.

Patron Model

The patron model serves for the particular purpose of fundraising. Its primary activities are to arrange, facilitate, and participate in fundraising activities. Thus, the board is primarily selected from a pool of wealthy and influential individuals in the community who contribute their own funds and solicit funds through their personal and business networks (Price, 2018).

MOTIVATING FACTORS FOR BOARD ENGAGEMENT

Nonprofits need to understand the reasons why individuals join and continue to serve on nonprofit boards. Understanding what motivates these individuals will help focus the boards' recruitment efforts (Milde & Yawson, 2017). Once the board understands the motivators, it can create an incentive plan targeting these specific motivators and individuals. Since nonprofits and for-profits are in direct competition for board members, should their recruitment policy be similar to for-profit recruitment policy? Understanding "why board members volunteer to serve on nonprofit boards will help nonprofit organizations attract and retain the best board members" (Miller-Stevens & Ward, 2019, p. 3).

Board participation is voluntary, so why serve? "Studies have found that people cite volunteering out of a sense of duty or commitment to a specific mission or public good" (Miller-Stevens & Ward, 2019, p. 63). According to Herzberg's need theory, motivators and dissatisfiers are factors that influence motivation (Worth, 2019). Commitment to a specific mission or public good can be described as an intrinsic motivational factor since it "relates to individual feelings and the nature of the job itself" (Worth, 2019, p. 249).

"Research also shows that many people volunteer because they have been asked to do so by others or because they desire social recognition for their good deeds" (Miller-Stevens & Ward, 2019, p. 63). Social acknowledgment and acceptance are also intrinsic motivators as they satisfy the need for recognition. In addition, McClelland's Three Needs Theory identifies "three principal needs that people have: the need for achievement, the need for power over others, the need for affiliation or good relationships with others" (Worth, 2019, p. 249). The need for affiliation or

good relationships with others can help explain why an individual may choose to accept an invitation to serve on a board.

It has also been argued "that individuals who volunteer may be inspired by an impure altruism, in that they possess a desire to help others but also are driven by the potential for personal gain" (Miller-Stevens & Ward, 2019, p. 63). Maslow's hierarchy of needs theory describes this as the need for self-esteem. "Maslow's (1954) theory states that human needs progress as the lower-level needs are met" (Worth, 2019, p. 246). There are five levels in Maslow's Hierarchy of Needs: physiological, safety, love, esteem (ego), and self-actualization (Worth, 2019). The individual is using volunteerism to satisfy their needs for self-esteem, also known as ego. These motivational factors can also explain why individuals choose to continue to serve on nonprofit boards.

While these motivating factors can be used to explain why individuals choose to volunteer in the nonprofit sector, it does not fully explain why an individual would want to participate on a governance board. "It's important to consider the reasons why individuals may be attracted to participate in a governance role that is situated at the top of the organizational chart" (Miller-Stevens & Ward, 2019, p. 63). Miller-Stevens & Ward (2019) further suggest that there are three reasons why leaders serve on nonprofit boards, the democratic model of leadership, the oligarchic model of leadership, and the leadership by default model.

- First, "the democratic model of leadership views leaders as individuals who aspire to such positions but who also value decentralization of power and are driven by the goal of serving the organization and contributing to its success" (Miller-Stevens & Ward, 2019, p. 64).

- Second, "the oligarchic model of leadership views aspiring leaders as coming from a small network of individuals who maintain control over knowledge and power in the organization and are more motivated by self-recognition than the organization's mission" (Miller-Stevens & Ward, 2019, p. 64).

- Third, "in the leadership by default model, there is a lack of interest among all organization members to lead, and those who end up in leadership roles are chosen because they may have a stronger commitment to the organization's goals" (Miller-Stevens & Ward, 2019, p. 64).

The models described provide insight as to reasons why leaders begin their tenure on nonprofit boards. The question of what factors motivate leaders to remain on nonprofit boards remains. A study conducted by Miller-Stevens & Ward (2019) recognized eight factors ranging

from a rating of important to critically important. These factors are: "serving the organization and contributing to its success, having a sense of duty/commitment to the mission, being helpful to others, because they really want to help the particular group that the organization serves, out of loyalty and respect for the organization, to contribute to society, to share their expertise and professional skills, and to learn more about the organization and the cause it supports" (Miller-Stevens & Ward, 2019, p. 71). Out of these factors, only one was unique to continued service, learning more about the organization and the cause it supports.

NONPROFIT VS. FOR-PROFIT BOARD RECRUITMENT

"The dramatic growth in the number of nonprofit organizations over the past decade means that a greater number of board members are needed, which may contribute to greater competition in recruitment" (Ostrower, 2007, p. 7). Not only is there an increased demand for a higher number of board members, but there is also an increasing focus and call for board diversity. "High levels of ethnic homogeneity on many boards raise questions about nonprofit boards' ability to be responsive to the diversity of the constituencies served by their nonprofits" (Ostrower, 2007, p. 8). "Most previous research on nonprofit boards concludes that they are largely white, male, and upper-middle-class (Ostrower, 2007, p. 23). The increased need for recruiting a board that is both diverse in gender and ethnicity is highly sought after by both for-profit and nonprofit boards. However, if nonprofit boards are competing amongst themselves for diverse representation on the board, how can nonprofit boards, drawing from the same candidate pool as for-profits, compete to find individuals with the criteria they need?

Nonprofit organizations cannot rely on the same board recruitment policies as for-profits because their purpose and missions are different. The lack of a driving focus on profit as the critical measure of success is the starkest difference between for-profits and nonprofit organizations (Horobiowski, 2004, p. 56). There is a common perception that nonprofit organizations should not make a profit, nor should they offer compensation to their board members and staff. Doing so would raise questions of conflict of interest and ethical violations. In his research, Ostrower presents data on board compensation and finds a low percentage in compensation in nonprofit organizations of the ones he researched. Additionally, he finds no evidence that compensating trustees help nonprofits attract board members with particular expertise (Ostrower, 2007, p. 11). "Without a clear financial bottom line, nonprofit organizations rely on the mission to attract resources and guide decision making," (Guo, Brown, Ashcraft, Yoshioka & Dong, 2011, p. 250).

As a result, mission statements are recognized as a robust management tool that serve to motivate nonprofit employees as well as board members and keep them focused and engaged on the organization's purpose (Guo et al., 2011, p. 250).

Another notable difference between for-profit and nonprofit boards is the strategy behind board composition, specifically for-profits awareness of the benefits of a diverse board. Nonprofit organizations tend to have homogeneous boards, whereas "for-profit boards are typically built with the opposite in mind" (Horobiowski, 2004, p. 59). This is a place where nonprofits can learn from for-profit strategy and focus on acquiring specific diversity attributes to help reduce board homogeneity.

Defining Diversity

For the purposes of this study, board diversity is defined as various compositions of the board of directors and their direct observance of aspects, i.e., gender, age, race, and ethnicity. And less visible aspects, for example, education and work experience. The questions surrounding the implications and impact of board composition represent a growing field of research. As mentioned by Ostrower (2007),

> Most previous research on nonprofit boards concludes that they are largely white, male, and upper-middle and upper class. These studies focused primarily on large nonprofits, and thus, a major question for this study was whether or not a more heterogeneous picture would emerge from looking at a more representative array of nonprofits. (p. 23).

The findings of Ostrower's work suggest a positive association between board member diversity and inclusion in terms of gender and racially diverse membership, leads nonprofit organizations to increased performance and agency success. Studies have discovered less diverse boards have increased difficulty to the varied needs of the population they serve (Forbes, 2015). These findings further highlight the need for recruitment strategies that include diversity.

Seven years after Ostrower's work, a study conducted by Harris examined the impact of board of director characteristics on nonprofit performance. While the study was limited in its size, results indicate that both board member diversity and expertise are associated with better-performing organizations (Harris, 2014). Harris's findings supported those of prior research on the topic. BoardSource (1999) reported that heterogeneity in groups promotes creativity and innovation, noting that the need for diversity is an essential part of making effective decisions and delivering appropriate services to minority clients (Harris, 2014). Furthermore, Katmon,

Mohamad, Norwani & Farooque, 2019) suggest the importance of board diversity can be explained from the theoretical perspective using the resource-based view theory (RBV), given the fact that, as part of an organization's strategic decision, board diversity signifies ''core competence or dynamic capability.''

Impact of attributes

Board diversity plays a vital role in the "discretion and decision-making process of the board, which are mainly derived from their personal (i.e., gender, ethnicity, nationality, age) and professional (i.e., education level, educational background, tenure) contexts" Katmon et al. (2019, p.448). "Organizations need diverse boards because of the important functions the board serves. Specifically, the board makes strategic decisions, develops links with external stakeholders, and helps engage talent from the labor market" (Ali, Ng & Kulik, 2014, p. 498). Katmon et al. (2019) consider board diversity to be a cornerstone to the "board uniqueness in line with the resource-based view (RBV) theory that supports the knowledge, intelligence and expertise of a heterogeneous group of board members as valuable firm resources" (p. 450). "The resource-based view (RBV) argues that when a firm's resources are economically valuable (exploiting opportunities and neutralizing threats), relatively rare, difficult to imitate, and imperfectly mobile across firms (remaining bound and available), they can explain the differences in firm performance" (Ruivo, Oliveira & Neto, p. 106). Board diversity is a valuable organizational resource that is relatively rare and difficult to imitate; in consequence, the owning organization is able to develop a unique competitive advantage. To take full advantage of board diversity, an organization needs to understand how the attributes of personal and professional diversity impact board performance.

Personal Attributes (i.e., gender, ethnicity, nationality, age)

Gender

Gender diversity "promotes a better understanding of the marketplace, thereby increasing its ability to penetrate markets" (Gallego-Álvarez, García-Sánchez & Rodríguez-Dominguez, 2019, p. 58). Gender diversity "enhances creativity and innovation and leads to more effective problem-solving since a more diverse board provides a wider variety of perspectives and, consequently, a higher number of alternatives to evaluate" (Gallego-Álvarez, García-Sánchez & Rodríguez-Dominguez, 2019, p. 58). Furthermore, it "may issue positive signals to markets – labor, products, and capital markets – by providing a greater degree of legitimacy to corporations

and improving their reputations" (Gallego-Álvarez, García-Sánchez & Rodríguez-Dominguez, 2019, p. 58). Lastly, "the RBV theory is that synergies between male and female interaction in the board are valuable" (Katmon et al., 2019, p. 453). Some of the disadvantages of gender diversity are that the teams "communicate less frequently, are usually less cooperative, and experience more conflicts" (Gallego-Álvarez, García-Sánchez & Rodríguez-Dominguez, 2019, p. 58). In addition, it may lead to a slower decision-making process due to the difference in leadership styles between men and women. Furthermore, increased conflict may generate more opinions and critical questions, which might enhance the overall work, but it may also delay the board's proceedings (Gallego-Álvarez, García-Sánchez & Rodríguez-Dominguez, 2019).

Ethnicity

Watson & Kumar (1992) suggest that "culturally diverse groups have the potential to generate a greater variety of ideas and other resources than culturally homogeneous groups" (p. 61). However, these multicultural groups have specific challenges to overcome before they reach their potential. For instance, they face problems such as "inability to communicate clearly, frequent disagreements on expectations, and attitudinal problems such as dislike, mistrust, and lack of cohesion" (Watson & Kumar, 1992, p. 54). If the group can overcome these problems, they have the potential to reach peak efficiency and effectiveness. Racial diversity in the board is viewed as valuable and has the potential to provide the company with a competitive edge (Katmon et al., 2019). The reason it creates a competitive edge is that "each culture carries its own set of values, norms, beliefs, or behaviors that shape their worldview which, to a certain extent, will influence their moral conduct and strategic decisions" (Katmon et al., 2019, p. 456).

Nationality

National culture has been found to have an enduring impact on executive mindsets and interpretation and response to strategic issues. These "cultural patterns of thinking, feeling, and acting are acquired in early childhood because at that time a person is most susceptible to learning and assimilation" (Nielsen & Nielsen, 2013, p. 374). "The RBV theory recognizes the presence of international human resources as one of the most valuable, unique and difficult-to-imitate resources owned by the firm. With an increase in business diversification, firms need dynamic resources to cater for international markets in order to achieve competitive advantage" (Katmon et al., 2019, p. 456). While there are benefits to having an internationally diverse board, it does have some disadvantages. For example, "the presence of foreign directors may impair the internal

governance due to a lower number of board meetings, thus signaling weak monitoring roles by the board" (Katmon, et al., 2019, p. 456). In addition, "the presence of different nationalities on boards may also lead to cross-cultural communication problems" (Katmon et al., 2019, p. 456). Nationality and ethnicity are closely related; therefore, we see the emergence of similar challenges for the board.

Age

"High board age diversity is associated with large donations for not-for-profit organizations and high return on assets in the case of for-profit organizations" (Ali, Ng, & Kulik, 2014, p. 498). An age-diverse board "can integrate a wider range of information to make more informed decisions" (Ali, Ng, & Kulik, 2014, p. 499). Research has found, "younger directors tend to be highly educated and familiar with new technologies, whereas; older directors bring to the board valuable experience that they accumulated in the industry" (Ali, Ng, & Kulik, 2014, p. 499). The organization can leverage these complementary attributes to improve its strategic decision making (Ali, Ng, & Kulik, 2014, p. 499). "Diversity in board members' age will lead to variation in values and perspectives since each generation is unique and special in the sense that their worldview is developed according to different experiences, social, political and economic environments, and events" (Katmon et al., 2019, p. 455). However, while different values and perspectives can be a positive, these differences "might lead to either the board efficiency or inefficiency in decision-making processes due to different levels of worldview experience and upbringing" (Katmon et al., 2019, p. 455). Minus the impact on decision making, these differing viewpoints create value and competitive advantage for the organization.

Professional Attributes (i.e., education level, educational background, tenure)

Educational Level

The firm can exploit a diverse board educational level in order to help the board in making strategic decisions to achieve a competitive advantage (Katmon et al., 2019). "Educational level shapes an individual's cognitive base and leads to a better ability to process information and ability to absorb new ideas" (Katmon et al., 2019, p. 454). There are both advantages and disadvantages of lower and higher levels of educational level diversity. Directors with lower levels of education have the opportunity to gain experience not taught in the classroom, whereas directors with higher educational levels may be tied to a specific depth of knowledge, which limits the absorption of new ideas (Katmon et al., 2019). Furthermore, higher educational level directors have created

social ties and networking links with other "university/alumni who one day become the main market players in the capital market and regulatory institutions" (Katmon et al., 2019, p. 454). These connections, according to the RBV theory, are valuable, rare, and hard to imitate. While lower-level educational directors may lack contributions tied to a formal educational background, they might be in a unique position to contribute a thorough amount of practical experience. Having a balance of educational and practical experiences represented on the board helps to create a "variety of opinions, perspectives, and experiences" (Katmon et al., 2019, p. 454). Ultimately, having various educational levels represented on the board will favorably influence the value of the decisions made by the board.

Educational Background

Studies have shown that an organization benefits from both a board's varying levels of education as well as a diverse field of academic knowledge. "Diversity of knowledge and ability of the board members derived from different educational background is crucial to speed up the strategic decision making, to improve board effectiveness in evaluating strategic implementation, to share knowledge and generate new knowledge, and to reduce the problem bounded rationality" (Katmon et al., 2019, p. 454). To facilitate robust discussions on different areas of expertise, the board requires members with multiple educational backgrounds before it can make efficient and effective strategic decisions. Having various educational backgrounds brings differences in individual attitude and intelligence and cognitive base that might be beneficial in improving the quality of innovation and decision making from various perspectives (Katmon et al., 2019).

Tenure

"Board tenure refers to the length of time directors hold directorship positions in the organization" (Katmon et al., 2019, p. 455). Again, there are advantages and disadvantages to having a board with long-tenured members. First, long board tenure has an advantage as directors have more considerable experience and expertise with the company's policies and monitoring and reporting process (Katmon et al., 2019, p. 455). In addition, "longer board tenure is associated with lower levels of misleading information and disclosure," increased ability to build organization-specific expertise, and are known as reputable and knowledgeable members of the organization (Katmon et al., 2019, p. 455). Some disadvantages of long-tenured board members are they may be unlikely or hesitant to undertake innovative activities, they often remain in their comfort zones, and repeat the same process (Katmon et al., 2019). These disadvantages, also evident in CEO

tenure, have a negative impact on organizational progress and change. The correlation between tenure and organizational change is attributed "to the fact that CEOs become extremely committed to their previously enacted strategic plans, avoidance of information that disconfirms their plans, having decreased interest in their present jobs, and having the power that enables them to avoid demand for change" (Buse, Bernstein, & Bilimoria, 2016, p. 1-2). These same tenure diversity pitfalls could impact the performance of nonprofits boards. Therefore, board tenure diversity would be advantageous for organizations as "companies with diverse board member tenure perform better than boards with homogeneous tenure" (Katmon et al., 2019, p. 455).

Board Size

Research suggests a positive correlation between board size and nonprofit performance. Specifically, larger boards allow board members the opportunity to take on certain smaller tasks so that one person does not feel pressure to accomplish the organizations' goals alone. The exception is in healthcare, where networks such as hospitals take in a majority of their payments from commercial insurance companies opening the possibility for board members to abuse their power and influence the decision making (Aggarwal, Aggarwal, Evans & Nanda, 2012).

Based on our review of the literature, it does not appear that there is a direct number associated with what is considered to be a large board or a small board. It is only viewed that the larger the Board, the more "positively related to the number of programs pursued, revenue generated, and expenditure on programs" (Bai, 2013, p. 173). A study was conducted with nonprofit and for-profit hospitals in California that did provide some insight to the board size. This was used as our example to review what nonprofit organizations have quantitative data like the state of California requires hospitals to report on three pieces of information: operational, financial, and governance to the Office of Statewide Health Planning and Development (OSHPD) (Bai, 2013). On average, nonprofits had 15 directors, while for-profits had 9 (Bai, 2013). The results from this study supports our conclusion that a larger board size is more beneficial for nonprofit organizations.

RECRUITING FOR DIVERSITY

Nonprofit organizations, like for-profit organizations, seek to recruit for diversity for several reasons: to forecast labor shortages, to increase minority representation to avoid legal scrutiny, to enhance their public image, to gain access to minority customers, and to increase organizational creativity and innovation (Mckay & Avery, 2005). "Diversity recruitment strategies

vary a great deal. So-called successful tactics include the use of recruitment advertisement photographs that depict a diverse workforce, minority recruiters, and communicating adherence to identity conscious staffing policies" (Mckay & Avery, 2005, p. 332). The goal of these efforts is to create a positive perception that the recruiting organization values diversity (Mckay & Avery, 2005). The challenge organizations face is that the positive perception presented to candidates may not be the reality within the organization. So, while the firm may be able to recruit the candidate, it may not be able to retain that employee or board member because perception and reality do not match.

To successfully recruit for diversity, organizations need to "obtain upper management endorsement of diversity initiatives and create corporate policies that support workplace diversity" (Mckay & Avery, 2005, p. 333). By obtaining this type of support, organizations ensure the success of their diversity initiatives and policies. McKay & Avery (2005) suggest that organizations take several steps before they begin to recruit for diversity. These steps include a diversity audit, diversity training, recruitment planning and implementation, and recruitment evaluation.

- *Diversity audit*: "A diversity audit can provide several key pieces of information useful in designing minority recruitment initiatives."
- *Diversity training*: "Diversity training is designed to sensitize organizational members to subconscious biases and prejudices that foster discriminatory behavior."
- *Recruitment planning:* "Organizational leaders should develop an action plan for targeting sources of minority applicants. Several sources of these include predominantly minority colleges and universities or regional/notational meetings of minority professional organizations."
- *Recruitment implementation*: "Information collected during diversity audits should form the basis of diversity recruitment implementation. The nature of diversity climate and organizational demographic data can be used to form the basis of the recruitment messages."
- *Recruitment evaluation:* "Diversity recruitment initiatives should be evaluated for their effectiveness. These efforts should be assessed on their level of minority hiring and retention."

As indicated earlier, the purpose of recruiting for diversity is to enhance creativity and innovation to facilitate practical problem-solving while providing a "wider variety of perspectives

and, consequently, a higher number of alternatives to evaluate" (Gallego-Álvarez, García-Sánchez & Rodríguez-Dominguez, 2019, p. 58). Incentives do not support this mission because rewards are the enemy of exploration and creativity (Kohn, 1993). The reason rewards kill creativity is because "when we are motivated by incentives, features such as predictability and simplicity are desirable, since the primary focus associated with this orientation is to get through the task expediently in order to reach the desired goal" (Kohn, 1993).

"Financial incentives and controls become less effective, as many individuals in nonprofits regard money as a means to achieve larger purposes and not as an end in itself, either professionally or organizationally" (Guo et al., 2011, p. 250). Nonprofit organizations should not employ incentive tactics to recruit and retain diverse board members. Instead, nonprofits should use strategies that draw on individuals' intrinsic motivations rather than on the extrinsic motivation of rewards such as money (Guo et al., 2011, p. 251).

BENEFITS AND CHALLENGES OF A DIVERSE BOARD

Organizations with diverse leaders and employees have a competitive advantage over homogeneous organizations. Horowitz & Horowitz (2007) support this theory finding that different backgrounds and experiences can lead to improved results. Providing opportunities for individuals to bring their diverse expertise and knowledge forward improves internal operations in several ways. Having individuals relate their experience to help overcome issues at hand is known as cognitive diversity. It is defined as "the degree to which team members differ in terms of expertise, experiences, and perspectives" (Horowitz & Horowitz, 2007, p. 989). This promotes "creativity, innovation, and problem solving, and thus results in superior performance" (p. 989). A second benefit is a likelihood that diverse boards are more concerned with ethical practices and own a responsibility to take action to reduce perceived risks (Kamon, Monhamad, Norwani & Faroque, 2017). Additionally, diversity among board members improves "the quality of corporate decisions, offering better problem solving, increasing organizational competitiveness and providing new insights that lead to innovation" (Kamon et al., 2017, p. 452).

Diverse board membership does not come without its challenges. One particular item to be aware of is when board members have a professional stake in a for-profit company while serving on a nonprofit board. There is a possibility of that member using their influence for their benefit. The Sarbanes-Oxley Act of 2002 is a federal law that established auditing and financial regulations to deter fraud (Ostrower, 2007). As a result, the industry has become more scrutinized because

nonprofit organizations today are feeling pressure to become more accountable and transparent to the public, changing the way policies and procedures are developed within the organization (Ostrower, 2007).

RECOMMENDATIONS & CONCLUSION

Nonprofits must contend with a number of constraints to exist and ultimately to thrive. Members of nonprofit governing boards are armed with the responsibility to safeguard their organizations' missions and provide value and support to the short-term and long-term goals of the organization. This undertaking imposes both careful and continuous thought and strategy into the overall board composition.

While the existing body of research on the impact of board diversity on organization performance is limited, we do find evidence of a positive association between board member diversity and inclusion, in terms of gender and racially diverse membership, as well as other attributes including individual's perspective and overall board size, leads nonprofit organizations to increased performance and agency success. In addition, research studies have discovered less diverse boards have increased difficulty to the varied needs of the population they serve.

Consequently, the want and need to recruit and retain capable and committed members of the board merits a comprehensive approach to identify a broad range of talent and expertise. By taking a proactive approach to board diversity, organizations can support not only the motivations of their members but also the long term value of the organization itself.

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The Legal and Ethical Considerations of Using Social Media in the Recruiting and Hiring Stages of Employment

Abstract

The use of social media in the recruiting and hiring process raises both legal and ethical considerations for employers. According to a 2018 survey, 70% of employers use social media to screen candidates during the employment process and 48% use social media to check on current employees (CareerBuilder, 2018). The obvious potential for abuse has generated legislative action, ethical debate, and an extensive search for best practices.

This paper will examine the current legal parameters of the use of social media at the recruitment and selection process stages of employment. The ethics and appropriate ethical considerations of social media as a component of the hiring process will be examined using a new model that evaluates the Total Utilitarian Ethical Analysis Impact Value. Finally, recommendations for best practices will be analyzed and suggested for the use of social media at the recruiting and selection stages of employment.

Key Words

Social Media, Discrimination, Ethics

Current Landscape of Social Media Use in Employment

In 2014, the EEOC acknowledged the use of sites such as LinkedIn and Facebook may reveal information about a candidate's race, ethnicity, disability, and other information the use of which in making an employment decision would be illegal (Release, 2014).

State legislatures have been more proactive than their federal counterpart. To date, according to the National Conference of State Legislatures, (State Social Media Privacy laws, 2019) 25 states have passed laws prohibiting employers from requiring job applicants to provide prospective employers with access to their social media. Additionally, some laws prohibit employers from demanding prospective employees to bring up their social media in the employer's presence or to change their privacy settings to make the site available to the employer. Indirect access to social media accounts by mandating accepting an agent of the employer as a friend is also prohibited in some cases.

Some of these laws apply specifically to social media accounts, such as a Facebook or Twitter account. However, other laws apply more broadly to "online accounts," which might include email, banking, financial or even commercial accounts.

In New Jersey, N.J. Stat. Ann. §§ 34:6B-5 to 34:6B-10 limits employer action regarding an applicant or current employee's personal social media account. Employers are not permitted to require or request that an applicant or a current employee provide any user name or password, or in any way provide the employer access to a personal account through an electronic communications device. The law does not restrict an employer from inquiring into whether an

applicant or an employee has a social media account or from viewing any social media sites or personal accounts that are in the public domain.

Whether LinkedIn profiles are personal accounts or for business purposes and therefore not subject to the statute's prohibition has been the subject of legal debate in New Jersey (NJBIA, 2016).

In Connecticut, Conn. Gen. Stat. Ann. § 31-40x prohibits an employer from requiring employees or applicants to disclose user names, passwords, or other login information to a personal online account or authenticate or access an online account in the presence of the employer. Employers may not require employees or applicants to invite, or accept an invitation from, an employer to join a group affiliated with a personal online account. An online account is one that is used exclusively for personal purposes, including email accounts, social media accounts, and retail website accounts.

If an employer does use an applicant's background information to make an employment decision federal antidiscrimination laws must be adhered to. These laws related to discrimination based on race, color, national origin, sex, religion, disability, genetic information, and age are administered by the Equal Employment Opportunity Commission (EEOC, 2019). In all cases treat all applicants or prospective applicants equally.

When background checks are done by a third party in the business of compiling background checks, the Fair Credit Reporting Act, administered by the Federal Trade Commission may require additional procedures be followed (Commission, 2019).

The Age Discrimination in Employment Act, 29 U.S.C. § 631(a), makes it illegal to discriminate against workers over the age of 40 when advertising, recruiting and hiring. A provision of the ADEA involving job postings generally makes it unlawful to "print or publish" notices or advertisements "indicating any preference, limitation, specification or discrimination, based on age." (Labor, 2020)

Preferences based on age are only appropriate when age is established as a legitimate qualification that is necessary for the normal operation of the business (Hodgson v Greyhound Lines, Inc., 1973).

The use of social media as a recruiting and vetting tool has increased dramatically. Employers are both formally and informally turning to social media sites such as Facebook, LinkedIn, Instagram, and YouTube for employee recruitment and vetting. As this approach has become the norm, legal issues have emerged related to discrimination and exclusion of protected class members.

In 2017, suit was brought in federal court based on some large employers' use of social media in hiring practices. A class action lawsuit was filed, alleging that Facebook-provided target marketing tools allowed employers to direct employment ads to younger applicants, thereby discriminating against older applicants.

The Communication Workers of America filed suit in the United States District Court for the Northern District of California (17-cv-07232, filed 12/20/17) alleging age discrimination in employment by T-Mobile US, Inc., Amazon.com, Inc., Cox Communication, and Cox Media Group. The complaint alleged the companies' use of Facebook (not a named defendant) to post employment ads was in violation of California age discrimination laws. Facebook permitted the employers to place upper age limits on the Facebook users eligible to receive the ads. Facebook advertisers were permitted to choose groups such as "Young and Hip" and "Millennials" to target the ads (CWA, 2017).

The plaintiffs cited several job advertisements posted to Facebook in 2018 or earlier. They appeared on users' news feeds as "sponsored" posts. The information allegedly obtained from Facebook indicates that the ads were targeted to users in specific age ranges, including "18 to 38" and "21 to 55."

In September 2019, the labor union Communications Workers of America released letters from the Equal Employment Opportunity Commission stating it found "reasonable cause" that the employer violated federal laws by excluding women, older workers or both from seeing their job ads on Facebook. The social network offers advertisers various tools for targeting their desired audience.

The ads are from 2018 and earlier. Facebook has pledged changes since then. (One of the authors found ads on his Facebook page today, January 8, 2020 targeting him based on age).

In March 2019, Facebook said it would pay nearly $5 million to settle several lawsuits that alleged its advertising platform allowed for discrimination in housing, employment and credit ads. As part of multiple settlements, it also announced major changes, including a separate advertising portal for housing, employment and credit ads that will offer significantly fewer targeting options (Yurieff, 2019).

While Title VII of the Civil Rights Act of 1964 is considered to be the primary federal antidiscrimination law, the Age Discrimination in Employment Act (ADEA) of 1967 also provides important protections for workers nationwide.

The ADEA and various state statutes prohibit employers from advertising job openings in ways that restrict eligibility on the basis of age. Federal Law prohibits discrimination for those 40 and older while many states such as New York protect applicants and employees 18 years of age and older.

 A pending federal class action against several major companies addresses the use of social media, specifically Facebook to advertise employment opportunities. The lawsuit alleges that the defendants restricted the dissemination of job advertisements to users in certain age ranges. Several recent decisions by the Equal Employment Opportunity Commission (EEOC) support the plaintiffs' position that this violates the ADEA's advertising restrictions.

In July 2019, the EEOC issued determination letters to seven companies based on charges filed under the ADEA. All of the charges alleged unlawful posting of job advertisements on the social

media platform Facebook, which allows companies to target advertisements to certain audiences. The EEOC reported that it found evidence that the companies "used language to limit the age of individuals who were able to view the advertisement." It notified the companies that it had found "reasonable cause to believe that [they] violated the ADEA." (Group, 2019)

This is a novel theory for the EEOC. Concluding age discrimination based on social media target marketing. In 2018, fifteen employers had allegedly used Facebook to target male users with job advertisements, excluding women. No litigation has been initiated specifically.

The Ethics of Social Media Recruiting

No universal formula exists to guide us ethically through the decision making process. Immanuel Kant advocated a duty-based ethics analysis. Regardless of an actions consequences, the ethics of a behavior was evaluated in relation to a guiding set of principles or beliefs. Whether the beliefs originated from religious beliefs or a secular foundation of guiding values the action is deemed right or wrong based on the action itself not the consequences of the action (Moore, 2016).

A different approach to ethical analysis is utilitarianism (Mill, 1863). The ethics of the action is determined by the consequences of the action. The greatest good for the most people is the appropriate consideration. It is with this consideration that a new model was developed by modifying the weighted scoring model to evaluate the ethical analysis of "Should employers use social media in the hiring process?" (Ball, 2019).

The hiring process is procedurally divided into recruiting candidates and evaluating candidates. These two stages of the hiring process raise different issues at each stage. Using social media to recruit candidates is significantly impacted by demographic variations in social media use. The use of social media in the candidate vetting process allows the gathering of both legally permissible and discriminatory information related to the applicants. The legality of such inquiries is separate and distinct from the ethics of the process

As an illustration, the following is an analysis of the use of social media in the new employee recruitment process. The proposed model allows variables to be weighted in the quantitative analysis of a set of considered criteria. The two possible decisions are to use social media or not use social media as part of the recruitment process.

For each of these two decision options, the following criteria were used to assess the greater good in utilitarian ethical analysis:
1) Invasion of nonemployee privacy
2) Locating best applicants (social media users)
3) Locating best applicants (non - social media users)
4) Impact on employer brand reputation
5) Cost effective hiring process

The utilitarian ethical analysis is valued based in the decision's impact for the overall good based on the expected outcome. In this model, each decision alternative and expected outcome is scored using a Utilitarian Ethical Analysis Impact Value (*UEAIV*) using the following scale:

- *UEAIV* = 1: strongly negative
- *UEAIV* = 2: negative
- *UEAIV* = 3: neutral
- *UEAIV* = 4: positive
- *UEAIV* = 5: strongly positive

Each criteria is assigned a weight and a Total Utilitarian Ethical Analysis Impact Value (*TUEAIV*) is evaluated for the decision. The objective is to determine the best decision alternative that will lead to an employer hiring strategy that hires the best people to do the job and best serves the stakeholders.

The first criteria considered was the possible invasion of non-employee privacy. Prospective employees need to be aware that their social media accounts may be researched by potential employers. As a result, it is proposed that, although the privacy of these prospective employees may be at risk, the utilitarian ethical impact is expected to be positive as candidates are more responsible with their social media accounts (e.g., *UEAIV* = 4). The opposite result may occur if it is known that potential employers will not review the social media accounts, thus resulting in a negative utilitarian impact value (e.g., *UEAIV* = 2). For this sample analysis, the weight of this criteria was 25%.

The second criteria addressed the need for organizations to locate the best possible applicants, and was viewed from both the perspective of prospective employees that are active social media users and those that do not regularly maintain social media accounts. For active social media users, it is beneficial for employers to research social media accounts during the hiring process. These candidates have a greater chance of being identified for the job, while also providing the company more targeted access to qualified candidates, especially when using professional-oriented accounts such as LinkedIn. Therefore, using social media in the hiring process suggests a strongly positive outcome (e.g., *UEAIV* = 4.8). Conversely, employees that do not use social media during the hiring process may miss out on these qualified candidates, thus providing a negative consequence for the organization and prospective candidates (e.g., *UEAIV* = 2). This criteria was also analyzed for non-social media users. In this case, employers that used social media in the hiring process yield a low score when compared to non-social media users because these candidates may not be identified by the potential employer (e.g., *UEAIV* = 2). This pool of candidates would benefit by potential employers not using social media during the hiring process because they are more active in the traditional job seeking approaches than social media users (e.g., *UEAIV* = 4.5). This overall criteria was awarded a total weight of 25% and split equally between the social media and non-social media user perspectives.

The next criteria considered the impact on the employer brand reputation from the perspectives of stakeholders such as the employer owners, competitors, vendors, and the general public. In this case, employers that use social media in the hiring process may be awarded an overall score of mildly negative (e.g., *UEAIV* = 2.5). Although the overall company product may be strong due to the increased quality of new hires, the potential invasion of privacy reputation may be

viewed as a net negative for the brand reputation. Conversely, the respect for prospective privacy may yield a net positive outcome for employers that do not use social media in their hiring process (e.g., *UEAIV* = 2.5). This criteria was assessed using a weight of 25%.

The final criteria factored into this analysis was the cost effectiveness of the hiring process from the collective perspectives of stakeholders such as the employer owners, employees, and consumers. When companies use social media during the hiring process, the overall utilitarian ethical analysis outcome score is expected to be mildly positive (e.g., *UEAIV* = 3.8). In this case, there may be initial costs associated with the search for qualified candidates, but the organization is more likely to hire a good candidate. Companies that do not use social media during the hiring process may save expenses initially, but have a reduced likelihood of hiring the best candidate. As a result, these organizations may incur costs such as additional training or even repeating the search process, thus leading to a mildly negative overall score (e.g., *UEAIV* = 2.5). The weight of this criteria for the model was assumed to be 25%.

The new model proposed in this paper uses the following criteria to calculate the total ethical analysis impact value (*TUEAIV*) for a decision:

$$TUEAIV_j = \sum_{i=1}^{n} w_i \cdot UEAIV_{i,j}$$

Where:

$TUEAIV_j$ = Total Utilitarian Ethical Analysis Impact Value for decision j ($j = 1 \rightarrow m$)
w_i = weight for criteria i ($i = 1 \rightarrow n$)
$UEAIV_{i,j}$ = Utilitarian Ethical Analysis Impact Value for criteria i and decision j ($i = 1 \rightarrow n$; $j = 1 \rightarrow m$)
m = number of decision alternatives
n = number of criteria

The results of this analysis are shown in Table 1.

Table 1: Total Utilitarian Ethical Analysis Impact Value Model

Criteria (*i*)	Weight (*w_i*)	Option #1 Employers Use Social Media in the Hiring Process	Option #2 Employers Do Not Use Social Media in the Hiring Process
Invasion of non-employee privacy	0.25	4.0	2.0
Locating best applicants (social media users)	0.125	4.8	2.0
Locating best applicants (non – social media users)	0.125	2.0	4.5

Impact on employer brand reputation	0.25	2.5	3.8
Cost effectiveness of hiring process	0.25	3.8	2.5
Total =	1.00	**3.43**	**2.89**

Based on the analysis shown in Table 1, the *TUEAIV* for Option #1 (employers use social media in the hiring process) is 3.43 and greater than the *TUEAIV* for Option #2 (employers do not use social media in the hiring process) of 2.89. This analysis suggests that, using the criteria, weights, and projected utilitarian ethical analysis impact values proposed in this paper, employers would maximize the *TUEAIV* if they used social media during the hiring process.

Best Practices for Social Media Use

The authors' best practices for using social media in the hiring process include the following:

1. Do not ask for social media user names or passwords. While this approach may be with good intentions and ultimately arguably voluntary, the disparity of bargaining power is problematic. Job applicants have successfully contended any "voluntary" consent given was in actuality coerced. In addition, nearly half the states have specifically prohibited the practice. Having an agent "friend" or "follow" any candidate or potential candidate is equally ill advised.

2. Use a third party to perform social media searches. Third party delegation will likely trigger Fair Credit Reporting Act limitations. Contractually agreeing to comply with all legal requirements may provide some insulation from liability. It remains unclear how courts will view the liability of employers if it is found discrimination by the third party provider had a disparate impact on the applicant pool or employee demography.

3. If social media is used, only search public sites later in the hiring process and only by trained employees not involved in the decision-making process. Even public sites will reveal protected class status. Information, which would never be permissible nor apparent during a job interview such as marital status, religious affiliation, parental status, political affiliation, and many others, may be revealed on social media. Is the social media search then more probative or problematic?

4. The two strongest arguments for social media use may be fact checking and negligent hiring prevention. Using LinkedIn, profiles as a basis for resume or job application comparison may be a prudent best practice. LinkedIn profiles are generally considered professional outreach. If the profile data does not match a submitted resume or job application, does this rise the level of actionable fraud? Alternatively, could the candidate argue minor discrepancies amount to puffery on LinkedIn and the business profile is contractually analogous to an invitation to negotiate?

The negligent hiring argument is something to consider, but is undecided in the courts. If almost 80% of employers report using social media in the employment process, does that then create a best practice duty to use social media in the employment process?

Conclusion

The use of social media in employment is ubiquitous while the legal and ethical parameters continue to evolve and be debated. Both employers and potential employees should be cognizant of the environment in which numerous stakeholders are impacted directly and indirectly. This paper also presented a decision model that employers can use that incorporates utilitarian ethical impact into the hiring process. Future research is recommended to improve the criteria selection and corresponding weights and utility values.

Using social media to recruit or be recruited is fraught with legal and ethical risks and opportunities. All social media users and non-users should remain vigil and purposeful to achieve their respective goals.

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Marketing and Consumer Behavior - Abstracts

Exploring the Development of Social Marketing Academic Research from the Perspective of Innovation Diffusion

Marketing and Consumer Behavior

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This study adopted Rogers' theory of innovation diffusion and applied main path analysis to measure the number of publications using social marketing over the years. The main development context of social marketing was then captured using the citation relationships between the academic papers to review the growth trajectory of its innovation diffusion.

Social marketing faced different development environments at different stages of innovation diffusion, from the early stage, which advocated the innovative application of marketing; to the stage of rapid expansion, which involved the incorporation of social issues; to the late stage, which involves the expansion of application orientations.

The Role of Third-party Justice in Online Complaint Management

Marketing and Consumer Behavior

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There is no doubt that online consumer reviews provide prospective consumers with valuable information about potential products or services that they may wish to buy. In this study, we mainly focus on negative reviews especially in terms of their relationships with prospective consumers' perceptions of products under consideration. Our discussion is rooted in the Attribution Theory. We attempt to develop a linkage between the most-frequently discussed cues embedded in negative reviews and to then explore how practitioners can utilize these cues to improve their online complaint management.

What makes me Click? Advertising Images in the Context of High Severity Diseases

Marketing and Consumer Behavior

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In general, it is believed that images facilitate processing over text, because information encoded from images does not have to be recoded (Joffe 2008). Further, images are stored both as the image and semantically (Viswanathan and Childers 2003). Thus, due to processing ease, images can be understood without exerting significant cognitive effort. It follows that messages that include images in addition to verbal components have favorable effects on learning and memory (Paivio 1991). The main objective is to understand the effectiveness of positive versus negative framing in *health messages across multiple countries* incorporating both images and verbal components,.

Marketing and Consumer Behavior - Papers

EXPLORING THE DEVELOPMENT OF SOCIAL MARKETING ACADEMIC RESEARCH FROM THE PERSPECTIVE OF INNOVATION DIFFUSION

ABSTRACT

Social marketing seeks to develop and integrate marketing concepts with other approaches to influence the behaviors of others, thereby benefiting individuals and communities for the greater social good. This concept was first proposed by Kotler and Levy in 1969. It was considered an innovation in academic research, and has now undergone 50 years of development. This study adopted Rogers' theory of innovation diffusion and applied main path analysis to measure the number of publications using social marketing over the years. The main development context of social marketing was then captured using the citation relationships between the academic papers to review the growth trajectory of its innovation diffusion.

Our study found that the innovation diffusion of social marketing academic research has moved from the early stage of innovation diffusion (1969–2001), through the rapid stage of diffusion (2002–2012), and gradually toward the late stage of innovation diffusion (2013 onwards). Social marketing faced different development environments at different stages of innovation diffusion, from the early stage, which advocated the innovative application of marketing; to the stage of rapid expansion, which involved the incorporation of social issues; to the late stage, which involves the expansion of application orientations. Each stage gave rise to research trends with different characteristics. This is of great significance in understanding the development of this academic field.

Keywords: Social Marketing, Innovation Diffusion, Main Path Analysis, Citation Network

INTRODUCTION

Social marketing involves the use of marketing concepts and methods to change people's ideas and behaviors to enhance the welfare of society. In 2013, the International Social Marketing Association (iSMA), the European Social Marketing Association (ESMA), and the Australian Association of Social Marketing (AASM) jointly proposed a definition of social marketing as follows: social marketing seeks to develop and integrate marketing concepts with other approaches to influence behaviors that benefit individuals and communities for the greater social good.

Although the concept of social marketing can be traced back to a question raised by Wiebe (1951), "Why can't you sell brotherhood like you sell soap?", the term itself was only proposed by scholars after 1969. Kotler and Levy (1969) were the first to argue that the nine concepts of marketing management—product definition, target group definition, customer behavior analysis, differential advantage, multiple marketing tools, integrated marketing planning, continuous marketing feedback, and marketing audits—can be applied to the marketing of services, persons and ideas by nonbusiness organizations. Social marketing was an innovation when it was first proposed, and social marketing research has been developing for 50 years so far. What has been its history of development from an innovative concept to a topic of concern for numerous scholars in the present day? This is the main purpose of this study, which aims to understand the innovation development of social marketing in academia, and hopes to gain a deeper understanding on the development of academic research and social science knowledge.

Paradigm shift is often one of the important forms taken by the development of academic research. Kuhn (1996) mentioned in his book, *The Structure of Scientific Revolutions*, that normal science is research that is based on one or more past scientific achievements recognized by the scientific community. These early studies can attract many believers and solve problems that have previously not been solved, thereby forming a

paradigm. Hence, normal science is intimately associated with paradigms. When a paradigm first appears, its scope and accuracy are very limited, but it receives recognition because it is better than its competitors at solving the key unsolved problems that have been discovered by scholars. For a paradigm to become more successful, it must either be able to completely resolve a single problem, or achieve significant results for most problems. Thus, the development of normal science is also constantly expanding the scope and accuracy of knowledge until a phenomenon occurs that differs from the previous understanding. This will then lead to changes in the paradigm category and procedures, which are often accompanied by resistance to these changes.

Compared to natural science, the process of change in social science paradigms is more complicated. Social science paradigms are rarely abandoned; instead, they are judged based on whether they are popular, appropriate, and have external validity (Babbic, 2012). In the social sciences, a new research approach does not necessarily stem from an unsolved problem, and innovative application is one of the important models. How is an innovative application developed? What is the development of its diffusion process? E. M. Rogers proposed a theory of innovation diffusion, arguing that the diffusion of innovation is the most universal process in social change, which includes a new idea, scheme, or product (Rogers, 2003). Therefore, this study will adopt the perspective of innovation diffusion to analyze the development process of social marketing based on a large amount of literature from academic research, thereby enhancing our understanding of the development of academic research in the social sciences.

The main purpose of the traditional literature review method is to collate and analyze past research results to identify the gaps in research that can serve as a direction for future research and theoretical development (Griffith, 1999). However, the 50 years of research on social marketing has led to the accumulation of more than 6,000 related academic papers. Therefore, it is not possible to manually process these papers to explore the development of

social marketing, hence a traditional literature review is no longer a suitable approach. This study employed the main path analysis method to construct a citation network based on the large amount of social marketing literature, extract the major development paths of academic research for analysis, and examine the research content of the literature on the main paths, to explore the development process of social marketing.

The following is a brief description of the research framework and principles of main path analysis, data collection method, and statistics of social marketing research literature. Main path analysis is used to extract the main path diagram of social marketing to analyze the innovation diffusion of social marketing, followed by a discussion on the research findings to address the research questions, as well as an explanation of the limitations of this study and recommendations for future research directions.

DATA AND RESEARCH METHODS

Interpreting the Development of Social Marketing Academic Research with the Theory of Innovation Diffusion

Rogers (2003) proposed that innovation diffusion refers to a process where an innovative idea, approach, or thing is spread among participants in a social system via specific channels within a given period. The development of academic research is always based on the foundation laid by its predecessors. Budding research ideas are introduced to the academic world through research conferences and journal publications. If these ideas subsequently attract the attention of other scholars, they will be discussed and further explored by different academic communities; only then will it gradually spread to the wider academic community and attract more scholars to join the ranks of this research. This is actually a phenomenon of the diffusion of innovative ideas. Realizing this process, Rogers proposed an S-curve of innovation diffusion, which presents the developmental characteristics of innovation diffusion at different stages. During the early stage of diffusion,

the number of adopters is low and progress is relatively slow. However, after some time, the number of adopters will increase substantially and innovation enters a stage of rapid growth. This persists until the late stage of diffusion, when adoption of the innovation approaches saturation, and the rate of progress begins to slow down once again. On the other hand, Rogers also pointed out that during the process of innovation diffusion, adopters or users will adjust and change that innovation according to the environment and needs they face, a phenomenon that he calls "reinvention." Therefore, the innovation diffusion of academic research not only follows different stages of development over time, but also exhibits different research trends in the face of different development environments.

This study adopted Rogers' theory of innovation diffusion as its analytical framework to perform the collection and statistical analysis of the cumulative growth in academic literature published on social marketing over the years. In addition, the context for the diffusion of academic research was observed from the perspective of literature citation relationships, to analyze the innovation diffusion of social marketing academic research, where different development stages and environments exhibit different research trends. The research concept is shown in Figure 1 below.
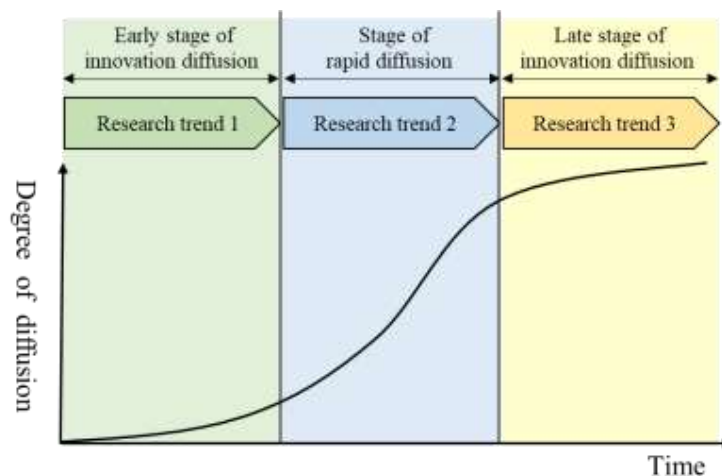
Data Compiled with reference to Rogers' curve of innovation diffusion

Figure 1. Conceptual diagram for the innovation diffusion of social marketing academic research

Main Path Analysis

Academic research is generally based on the foundations laid by its predecessors. Hence, the citation data of papers not only reflect their degree of importance, but also contains rich information such as how knowledge is disseminated. Garfield, Sher, and Torpie (1964) pointed out that the development of science follows the chronological order in which events occur, and each new discovery is based on past research results. They selected 40 academic papers on the discovery of DNA as examples to plot topological network diagrams, and they explained the development of academic research in a specific field based on the analysis of citation relationships. On the other hand, with the increasing number of academic papers accumulated over the years, their citation relationships can be better used to trace the evolution of academic research over time (Kostoff, 1998). Main path analysis uses the citation information of academic literature as its basis to evaluate and extract the main path of academic research and development from a large number of complex citation relationships.

Main path analysis first involves using the citation relationships of academic literature to create a network diagram where the nodes represent academic papers, and nodes with a citation relationship are connected by links. How then do we determine which links between the nodes are the most important within a citation network, and how should this be calculated and evaluated? To address these issues, Hummon and Dereian (1989) proposed three methods: search path link count (SPLC), search path node pair (SPNP), and node pair projection count (NPPC), which can be used to calculate the importance of the links between the nodes and give a numerical evaluation (i.e., link weights). Batagelj (2003) developed another method of calculation, the search path count (SPC), which provided an alternative for calculating the link weights in main path analysis. Figure 2 is an example that briefly illustrates the SPC weight calculation method in main path analysis.
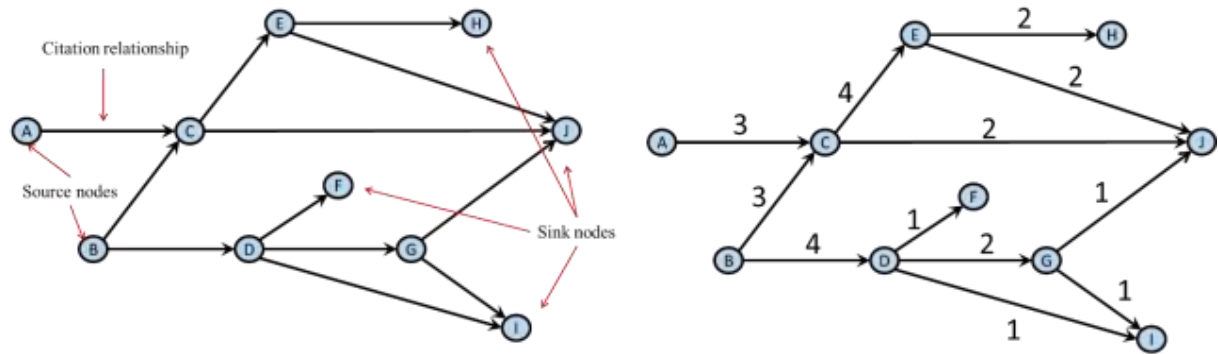
Data source: Lu and Liu (2014)

Figure 2. Example of SPC weight calculation in a citation network

The example in Figure 2 is a citation network that consists of 10 papers (A to J). In the diagram on the left, paper C cites paper A and the arrow represents the citation relationship between them. Papers A and B are only cited by other papers, and do not themselves cite other papers, hence they are known as "source nodes"; also, they are usually published at an earlier date. Papers F, H, I, and J only cite other papers but are not themselves cited, so are known as "sink nodes," and are usually more recent publications. The SPC method calculates the number of times a link is traversed for all possible paths from all source nodes to all sink nodes, which is used to assign the weight of that citation relationship. The diagram on the right shows that the link C-E has a weight of 4, which implies there are four paths—A-C-E-H, A-C-E-J, B-C-E-H, and B-C-E-J—that traverse through it. Since it has the greatest weight within the citation network, this citation relationship is known as a key route; link B-D is another key route. Main path analysis does not directly evaluate the value of each paper; instead, it evaluates the citation links between the papers, and reveals the important paths rather than the important papers. Nevertheless, the papers on the main paths still carry a certain value relative to other papers in the same period (Liu & Lu, 2012).

Once the weights of each link have been assigned in the citation network, the selection of the main paths can be carried out. Main path analysis involves first calculating the

importance of the links between the nodes based on the literature citation network, then connecting the important links together to form the main paths. The traditional approach is to use local main path analysis to connect the important paths. This involves starting from all source nodes and searching for the link with the greatest weight, which is traversed to connect to the next node, then starting from this node, to search for the link with the next greatest weight, so on and so forth until one reaches a sink node (Verspagen, 2007). Using Figure 2 as an example, the main paths selected using local main path analysis are B-D-G-I and B-D-G-J, which ignores the key route C-E, as well as the early important paths A-C and B-C. Liu and Lu (2012) pointed out that local main path analysis has the following shortcomings: 1) It is unable to guarantee that the overall path is the path with the highest sum of weights in the citation network. 2) It is prone to missing out important papers in the early stages. 3) It is unable to generate other auxiliary paths to facilitate the understanding of the research topic. 4) It may miss out links with the greatest weights between the nodes. Therefore, to address the shortcomings of local main path analysis, they proposed key-route main path analysis and global main path analysis, which can be combined to form global key-route main path analysis.

Key-route main path analysis mainly solves the problem found in local main path analysis of missing out links with the greatest weight. The process of linking the main paths is as follows: 1) Selecting key routes, which are links with the greatest weight in the citation network. 2) Begin searching from the terminal node of these key routes to find the most important links until a sink node is reached. 3) Begin searching from the starting node of these key routes to find the most important links until a source node is reached. Key-route main path analysis can guarantee that all important links are included in the main paths. Global main path analysis, on the other hand, adopts a global perspective to search for the path with the largest sum of link weights among all possible paths. Using Figure 2 as an

example, the paths with the largest overall weight are A-C-E-H, A-C-E-J, B-C-E-H, and B-C-E-J, all with a path weight of 9.

Key-route main path analysis and global main path analysis can address the shortcomings of local main path analysis, as they adopt different perspectives when searching for the most important research paths in the citation network. However, a single main path may not allow us to fully grasp the development of different sub-areas within a topic. Hence, the scope of analysis for the citation network can be expanded to address this issue. In view of this, Liu and Lu (2012) proposed that the search tolerance can be relaxed, to the extent that links falling within a certain weight range can be selected when establishing the main paths. This selection of multiple main paths can enrich the connotations of the results from citation analysis. For example, selecting global main paths with the top ten total sum of weights rather than global main paths with the greatest sum of weights will enable us to observe more processes of development.

Main path analysis is a social network analysis based on the citation relationships of academic literature. It represents the relationships between the research results of scholars and others within the same field, and can be used to explore the diffusion of academic knowledge (Lu & Liu, 2014), the stages and trends of development in scientific research (Ho, Saw, Lu, & Liu, 2014), as well as the different development topics and state of research in the academic domain (Kraus, Filser, O'Dwyer, & Shaw, 2014). Social marketing mainly involves applying the principles of commodity marketing to organizational services and mass marketing in non-commercial environments and social issues (Kotler & Levy, 1969), so it is appropriate to adopt main path analysis to analyze its innovation diffusion. Therefore, this study adopted global key-route main path analysis, which not only includes key routes but also selects paths with the greatest overall weight, to analyze the citation network of social marketing to enhance our understanding of the development process of academic research.

Data Source

"Social marketing" was used as the keyword to search through the titles, keywords, and abstracts of papers published through 2017 on the Scopus database of academic literature.[1] Items without authors or publication sources were removed, which yielded a total of 6,200 papers. Based on the analysis of the citation relationships, 3,150 papers were used to form the citation network, which served as the dataset for the main path analysis and had a citation percentage of 50.8%.

Growth Curve of Social Marketing Literature Publication

The number of publications and their cumulative growth over the years are shown in Figures 3 and 4. The earliest publication was the pioneering paper on social marketing by Kotler and Levy (1969), but few researchers were involved in the early stages of research and the number of early publications on social marketing was limited. From 1984 onward, the number of papers gradually began to increase, and remained stable from 1994 to 2001, with about 50 papers published per year and showing a slow rate of progress. Since 2002, the number of papers increased rapidly and entered a stage of rapid diffusion, where the number of research papers published each year increased at an accelerating pace and reached its peak in 2011. However, there has been a trend of gradual decline in recent years. The figures show that the diffusion of social marketing research has moved from the early stage of innovation diffusion to the stage of rapid diffusion and is now gradually entering the late stage of innovation diffusion.

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[1] The Scopus database covers nearly 20,000 peer-reviewed academic journals, more than 400 trade journals, and more than 360 book series. It is the world's largest abstract and citation database, created by Elsevier.
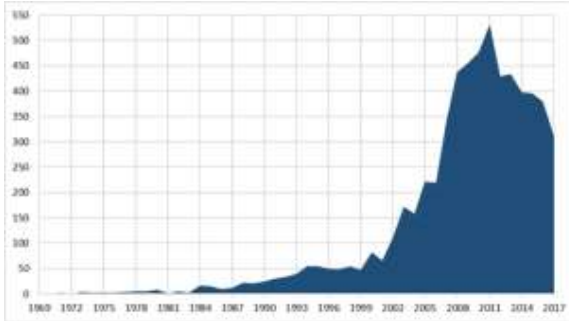
Figure 3. Number of publications on social marketing over the years
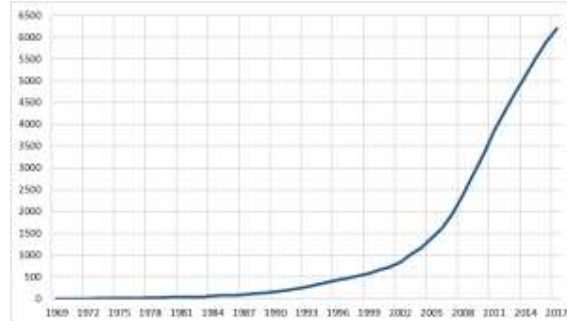
Figure 4. Cumulative publications on social marketing

RESEARCH RESULTS:

Innovation Diffusion of Social Marketing Research

The 3,150 papers related to social marketing formed 8,897 citation links. Thus, it is only by applying main path analysis can we identify the most important relationship paths among these complex and intricate citation relationships. Global key-route main path analysis was adopted in this study, and search path count (SPC) was used to calculate the link weights of the citation network. All key routes and paths with the largest overall weight were also selected to create the main path diagram of social marketing academic development (Figure 5). The main path included a total of 26 papers from 1971 to 2017 (see Appendix 1 for table of codes),[2] and the thickness of the links denotes the difference in the sizes by weight. By analyzing and comparing the contents of the 26 papers, we explored the development environments and trends of social marketing at different stages of innovation diffusion. The early stage of innovation diffusion involved promoting the innovative application of marketing; the stage of rapid diffusion emphasized the incorporation of social issues; while the late stage of innovation diffusion is concerned with expanding the application orientation

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[2] The nodal papers on the main path were expressed as the author's name and the year of publication. If multiple authors were present, only the first letter of the last names from the second author onwards was included. For example, KotlerZ1971 denotes the paper published by the authors Kotler, P, and Zaltman, G, in 1971. Please refer to the references for the nodal papers on the main path.

of social marketing. The following is an analysis of the development features and trends of social marketing research at different stages.
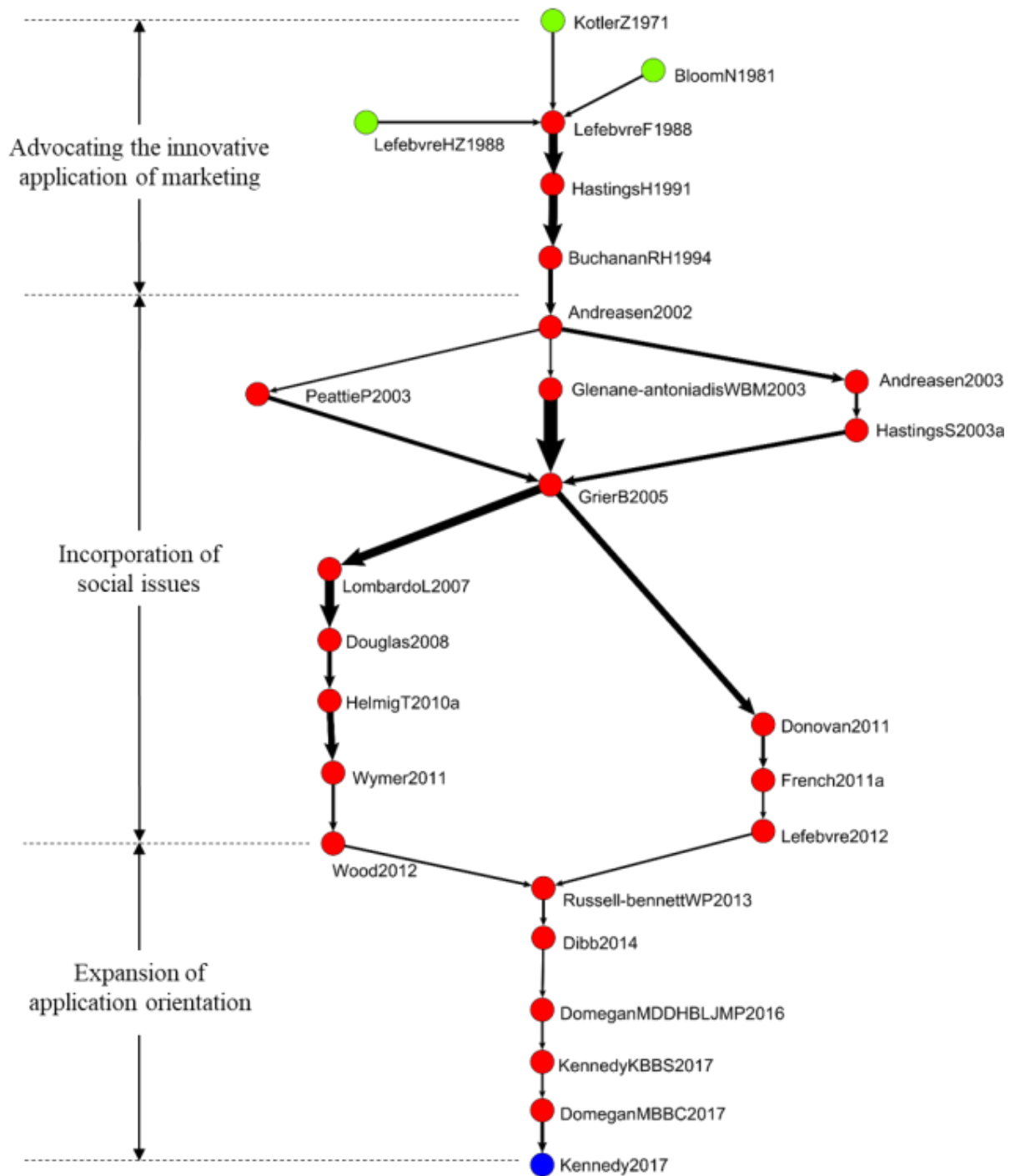
Figure 5. Global key-route main path diagram of social marketing

1. Advocating the innovative application of marketing (1969–2001)

The main path of social marketing included six papers during the stage of promoting the innovative application of marketing. When faced with the issue of expanding the application of the social marketing concept, the characteristics and trends of research during this stage included developing an innovative application and highlighting the effectiveness of social marketing.

Initial application of marketing concepts on social issues

Kotler and Levy (1969) proposed a groundbreaking concept for social marketing, which was immediately subjected to doubts and criticism. Hence, the first paper in our main path analysis, "Social Marketing: An Approach to Planned Social Change," provided an explanation on the meaning, purpose, abilities, and limitations of social marketing. Kotler and Zaltman (1971) believed that social marketing is one of the means to achieve planned social change. The paper first stressed that the core idea of marketing lies in the exchange process, and that an increasing number of nonbusiness institutions have begun applying marketing concepts to promote their institutional goals. For example, the suggestions of marketing personnel have been used to increase membership in churches, fundraising by charities, and patrons or audience by museums and symphonies. The significance of social marketing is in the use of marketing techniques to promote social campaigns more effectively.

Kotler and Zaltman (1971) argued that specific social issues can benefit from marketing concepts and practices. For example, the problems of pollution control, public transportation, education, drug abuse, and public healthcare all require innovative solutions and approaches to gain public attention and support, which can be improved through social marketing. However, compared to business marketing, social marketing must place more emphasis on the core beliefs and values of the market; must strive harder to find meaningful methods of

transaction; and has greater need to integrate different marketing channels to ensure the adoption of its product. On the other hand, the application of social marketing to social issues may also be considered "manipulative," "promotional noise," and in danger of increasing costs.

Kotler and Zaltman (1971) described the implications of the marketing mix (4P) in social marketing. Product: In business marketing, sellers study the demands of the target customers, and then design products and services that meet the latter's demands. The same is true of social marketing, where social ideas must be packaged in a manner that their target audience will find desirable and are willing to accept. Promotion: Marketing communication is used to make a given social idea familiar and acceptable to the target audience, even prompting them to change their behavior. The methods that can be adopted include advertising, personal selling, publicity, and sales promotion. For example, in their attempt to promote family planning, the Indian government paid referral fees to salesmen who bring in consenting males for sterilization and offered gifts to couples who agree to use contraception. Place: Social campaigns should be provided with adequate and compatible channels for distribution and response, which will enable motivated individuals to know where and how they can change their ideas and behaviors. For example, smokers' clinics were set up in many large cities by anti-tobacco groups. Price: This represents the costs the buyer must accept to obtain the product. It includes capital costs, opportunity costs, resource costs, and mental costs. For example, when promoting immunization shots, it is necessary to consider the costs that the recipient must accept, including possible expenses, lost opportunities, consumption of resources, and psychological concerns over the idea of immunization. Social marketing initiatives originate from an institution's desire for change. Thus, information is collected for environmental analysis to formulate short-term or long-term social marketing plans, the variables of which include product, promotion, place, and price. Communication channels, such as mass or specialized media, agents, and volunteer groups, are then used to promote the

initiative in different target markets. Finally, the effectiveness of the social marketing plan is continuously reviewed for the refinement and readjustment of the plan.

When Kotler et al. developed the concept of social marketing, they seldom compared and discussed the effectiveness of other approaches to improve social issues, such as social campaigns or civic movements. Nor did they discuss the ability or inability of these approaches to effectively resolve social issues, or discuss what necessitated the use of marketing approaches. In other words, the reason for proposing social marketing is unlike that of normal science, which seeks to solve a previously unsolved problem. The innovative application of social marketing mainly originates from thinking about the nature of "exchange" that is common to both business and nonbusiness fields. Whether social marketing could truly and effectively improve social issues was subject to many doubts, and still required verification in practice. This is what prompted Kotler and Zaltman (1971) to provide a complete explanation concerning the application of social marketing.

Highlighting the effectiveness of social marketing

An innovative application must first be shown to be effective before it can be widely accepted and undergo diffusion. Thus, highlighting the effectiveness of social marketing during the early stage of its innovation diffusion is another research feature of this stage. Bloom and Novelli (1981) strongly advocated that marketing can make significant contributions to social action programs, and proposed eight basic decision-making areas in marketing: market analysis, market segmentation, product strategy, pricing strategy, channel strategy, communications strategy, organizational design and planning, and evaluation. They laid out the problems encountered by social marketers when implementing social marketing, and hoped that these problems could be resolved to ensure the success of social marketing.

Lefebvre, Harden, and Zompa (1988) applied social marketing to reduce the incidence of cardiovascular disease in society. Based on the previous practical experience of applying

social marketing in public health intervention, Lefebvre and Flora (1988) emphasized the usefulness of promoting community-based health education programs through social marketing, and discussed the advantages of applying social marketing based on eight aspects: consumer orientation, exchange theory, customer analysis and segmentation, implementation methods, channel analysis, marketing mix, process tracking, and marketing management.

Hastings and Haywood (1991) pointed out that communication is the core aspect of health promotion, and social marketing is an excellent tool for health promoters to develop media communication. The paper examined social marketing concepts such as consumer orientation, voluntary and mutually beneficial exchanges, internal and external environments, threats and opportunities, objective setting, market segmentation and target markets, and marketing mix, particularly their relevance to media communication in health promotion, which was then followed by the consolidation and development of a framework for their practical application.

The papers above attempted to incorporate marketing concepts into actions to improve social issues, and their discussion mainly focused on the application and implementation of marketing concepts in non-commercial environments.

Rogers (2003) pointed out that not all innovations are of equal importance, and their rates of diffusion and adoption are influenced by five attributes of innovations: 1) whether the innovation is more effective than its predecessors; 2) whether its level of difficulty is too complex; 3) whether repeated experimentation is possible; 4) whether the results of the innovation can be observed; and 5) whether the innovation is compatible with the values and past experiences of potential adopters. The main path papers above mainly focused on discussing the first four attributes of innovations, i.e., the instrumental attributes of social marketing. However, the origin of social marketing as an innovation is to apply the principles of profit-oriented commodity marketing to the marketing of nonprofit causes. Hence, the fundamental discrepancy between the two marketing objectives may lead to conflicts in basic

ideas due to differences in values among potential adopters in the innovation diffusion of social marketing (i.e., scholars originally engaged in research on improving social issues). Kotler and Zaltman (1971) suggested that the overt marketing of social objectives may be resented and resisted by some scholars due to accusations of being "manipulative," which would affect the diffusion of social marketing research among them.

Buchanan, Reddy, and Hossain (1994) raised three questions concerning social marketing: 1) Are ideas about the principles of social marketing new? 2) Are these principles more effective than existing health promotion practices? 3) Does their application give rise to any ethical concerns? The paper was especially concerned with the conflicts in basic values, criticizing the distortions of social marketing practices, such as using sexual cues to reduce smoking opportunities, and using greed and lust as advertising themes. The authors believed that that these practices were ethically irresponsible. On the other hand, the authors also questioned whether the invasion of the market economy model would change the original intentions of public health promoters who entered the field out of their sense of caring for others. In other words, they may overemphasize instrumental issues, placing too much focus on product, price, place, and promotion, while neglecting social justice, ignoring the quality of public life, tolerating poverty, and not respecting the rights of minorities in a democratic system. Clashes over these basic values would have had an impact on the innovation diffusion of social marketing academic research.

The attributes of innovations are key factors influencing their adoption rate (Rogers, 2003). Taking the innovation diffusion of social marketing as an example, early research on this topic focused on highlighting the effectiveness of social marketing, but the conflicts with the basic values of some scholars had an impact on its degree of diffusion.

2. *Incorporation of social issues (2002–2012)*

During the early stages of development in social marketing, most papers discussed how to apply key marketing principles to non-commercial issues (Bloom & Novelli, 1981; Hastings & Haywood, 1991; Kotler & Levy, 1969; Lefebvre & Flora, 1988). The many cases of success attracted growing attention to social marketing, while participation from governmental agencies, nonprofit organizations, and scholars increased continuously (Grier & Bryant, 2005). However, the development of social marketing was hindered to some extent by the value conflicts resulting from its application in non-commercial environments. Andreasen (2002) argued that social marketing faced major barriers to its practical and academic development, and that its scope and role are unclear compared to other approaches of social change. Based on the contents of the main path papers, the research environment at this stage involved developing a close relationship with various social issues in a non-commercial environment. In addition, there were two research trends. The first included discussions on deepening the application of social marketing for social issues. The second was the integration and modification of social marketing tools to reconcile the value conflicts between commercial marketing and the handling of social issues.

New directions in social marketing development

From 2002 onward, there was a rapid increase in the number of studies on social marketing, and some of the papers published at that time had a critical influence on its development. These scholars believed that social marketing should be repositioned, and that its own theories and tools should be developed, to diminish the influence of traditional marketing tools.

In terms of exploring the meaning of social marketing, Andreasen (2002) proposed that the nature of social marketing is not limited to what Kotler and Zaltman (1971) described as increasing the acceptability of social ideas, but that its ultimate objective should be behavior

change. Hence, it can be applied to any socially critical individual behavior that needs to be addressed. As for identifying what fell within the scope of social marketing, Andreasen proposed six benchmarks of measurement: 1) Behavior change serves as the benchmark for the design and evaluation of interventions. 2) Research of the target audience is performed consistently throughout the intervention. 3) Segmentation of the target audience is performed to maximize efficiency and effectiveness using minimal resources. 4) The core of the strategy is to establish attractive and motivational exchanges with the target audience. 5) The marketing mix (4P) is applied. 6) Close attention is paid to the competition faced when changing the target behavior. Andreasen (2003) further revised the definition of social marketing as follows: Social marketing applies the techniques of commercial marketing in the analysis, planning, implementation, and evaluation of programs that can affect the voluntary behaviors of the target audience, thereby improving their personal welfare and the interests of the society they belong to. He also stressed that to achieve a sustainable development in the field of social marketing, it is necessary to highlight the differences and functions of social marketing in relation to other approaches of social change (e.g., education, communication, lawmaking, and community mobilization), as well as for social marketing to complement the shortcomings of the other approaches.

Hastings and Saren (2003) agreed with Andreasen's ideas, and suggested that there are two vastly different views on "marketing." Apologists argue that marketing is beneficial to economic development, and its application should be limited only to the commercial sector, whereas the critics of marketing are not only critical of its outcomes, but also the impact that marketing concepts and process can have on human beings. The significance of social marketing is that it bridges the gap between these two views, eliminates the discrepancy between the commercial and social sectors, promotes a mutual understanding between the two sectors, and employs marketing approaches to change human behavior, thereby enhancing the welfare of individuals and society.

At the same time, Peattie and Peattie (2003) also argued that overemphasizing the application of mainstream marketing methods in solving social issues may cause confusion regarding the theoretical basis of social marketing. This is because the differences between the two—including the extension of commercial marketing vocabulary, the poor image of marketers in society, ethical dilemmas, and the different trajectories of commercial and social marketing—can all affect the development of social marketing. Therefore, the authors recommend that social marketing should develop its own distinctive vocabulary, ideas, and tools, while also searching for more suitable models and theories to apply from economics, psychology, sociology, and communications theory.

Glenane-Antoniadis, Whitwell, Bell, and Menguc (2003) argued that when social marketers are dealing with social issues, the outcome is not caused by factors of supply and demand in the market. Take the promotion of smoking cessation, for example: how do social marketers implement marketing among those who do not have the motivation to participate in the exchange (i.e., those who are unwilling to quit smoking)? How can a person be prompted to perform behaviors within the exchange relationship that will benefit other parties outside of the transaction? These issues are difficult to solve using the tools of traditional marketing. However, individuals may be willing to change part of their behavior to establish good relationships with others. Therefore, Glenane-Antoniadis et al. proposed that combining social capital theory with social marketing can help facilitate social change.

Grier and Bryant (2005) pointed out that social marketing has grown in importance and popularity in the public health domain, but still needs to overcome several challenges. These include barriers to the diffusion and application of social marketing; the need to develop more effective methods; the changes required to the use of commercial marketing as a theoretical basis; and the ethical considerations during the social marketing process—for example, incorporating the target audience in the design, implementation, and evaluation of social marketing programs would help reduce ethical controversies.

The above papers suggest that it was time for adjustments to social marketing academic research, and that social marketing should reexamine the nature of its application to social issues to integrate more completely into non-commercial environments. In addition, applying the theories and methods of traditional commercial marketing principles should be reduced and combined with other theories and tools to better deal with social issues (Glenane-Antoniadis et al., 2003; Grier & Bryant, 2005; Peattie & Peattie, 2003).

To spread the use of social marketing on social issues, the research trends in this study can be divided into two parts: reviewing and strengthening the application of social marketing to social issues; and consolidating and changing the tools of social marketing. At this point, social marketing research no longer emphasized the application of commercial marketing tools, but instead absorbed and converted marketing concepts, while drawing on other theories to develop the concepts and operational methods of social marketing itself. This will enable us to bridge the gap between commercial marketing and the handling of social issues, thus allowing social marketing to become one means by which to social change could be promoted.

Deepening the application of social marketing to social issues

As a tool to promote social change, social marketing involved the innovative application of commercial marketing to solving social issues; linking it with the social-contextual environment to enhance its effectiveness became an important direction of development. Papers on this main path emphasized that the application of social marketing must first involve a deeper understanding and integration of the social environment and social issues. Key papers in this period include the critical reflection by Lombardo and Léger (2007) on the social marketing activities of the HIV/AIDS prevention campaign in Canada. The paper reviewed the prevention campaign's strengths and weaknesses, as well as the experiences and

lessons from its social marketing campaign, and argued it was necessary to take the social context into consideration.

Douglas (2008) conducted a literature review to compare the differences in the research design and methodologies of three approaches to social change: social marketing, social movements, and social entrepreneurship. She found that research based on these three approaches was influenced by their foundation disciplines. Social marketing is linked with psychology, is widely applied in the field of health, and is generally examined using experiments. Despite the differences in research methodologies, social marketing shares many features with social movements and social entrepreneurship; for example, they are usually initiated and carried out by citizens acting to address a particular social issue, aiming to serve the public good rather than personal interests.

Helmig and Thaler (2010) also discussed the factors influencing the effectiveness of social marketing, and emphasized the construction of a holistic model based on multidisciplinary findings that covered a multitude of social marketing topics, including: 1) whether the focus of social marketing messages was self versus others, known versus known testimonials, or stranger versus friend; 2) whether the direction of behavioral influence was positive or negative; 3) whether the tone of the messages was rational or emotional; 4) whether the time horizon was short-term or long-term; and 5) whether the content of social marketing messages contain multiple or single recommendations, causal or preventive recommendations, and quantitative or non-quantitative messages. Analyzing the interactions of these factors can help facilitate the scientific development of social marketing.

Wymer (2011) defined the effectiveness of social marketing activities as the degree to which they achieve their intended purpose or function. He argued that many social marketing activities are ineffective mainly due to the erroneous understanding by social marketers of the social problems and their overemphasis on individual behavior change. Wymer pointed out that multiple levels of individual and environmental factors exist in social problems, and if

social marketing fails to remove environmental barriers, then its effectiveness will be reduced. Therefore, Wymer recommends decreasing the use of commercial marketing concepts, while also absorbing the concepts from other fields such as public health, political science, and social movements, to promote the development of social marketing.

Wood (2012) posited that social marketing is currently at a critical stage of its life cycle. Due to the rapid development of social media, many have regarding social media marketing as social marketing. On the other hand, companies have adopted a more flexible approach for profit-making through their attempts to influence politicians and public opinion, while for-profit organizations have shown an increase in their participation in social marketing. Therefore, the author proposes that the theory and practice of social marketing should be focused on providing better nonprofit services for social and public interests. There is no longer a need to emphasize the application of commercial marketing concepts such as 4P; instead, social marketing should be a part of any movement campaigning for social justice, environmental improvement, or health equality. The aim of Wood's paper was to encourage social marketers to consider the core purpose of social marketing, and to refocus on matters that are truly important, such as the public, nonprofit services, the social good, marketing, sectors served, and functions and technologies. Marketing should be focused on behavior change, using services and nonprofit and organizational marketing to build solid theories and models, while also emphasizing relationships and internal marketing concepts. The overall goal of social marketing is to help people and improve society; hence, it is necessary to refocus on its public service role to fulfill its social functions.

Integration and transformation of social marketing tools

In addition to the desire for social marketing to be more closely integrated with the social context, the adjustment of social marketing tools has also become a focus of social

marketing research. Another path in the main path analysis has focused on the tools of social marketing, and the relationship between social and commercial marketing.

Donovan (2011) stressed that the essence of social marketing is the use of marketing to achieve socially desirable goals. Hence, it is necessary to have a clear understanding on the concepts and tools of marketing, especially consumer orientation and the exchange process, otherwise there will be a negative impact on the practice of social marketing, thereby affecting the effectiveness of its implementation. Donovan therefore suggests that those who wish to engage in social marketing should first grasp the concepts of marketing and its history through basic online research.

French (2011) developed four forms of exchange, depending on whether the behavior change is voluntary or involuntary, and whether the approach of social change uses incentives (rewards) or disincentives (punishment), thus providing governments and organizations with a frame of reference for the promotion of social change. The French also proposed a few conceptual tools to enhance the understanding on the nature of exchange.

Lefebvre (2012) believed that social marketing must incorporate the concepts and techniques from other disciplines that are people-centered and have socially oriented core ideas to maintain the development of social marketing. In addition, Lefebvre introduced the service-dominant logic of marketing into the application of social marketing, holding that a key focus of social marketing is one of facilitating and supporting a process of value co-creation.

Based on the main path analysis of social marketing, we can see that the publication of relevant research increased sharply during this stage, while the connotations and implementation approaches of social marketing also underwent gradual adjustments and revisions, thus eliminating the problems arising from the initial application of the innovation, and expanding the layout of its application development.

3. *Expansion of application orientation (2013 onward)*

According to the number of academic articles published on social marketing, we can see that this stage has gradually moved toward the late stage of innovation diffusion. The research focus is no longer on dealing with the value conflicts between commercial marketing and social issues, but on how to expand new orientations of development. Wood (2012) argued that we must redefine the core objectives of social marketing, and adopt new marketing ideas to help people and improve society, so it is necessary to refocus on its public service role to fulfill its social functions. On the other hand, Lefebvre (2012) believed that past theories and experiences have become mired in old ways of thinking, and thus need to be adjusted and updated. In either case, the concepts and techniques from other disciplines must be reviewed and incorporated to solve complex social problems and enhance the well-being of the people.

By combining the arguments of the two scholars above, the purpose of social marketing at this stage is not only to promote the acceptability of social ideas or behavior change, but also to more broadly help people to solve social issues and enhance their well-being, while also emphasizing the integration of different disciplines and applying new concepts and tools of marketing to implement social marketing. If we reflect on the definition of social marketing jointly proposed by iSMA, ESMA, and AASM, social marketing seeks to develop and integrate marketing concepts with other approaches, not only to influence the behaviors of others, but also to benefit individuals and communities for the greater social good. This is a new expansion in the application orientation of social marketing.

Main path analysis of the literature revealed that the research trends at this stage initially involved expanding the application of new tools and theories. For example, Russell-Bennett, Wood, and Previte (2013) integrated services marketing theory into social marketing, believing that when implementing social marketing with partners and community groups, the

ideas derived from services marketing can enhance the effectiveness in changing individual behavior.

Secondly, Dibb (2014) proposed that to ensure a more favorable development of social marketing practice and research, we should expand the application of social marketing in analyzing and solving social issues. These include changing individual behavior downstream, incorporating the development of community environments midstream, and driving changes in legislation and supervisory mechanisms upstream, while also integrating the downstream, midstream, and upstream elements to expand and deepen the applications of social marketing and seek new directions. In addition, the common ground between social and commercial marketing should be explored to uncover new ways to unlock the potential of commercial marketing tools, and to benefit from innovative technologies.

Domegan et al. (2016) believed that the focus of early social marketing on changing individual behavior is too narrow and has a limited scope of impact. Moreover, it is insufficient to produce sustainable social change in the face of complex problems. Domegan et al. proposed that particularly for difficult problems—i.e., social problems that are extremely complex, for which it is difficult to identify a single cause or a definite solution, generally involving multiple stakeholders whose values are often contradictory (Horst & Webber, 1973)—holistic and systems-based analysis must be adopted to develop social marketing programs. To solve the problem of rapidly changing public tastes, Domegan et al. suggested that social marketing practices should focus on moving downstream consumers toward ethical considerations; advocate labor human rights and labor rights for midstream retailers and suppliers; and promote relevant legislation by upstream governance departments, in order to reach a systems-based solution.

Kennedy, Kapitan, Bajaj, Bakonyi, and Sands (2017) used systems thinking, systems theory, and Camillus' (2008) framework for responding to difficult problems to provide social marketers with a systems-thinking theoretical basis for strategies to address such complex

problems. Domegan, McHugh, Biroscak, Bryant, and Calis (2017) used non-linear causal modelling techniques and methods to further the understanding of the causal links behind complex problems in social marketing. Kennedy (2017) combined systems thinking and systems theory to establish the philosophy and methodology of macro-social marketing, which is the use of social marketing up-, mid-, and downstream to affect holistic system change, thereby expanding the effectiveness of social marketing to solve social problems.

CONCLUSION

When Kotler and Levy proposed the idea of social marketing in 1969, i.e., when they pointed out that the principles of commercial marketing had not previously been used to solve social problems, they produced an innovative study. The present study collected more than 6,200 papers related to social marketing over the years and plotted a growth curve according to the year of publication. Main path analysis was also performed based on the citation relationships to analyze the course of its innovation diffusion. We found that the innovation diffusion of social marketing academic research has moved from the early stage of innovation diffusion (1969–2001), through the rapid stage of diffusion (2002–2012), and gradually toward the late stage of innovation diffusion (2013 onward). The analysis of the contents of main path papers revealed that social marketing faced different developmental environments at different stages of innovation diffusion, which also gave rise to different features of research trends. These results are collated in Table 1. In the early stage of innovation diffusion, the focus was on elucidating the meaning of social marketing, explaining the application of different marketing management concepts on social marketing, introducing the concept of social marketing to scholars in non-commercial fields, and highlighting the effectiveness of social marketing. During the stage of rapid diffusion, the concept of social marketing had already been accepted by scholars engaged in research on social issues, and had undergone adjustments and changes according to their needs, thus giving rise to the

phenomenon of "reinvention." The focus of research trends was on understanding the social issues and environmental context to enhance the ability of social marketing to effectively resolve social issues. Research trends in the late stage of innovation diffusion mainly involved expanding the application of new tools and theories, as well as conducting holistic and systems-based discussions centered on social problems regarding the different aspects of applying social marketing to solve social issues.

Table 1. Analysis on the research trends at different stages in the main path innovation diffusion of social marketing

Stage of innovation diffusion	Development environment	Research trends
Early stage of innovation diffusion—advocating the innovative application of marketing	1. Initial application of marketing concepts on social issues	1. Elucidating the meaning, purpose, ability, operational framework, and limitations of social marketing, and providing case studies of its application to social issues. 2. Explaining the significance and application of marketing management concepts in social marketing, including target markets, customer behavior analysis, differential advantages, marketing mix (4P), continuous marketing feedback, marketing audits, etc.
	2. Highlighting the effectiveness of social marketing	1. Using the framework and concepts of marketing management to review the results, experiences, and advantages in the actual operation of social marketing. 2. Using actual case studies to explain how marketing principles should be applied to promotional activities and operational approaches of non-commercial organizations.
Stage of rapid diffusion—incorporation of social issues	1. New directions in social marketing development	1. Repositioning the meaning of social marketing, and emphasizing the attributes of the approaches to social change. 2. Analyzing the shortcomings of commercial marketing methods in solving social problems, and prompting social marketing to develop its own methods and theoretical basis.
	2. Deepening the application of social marketing to social issues	1. Reviewing how to enhance the effectiveness of social marketing from the orientation of social issues, including analyzing social background, understanding social problems, and impacting the social environment, to resolve

Stage of innovation diffusion	Development environment	Research trends
		social problems more effectively.
		2. Analyzing the practices of social marketing from its aim of dealing with social problems to fulfill its social functions.
	3. Integration and transformation of social marketing tools	1. Advocating that the essence of social marketing lies with achieving social expectations, and reviewing and expanding the means and tools of social marketing—for example, introducing tools from other disciplines that can be applied.
Late stage of innovation diffusion—expansion of application orientation	Expansion of new development orientations.	1. Expanding the application of new tools and theories, extensively integrating different disciplines, and applying new marketing concepts and tools to implement social marketing.
		2. Conducting the holistic and systems-based investigation centered on social problems regarding how the different aspects of social marketing, such as individual behavior, organizational community and environment, legislation, and governance, should be integrated at various levels.

The development of a research area can be divided into three stages: introduction and elaboration of the concept, evaluation and debate, and reinforcement and acceptance. The creation of a new concept may involve the introduction of an existing concept into new areas, thus producing cross-disciplinary links; or it may originate or evolve spontaneously within the area itself. Once a new concept has been created, it must be subjected to the test of legitimacy before it can resonate with academic peers in the area. This is the first stage. The concept is then refined after intensive research, criticism, and revision. This is the second stage. Finally, once the results have stabilized and researchers understand what the facts are, the debates begin to subside. The development of the concept has reached maturity and researchers are no longer interested in this concept. This the third stage. In relation to social marketing, the creation of this new concept was proposed by Kotler and others in the field of marketing, originating from the nature of "exchange" that is common to both business and

nonbusiness fields. It innovatively applies the original concept of marketing in the business field to the marketing of services, persons, and ideas in the nonbusiness fields, and attempts to solve social issues. The present study found that during the early stage in the development of social marketing, its legitimacy was reinforced through the clarification of its concepts and through highlighting the effectiveness of its actual operation. However, since it involves extending the scope of profit-oriented marketing principles to nonprofit purposes, the essential differences between the two may have led to value conflicts among scholars engaged in research on social issues, thereby affecting its degree of acceptance. When the concept of social marketing was accepted by some scholars and it entered the stage of rapid diffusion, the core focus of this stage was on making adjustments and revisions, in order to better align the concepts and tools of social marketing with their application in the field of social issues, thereby resolving social problems more effectively. Based on the state of innovation diffusion, social marketing is gradually moving toward the third stage, as the number of publications on the subject has declined each year. However, continuous adjustments and changes have been made to the concept and application of social marketing.

Academic research always advances by standing on the shoulders of its predecessors, and observing the development of social marketing academic research has enhanced our understanding of the development of social science research. An innovative research approach to social science does not necessarily come from an unsolved problem, and thinking about the commonalities of human behavior among different disciplines is one of the modes of innovative research in social science. Kotler and Levy (1969) initiated the research on social marketing by advocating that marketing is a universal social activity based on the exchange behaviors of human beings. In addition, the diffusion of an innovative concept in academic research can be encouraged by applying the theory of innovation diffusion. Apart from gaining a rough understanding of the stages of its diffusion based on changes in the number of publications, the cognitive attributes of the innovation can also be enhanced,

including its relative advantage, trialability, low complexity, observability, and compatibility, which will increase its adoption rate within the community. Using social marketing as an example, the early stage of innovation diffusion required a clearer explanation of its meaning, functions, characteristics, operational framework, range of applicability, and limitations, while also highlighting its relative advantage at improving social problems and laying the foundation for its practical application. As to whether it is accepted by the scholars and enters the stage of rapid diffusion, this requires overcoming conflicts in ideas and values to improve its compatibility. In the early development of social marketing research, there were conflicts in the application of commercial marketing principles to non-commercial environments (Buchanan et al., 1994), which affected its adoption rate. Nevertheless, the continuous verification and accumulation of successful cases in social marketing, as well as the deepening of its application to social issues by adjusting its concepts and scope, prompted social marketing to enter a stage of rapid expansion. The process of innovation diffusion is not static—particularly so in academic research—which generally involves improving and developing upon the foundations of its predecessors, while also making adjustments and changes according to the needs of the adopters. The phenomenon of "reinvention" in the theory of innovation diffusion can be found in the greater extent of adjustments and changes that occur with the increasing number of publications in social science research.

The innovation diffusion process of social marketing presents three different research orientations and priorities, which can serve as a guide for future directions in social marketing research. The first is the innovative application of marketing. This stage is oriented toward marketing issues, with marketing as the main research orientation, focusing on the relationship between marketing and social marketing. What is the impact of new marketing theories on social marketing? Can new tools and development in marketing science be used, and how can they be applied to social marketing, such as online marketing, social selling, Internet celebrities, and automated marketing in social marketing? The second is the

incorporation of social issues. This stage is oriented toward social issues, with social issues as the main research orientation, focusing on the relationship between social environmental development and social marketing. What is the impact of new trends in social development on social marketing? For example, changes in social structure and function, the concentration of urban population, changes in value ideas and social norms, changes in family structure, changes in interpersonal relationships, and so on, can all have an impact on the application of social marketing. The third is the expansion of application orientations. This stage is oriented toward problems and integration, and involve the extensive integration of different disciplines and tools to promote social marketing. It is centered on social problems, involving holistic and systems-based discussions on the application of social marketing, with a focus on integrating the application of different disciplines and marketing tools to solve complex social problems. For example, how can different disciplines and marketing tools be integrated to improve the ecological environment, labor and employment, drugs and juvenile delinquency, declining birth rate and aging, and other issues?

Based on our analysis of the innovation diffusion process of social marketing academic research, we offer the following suggestions: 1) Innovative applications can be used to carry out new academic research. Thinking about the nature of behavior in different fields can facilitate the discovery of opportunities for innovative applications. 2) The innovation diffusion of academic research exhibits different research characteristics at different stages, which can serve as a reference for selecting the appropriate research topic. 3) During the early stages of innovative academic research, not only should it highlight its own positioning and scope, it should also reinforce its innovative attributes—that is, it should strengthen its relative advantage, compatibility, trialability, and observability, and lower its complexity, which will enhance its opportunities for adoption and diffusion. 4) Main path analysis based on the citation network of academic literature is an effective tool for investigating the

development and changes of academic research. It can help us to extract the main paths of academic development from a vast number of academic papers.

Although main path analysis can effectively capture the main paths of academic development, and the present study had collected more than 6,000 papers on social marketing, only the European and American papers found in the Scopus database were included, which prevents us from fully grasping all the research content on social marketing. Furthermore, the research on social marketing is still ongoing and is actively drawing the attention of many scholars. Hence, further observation is needed to monitor its future development.

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APPENDIX

Comparison of nodal papers on the global key-route main path

Stage of development	Code	Author/Year of publication/Title	Nature of paper
Early stage of innovation diffusion – advocating the innovative application of marketing	KotlerZ1971	Kotler, P., & Zaltman, G. 1971. Social Marketing: An Approach to Planned Social Change.	Conceptual
	BloomN1981	Bloom, P. N., & Novelli, W. D. 1981. Problems and Challenges in Social Marketing.	Conceptual
	LefebvreHZ1988	Lefebvre, R. C., Harden, E. A., & Zompa, B. 1988. The Pawtucket Heart Health Program. III. Social Marketing to Promote Community Health.	Empirical
	LefebvreF1988	Lefebvre, R. C., & Flora, J. A. 1988. Social Marketing and Public Health Intervention.	Empirical
	HastingsH1991	Hastings, G., & Haywood, A. 1991. Social Marketing and Communication in Health Promotion.	Conceptual
	BuchananRH1994	Buchanan, D. R., Reddy, S., & Hossain, Z. 1994.Social Marketing: A Critical Appraisal.	Conceptual

Stage of development	Code	Author/Year of publication/Title	Nature of paper
Stage of rapid diffusion – incorporation of social issues	Andreasen2002	Andreasen, A. R. 2002. Marketing Social Marketing in the Social Change Marketplace.	Conceptual
	Glenane-AntoniadisWM2003	Glenane-Antoniadis, A., Whitwell, G., Bell, S. J., & Menguc, B. 2003. Extending the Vision of Social Marketing Through Social Capital Theory: Marketing in the Context of Intricate Exchange and Market Failure.	Conceptual
	Andreasen2003	Andreasen, A. R. 2003. The Life Trajectory of Social Marketing: Some Implications.	Conceptual
	HastingsS2003	Hastings, G., & Saren, M. 2003. The Critical Contribution of Social Marketing: Theory and Application.	Conceptual
	PeattieP2003	Peattie, S., & Peattie, K. 2003. Ready to Fly Solo? Reducing Social Marketing's Dependence on Commercial Marketing Theory.	Conceptual
	GrierB2005	Grier, S., & Bryant, C. A. 2005. Social Marketing in Public Health.	Review
	LombardoL2007	Lombardo, A. P., & Léger, Y. A. 2007. Thinking About "Think Again" in Canada: Assessing a Social Marketing HIV/AIDS Prevention Campaign.	Empirical
	Douglas2008	Douglas, H. 2008. Creating Knowledge: A Review of Research Methods in Three Societal Change Approaches.	Review
	HelmigT2010a	Helmig, B., & Thaler, J. 2010. On the Effectiveness of Social Marketing-What Do We Really Know?	Review
	Wymer2011	Wymer, W. 2011. Developing More Effective Social Marketing Strategies.	Conceptual
	Wood2012	Wood, M. 2012. Marketing Social Marketing.	Conceptual
	Donovan2011	Donovan, R. 2011. Social Marketing's Mythunderstandings.	General review
	French2011	French, J. 2011. Why Nudging is not Enough.	Conceptual
	Lefebvre2012	Lefebvre, R. C. 2012. Transformative Social Marketing: Co-creating the Social Marketing Discipline and Brand.	Conceptual

Stage of development	Code	Author/Year of publication/Title	Nature of paper
Late stage of innovation diffusion – expansion of application orientation	Russell-BennettWP2013	Russell-Bennett, R., Wood, M., & Previte, J. 2013. Fresh Ideas: Services Thinking for Social Marketing.	Conceptual
	Dibb2014	Dibb, S. 2014. Up, Up and Away: Social Marketing Breaks Free.	Conceptual
	Domegan MDDHBLJMP2016	Domegan, C., McHugh, P., Devaney, M., Duane, S., Hogan, M., Broome, B. J., Layton, R. A., Joyce, J., Mazzonetto, M., & Piwowarczyk, J. 2016. Systems-Thinking Social Marketing: Conceptual Extensions and Empirical Investigations.	Empirical
	KennedyKBBS2017	Kennedy, A.-M., Kapitan, S., Bajaj, N., Bakonyi, A., & Sands, S. 2017. Uncovering Wicked Problem's System Structure: Seeing the Forest for the Trees.	Conceptual
	DomeganMBBC2017	Domegan, C., McHugh, P., Biroscak, B. J., Bryant, C., & Calis, T. 2017. Non-linear Causal Modelling in Social Marketing for Wicked Problems.	Conceptual
	Kennedy2017	Kennedy, A.-M. 2017. Macro-Social Marketing Research: Philosophy, Methodology and Methods.	Conceptual

THE ROLE OF THIRD-PARTY JUSTICE IN ONLINE COMPLAINT MANAGEMENT

Abstract

There is no doubt that online consumer reviews provide prospective consumers with valuable information about potential products or services that they may wish to buy. In this study, we mainly focus on negative reviews especially in terms of their relationships with prospective consumers' perceptions of products under consideration. Our discussion is rooted in the Attribution Theory. We attempt to develop a linkage between the most-frequently discussed cues embedded in negative reviews and to then explore how practitioners can utilize these cues to improve their online complaint management.

Keywords

Complaint Management, Communication Psychology, Consumer Psychology

Introduction

e-Commerce provides consumers with great convenience by enriching and exploring their potential selection of products and services. Along with the development of e-Commerce, a mature online review system has gradually been established to help consumers exchange their opinions concerning the quality of products or services and, more importantly, to share their complaints if there have been any unpleasant experiences. An extensive number of studies have demonstrated the powerful force of online reviews within consumer market. An online product review is typically written to either recommend or discourage others from purchasing a product under discussion. Moreover, some studies have further uncovered the disturbing insight that negative reviews are likely to be be considered to be more valuable by the readers of online reviews than positive ones. Unfavorable ratings in particular tend to have a greater impact on purchase intention/customer satisfaction than do favorable product ratings. It seems that consumers normally weigh negative reviews more heavily than positive ones in terms of both product judgment and final decision-making.

Researchers have developed several ways to explain this interesting phenomenon. For example, some think that this widely observed negativity effect is a function of the individual's social environment (Sen & Lerman, 2007). They think that this is just because, for single

individuals, his orher social environment may be affected by a great number of positive cues rather than negative ones which are generally perceived as counter normative. However, compared to positive cues, those negative cues that do appear tend to attract more attention and are more likely to be attributed to stimulus object (Sen & Lerman, 2007). Similarly, as addressed in the Negative Bias theory, it is believed that when it comes to people have difficulties to making inferences about the actions of someone when that particular person simply behaves in an expected way; on the other hand, it is easier to make negative inferences when an individual behaves quite differently from acceptable social norms as they relate to that behavior. Within the context of this theory, some researchers argue that when it comes to decision making negative reviews actually are more helpful especially when behaviors deviate from the widely accepted norms of remaining positive (Salehan & Kim, 2016).

In the context of consumer behavior, negative reviews provide a foundation for the establishment of an online complaint or e-complaint system. As a web-based market feedback system, the e-complaint system also draws a clear map of the relationships between the origins and causes of customer dissatisfaction and shows how efficient and effective e-business owners deal with customers' complaints, which to some extent may also be indicative of how much these business owners value their customers. In essence, an e-complaint communication environment is fairly different from its counterpart in the offline environment because of its wide reach and the anonymity of complainers. e-Complaints normally are posted on public platforms such as Amazon, eBay, or Facebook that provide tremendous convenience for information seekers and consequently have posed a far-reaching influence on corporate image and even small business perceptions.

Plenty of studies have discussed the effects of customer reviews from the perspective of sender-receiver relationships. In this study, we want to focus on the relationship between senders and observers, specifically the prior customers who have posted negative reviews and the companies whose products are the subjects in the reviews and performing as observers of these feedback. We are interested in people's judgment about the products or services that are discussed in negative reviews and the degree to which their purchase decisions are affected by the cues in these negative reviews, particularly the semantic patterns of these negative reviews and potential consumers' subsequent perceptions of these products orservices. We plan to utilize the Attribution Theory as the foundation upon which to explore this relationship. In the sections

that follow, we will discuss the cues that may be found in negative reviews and the psychological paths that people use to process those cues in their minds.

Semantic Cues in Online Customer Reviews

A substantial number of studies have demonstrated the influence of semantic cues within customer reviews on prospective consumers' perceptions such as the perceived helpfulness of reviews and expressions of purchase intention, etc. The factors frequently appearing in related studies include star ratings, review length, total number of helpfulness ratings, total number of product reviews, the number of typed characters per product review, and so on. For example, Robinson et al. used a single variable approach to extract influential and useful information from raw opinion data in product reviews (Robinson, 2012). They interviewed and surveyed 136 people to investigate the candidate factors which influence potential consumer perceptions of the product being discussed in the reviews. In doing so, they found that certain factors are actually related to the positive/ negative alignment of reviews, such as the balance of positive/negative features (the overall balance of the number of positive comments concerning product performance to the number of negative comments), explicit statements (the explicit nature of the review concerning its positivity or negativity), the semantic orientation of words, the presence of very negative features, etc. On the other hand, some factors are unrelated to this positive/ negative alignment but are nonetheless quite influential. For example, the depth of the description of features, the perceived objectivity of the reviews, the relevance of features to readers' interests, the range of features covered, any discussion of non-product aspects, comparisons to other products, etc. As the statistics of the interview results also indicate, metrics such as accuracy, comparison to other products, information about customer support, overall star ratings, technical information, and persuasive words may be more influential, as compared to other metrics such as the presence of rude and racist words, ambivalence/neutrality, spelling and grammatical mistakes, brevity and other reviewers' ratings and comments.

Salehan and Kim (2016) aim to explore the factors determining the likelihood of a consumer paying attention to a review and the perceived helpfulness of a review. The exploration was rooted in a sentiment analysis of the content of reviews. They considered howfactors such as longevity (the number of days since the review was created), title sentiment, title length and review length could positively influence the readership of the review. A positive relationship was

also proposed in terms of the effect of review length and review sentiment on the perceived helpfulness of the review. It turns out that reviews with stronger positive sentiments may attract more readerships, and that a reviews with neutral polarity are normally perceived to be more helpful. In addition, the length and longevity of a review may positively influence both its readership and helpfulness. However, the authors wonder if this may be a result of bias caused by current sorting methods.

Min and Park (2012) developed a metric with two major indicators to assess the quality of reviews. They believe readers of reviews may derive more useful information from the discussion of consumers' personal experiences. One indicator relates to the identification of tense and time expressions, and the other relates to identification of the terms with experiences with comparableprevious or current entities. They find that tense and time expressions are useful cues to interpret reviewers' experiences, especially when assessing their previous experiences when using that product.

Overall, it is obvious that readers' perceptions, no matter what the quality of the reviews or the usefulness of the information may be, can be altered by the format of the reviews. If we take a closer look it is also clear that some of the cues are more influential to readers' emotions and others are more influential to readers' rationality, which to some extent align with our research questions discussed in the previous section. In this study we particularly want to explore how these cues in negative reviews would alter consumers' perceptions concerning the quality of products and how e-businesses may utilize this information to improve their performance.

Attribution Theory

Attribution Theory is one of the commonly used motivation theories when it comes to exploring how a person construes the meaning of an event based on either his/her motives or his/her knowledge of the environment to infer a cause. Basically, the theory explores how people make sense of their world and what cause-and-effect conclusions they may make about the behavior of others and of themselves. The purpose of such an attribution is to achieve a cognitive control over one's circumstances by attempting to explain and better understand the causes behind certain behavior and environmental occurrences. It is assumed that when people make attributions, they analyze the situation by making inferences, which go beyond the information given, about the dispositions of others and themselves as well as inferences about the

environment and how it may have caused a person to behave. In addition, such inferences are believed to be made through two channels which involve both internal and external attributions. Particularly, the internal attribution refers to a dispositional analysis while the external attribution refers to a situational analysis.

Researchers have attempted to apply the theory to explain consumer behavior with different focuses in various circumstances. For instance, in the Correspondent Inference Theory developed by Heider and Jones, it is posited that if an individual is capable of being responsible for his/her own behavior (in short, has power), the factors affecting the attributions that the observer will make include the observer's knowledge of environmental factors impinging on the actor, the observer's motives, and the observer's perspective as a bystander or an actor. The Covariation Model proposed by Harold Kelly focuses on conditions that lead a perceiver to attribute a cause to an environmental entity with which the individual interacts. The model includes four rules of logic that are at work when people make attributions, including Covariation (if a behavior or object is always present when another behavior or object is present, they covary), Extremity (the more extreme the effect of a behavior, the more likely people are to make internal attributions), Discounting (the more people know about environmental conditions surrounding a behavior the less likely they are to make internal attributions), and Augmentation (the strength of a facilitative force being perceived as greater if an event has occured in the presence of an inhibitory force).The model particularly suggests three factors to consider when the Covariation, which includes the Distinctiveness of the entity (the behavior only occurs when the entity is present), Consensus (the similarity of responses to a certain entity), and Consistency (the extent to which a frequent occurrence of a certain act occurs in the presence of an entity). In general, it is assumed that high distinctiveness, high consensus, and high consistency would lead to an external attribution; conversely, low distinctiveness, low consensus, and low consistency lead to an internal attribution. In Weiner's Model of Achievement Attributions, it is posited that an individual's causal attributions of achievement behavior affects subsequent achievement behaviors and motivation, future achievement expectancies, persistence at similar tasks, and pride or shame felt following success or failure. Particularly, this causal attribution can be gauged through three dimensions including stability, locus of causality and control. Specifically, stability attributions affect people's predictions for the future; causality attributions influence affective/emotional reactions to success and failure; and controllability affects persistence on

task. The model additionally posits four attributional factors (effort, task difficulty, luck, and ability) which affect people's understanding of an event as well as the surrounding environment.

In the context of consumer behavior, researchers have used the Attribution Theory to explain the predictors of source credibility and other factors related to consumer perceptions and inference formation. For example, the theory has been used to explain consumers' perceptions regarding the helpfulness of online consumer reviews. When reading a review, readers may consider the motivation of the author of that review and decide whether or not to value the information embedded in the review. Readers may attribute a viewpoint in the review to either external (product-related) or internal (reviewer-related) reasons. If readers feel that the review is derived from external reasons, they are more likely to accept it. However, if readers believe that it is derived from internal reasons, they are more likely to disregard it.

Attribution Theory has been used to improve understanding of the causal inferences consumers make when they recommend products to other consumers and when they complain about problems. According to the Attribution Theory paradigm, readers who are considering whether or not to use an eWOM product review will base their decision on the causal inferences they make regarding the reviewer's motivation in positing the review. Products and services are purchased because consumers infer a causal relationship between consuming the product and deriving the benefit sought.

From the reader's perspective, the Attribution Theory paradigm is helpful for understanding the inferences made by readers about reviewers' motivations in posting the review and about the veracity of the opinions in the review. Inferred communicator biases (about the accuracy of knowledge and reporting) by the recipient also have an effect on the persuasiveness of the message and on the likelihood that opinions will change.

Attribution Theory explains how people make such causal inferences using their common sense explanations of the world; that is, people recognize two categories or types of influences: actions as a result of personal interactions/experiences and those related to the environmental situation. Readers' attributions about the reasons underlying the reviewers posting of the review will include whether the opinions expressed are based on external (product) reasons or internal (reviewer) reasons. Moreover, regardless of the accuracy of this inference, this perceived causality will influence the reader's subsequent actions. If readers make the attribution that the review is based on external or product reasons they will perceive the review to be legitimate,

believable and actionable, and will consider the reviews to be useful. In contrast, if the readers believe that the review is based on internal or reviewer reasons, they will discount it.

Discussion

It is obvious that people use a dual process to interpret the information in online reviews. This is reflected in the discussion of both semantic cues and Attribution Theory. Consequently, it is quite promising to use Attribution Theory to discuss the negativity effect in consumer reviews. By doing this study, we also hope to better understand how e-businesses should resolve their customers' complaints which can actually lead to a "defective marketing" strategy or a "zero-defections" strategy aiming to diminish or even eliminate customer dissatisfaction. This handling of customers' complaints in an e-complaint system is a critical issue for online customer service solutions and electronic customer relationship management (e-CRM). As addressed in the recovery paradox, a customer would think more highly of a company after the company has corrected a problem with their service, compared with how he or she would regard the company if a non-faulty service had never been provided at all[1]. As such, an effective complaint management approach should have the ability to utilize the information embedded in complaints and thereby establish a foundation for staff communication training including generous guarantee and return policies especially in those direct, one-to-one communication scenarios between complainers and companies via phone, emails or in person (Breitsohl, et al., 2014).

However, this is only a first step in our study plan. There are still several questions for us to resolve. This has been addressed by many researchers, while utilizing Attribution Theory in order to understand consumer behavior, there are several biases that businesses should pay attention to, for example, Correspondence Inference Bias and Actor-Observer Bias.

Correspondent Inference Bias. When observers can only make inferences based on perceived, actual, or situational causes and if the actor behaves in an expected fashion, it would be difficult for an observer to make a corresponding inference about the disposition of the actor. However, when the actor departs from the norm of expected behavior, the action provides better dispositional information to the observer. According to the Correspondent Inference Theory, this occurs when the observed behavior is unusual or unexpected, because the unusual information about the actor provides the observer with meaningful information about the actor's actual

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[1] https://en.wikipedia.org/wiki/Service_recovery_paradox

disposition. In the negative review context, Correspondent Inference Theory suggests that to an observer (reader), negative reviews would have more dispositional value about the actor (reviewer), compared to the more expected positive reviews. (Sen & Lerman, 2007)

Actor-Observer Bias. The actor-observer bias may affect the reader's determination of whether the motivation behind a review is external or internal. It has been found that although an actor is more likely to attribute his or her action to situational factors, the observer is inclined to attribute the actor's behavior to the actor's personal disposition. That is, although the reviewer perceives and expresses his views as the consequence of external/product reasons, the reader may perceive the opinion to be arising because of the reviewer's personal reasons (and not as a result of the objective product or consumption facts).

There are a number of challenging issues here that we would encourage future researchers to explore.

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What makes me *Click*? Advertising Images in the Context of *High Severity Diseases*

INTRODUCTION

In general, it is believed that images facilitate processing over text, because information encoded from images does not have to be recoded (Joffe 2008). Further, images are stored both as the image and semantically (Viswanathan and Childers 2003). Thus, due to processing ease, images can be understood without exerting significant cognitive effort. It follows that messages that include images in addition to verbal components have favorable effects on learning and memory (Paivio 1991). The main objective of our research is to understand the effectiveness of positive versus negative framing in *health messages across multiple countries* incorporating both images and verbal components, specifically, in the context of high severity diseases.

BACKGROUND

Visuals are easier to understand, but this depends on the image's composition and the individual's prior knowledge (Geise and Baden 2014). In the context of numerical data, an image format may be too difficult to process, and the facilitating effects of image over text may disappear (Gigerenzer et al. 2007). This could be explained based on Chaiken and Eagly (1976), who suggest that visuals are most effective in influencing opinion when the message is easy to understand; text is more effective when the message is more complex.

Limited message framing research exists that examines messages that use both imagery and text combined. Visual aids have been shown to reduce framing biases in health related messages when pairing a consistent graphical display of data with text that employs either a positive or negative frame (Garcia-Retamero and Cokely 2011; Garcia-Retamero and Galesic 2010). Other research shows that images only attenuate the bias under certain conditions: (1) partial attenuation if both positive and negative attributes are presented in text with only one attribute presented graphically, and (2) complete attenuation when both text and graphical image depicts both positive and negative outcomes of the attributes (Gamliel and Kreiner 2013). In contrast to images that use graphical displays of outcomes, images that are "scene based" (e.g. experiential) have been examined in the communications literature. Here, images of war and conflict alone generated stronger framing (obligation vs. risk) effects on opinions and behavioral intentions as compared to text alone. However, when images and text were presented together, the text influenced opinion regardless of an image present/absent, but the frame carried by the image influenced behavioral intentions irrespective of text (Powell, Bomgaarden, De Swert and DeVrees 2015).

In line with theory on imagery, we suggest that for pandemic situations perceived as high severity, imagery may be useful to facilitate processing. We suggest this because individuals may not process the verbal message when the perceived severity is at an extreme and/or it promotes risk aversion, in line with arguments by Levin et al. (1998). Even though some research shows attenuation of framing effects when images accompany text, there are very few studies demonstrating this. These studies also rely on graphical presentation of data that is also described by text. Differently, our arguments are based on the use of imagery that is more social

based and therefore more aligned with images of war and conflict used by Powell, Boomgaarden, De Swert and de Vrees (2015). Relevant and non-threatening images are more engaging (O'Neill and Nicholson-Cole 2009). Further, when advertising imagery is relevant or advertising induces self-referencing, attitude toward an ad is more favorable (Burnkrant and Rao Unnava 1995). Thus, we expect that social imagery, by adding relevance, will prompt respondent to process messages that would otherwise be avoided (i.e. text messages for high severity diseases).

If this is the case, we should see a pattern of results that is similar to when diseases are perceived to be moderately severe. In this regard, Asare et al. (2019) demonstrated how positive (vs. negative) framing is more effective for health message about a pandemic disease, specifically, diseases perceived as moderately threatening (but not when the disease is perceived as highly or minimally threatening). In other words, the personal relevance is expected to "soften" the reaction to a high severity disease by making the message more acceptable. Because severity will not be considered at the extreme, as before we hypothesize that a positively framed message will more favorably influence intention compared to a negatively framed message.

Key Hypothesis: Intention to click will be significantly higher for positively framed messages with images and text as compared to negatively framed messages with images and text when the threat of disease is perceived as high (and not moderate or low).

STUDIES

As mentioned before, the main objective was to focus on diseases perceived as high severity to examine framing effects when social images accompany the text framing. In accordance, first we focus on demonstrating framing effects of messages incorporating both text and images, in case of high (but not, low or moderate) severity diseases. Second, we focus only on the high severity diseases in a more real time study. We conduct the studies across three countries across different continents (namely, US, China, and Ghana) stimuli. Study was executed in three parts – U.S. (Study 1A), China (Study 1B) and Ghana (Study 2). To find images that were social-based, country-relevant and disease-related, we conducted an internet search for ad imagery that met the three criteria. The images were reviewed by faculty in the respective countries for acceptability. See Appendix for example.

For Study 1A and Study 1B, a 2 message frame (positive, negative) x 3 threat magnitude (high, medium, low) between-subjects experiment was used. The experiment was delivered to participants via an emailed link. Both message frame and disease type was manipulated via the ads. Participants were first told that they would be viewing an ad that was recently posted. They then viewed one of the six randomly assigned message frames and diseases. Finally, they were asked to indicate their intention to click and relevant covariates. For both the studies diseases were chosen based on pretests where respondents who were similar to those that participated in the experiments rated 10 diseases on perceived magnitude of threat. Note that perceived threat is defined as the thoughts about danger or harm in the environment (Witte 1994).

For Study 1A, ninety-seven individuals participated from Amazon Mechanical Turk. Based on the ratings, HIV/AIDS (high), Ebola (Moderate) and Tuberculosis (Low) were selected. ANOVA showed a significant valence framing by disease interaction, $F_{(2, 91)} = 3.65$, $p < .05$. Follow-up

analyses showed that only for HIV, the highly severe disease, positive (vs. negative) valence framing resulted in significant differences for click intention, 2.85 vs. 4.21, t (30) =3.20, p <.01. There were no such patterns for Ebola (moderately severe), p >.3, or TB (low severity), p >.8. This supports H1. Note, lower mean equivalent to higher intention to click.

For Study 1B, seventy-two undergraduate students from a Chinese university were randomly assigned to either the positive or negative framing condition of the ads for one of the three diseases (low/Ebola, moderate/Tuberculosis, or high severity/MERS). ANOVA showed, as expected, a significant valence framing by disease interaction, F (2, 66) = 3.69, p <.05. Follow-up analyses showed that only for MERS, the high severity, positive (vs. negative) valence framing resulted in significantly greater intention to click, 2.07 vs. 3.87, t (13) =5.31, p <.001. There were no such patterns for Ebola, 2.98 vs. 3.24, t (29) < 1, p >.5, or TB, 2.61 vs. 2.63, t (24) <1, p >.9), the low and moderate severity conditions. Thus, once more H1 is supported.

In Study 2, we use a "real time" design, and we compare text+image to text only ads. Rather than use the pretested diseases for severity, we redesigned the experiment so that participants were asked to rank a set of 10 diseases based on perceived severity as part of the experiment to rule out the possibility that our pretested severity levels no longer held when executing Study 1. The disease ranked as most severe was dynamically served during the experiment for the disease condition. The core objective of this study was to test H1 with a different experimental design and image+text was compared to just text for each message frame. A total of 128 undergraduate students from a Ghanaian university participated in this online experiment which was a 2 message frame (positive vs. negative) by 2 message format (text only vs. images+text) between subject design. ANOVA showed that there was a significant message frame by message format interaction, F (1,124) = 3.80, p =.05). Once more, consistent with our hypotheses, positive (vs. negative) frame resulted in significantly greater intention to click, 2.90 vs. 3.81, t (61) = 2.48, p <.02, only for the image+text condition.

CONCLUSION

As hypothesized, framing effects materialized when social-based images accompany text-based frames. Such inclusion improved response to levels above the other conditions for a positively framed message. However, based on our findings that show significantly lower response for the negative frame in the high severity conditions, caution might be exercised when using visuals. Based on the results, for diseases perceived as highly severe, imagery should accompany text in a message when the message is positively framed. Interestingly, framing effects disappear in the moderate and low severity conditions, which might also be an outcome of "softening" processing too much. Where we expect images to increase cognitive elaboration in the high severity condition, it may actually trigger more heuristic processing (reduce cognitive elaboration) in the other conditions. More research into these effects is warranted. To conclude, our studies demonstrate that when diseases are in the high threat stage, social-based images appear to be helpful to facilitate processing, but only when the message frame is positive. This finding should have crucial implications for the purposes of health messages.

References-on request.

Appendix 1
Stimuli Examples*

US-Image+Text (Study 1A)	China Image+Text (Study 1B)

Ghana (Study 2) – Image+Text	Ghana (Study 2) –Text Only

*Images were adapted for each country, but otherwise did not differ by condition. Disease was changed by condition. Across all ads, Message Frame: Encouraging(Discouraging) Data Released on [Disease], Early(Late) detection…, …about 30%(70%) are cured (do not survive) the disease.

Operations Management and Operations Research - Abstracts

A MODIFIED CONTINUOUS-REVIEW (s, Q) MODEL WITH BETA-BINOMIAL DISTRIBUTION FOR CONFORMING UNITS IN A LOT

Operations Management and Operations Research

Dr . Javad Paknejad [1] *, Dr . Farrokh Nasri* [1] *, Dr . John Affisco* [1]

1. *HOFSTRA UNIVERSITY*

In this paper we extend the basic framework of a stable continuous review (s,Q) model by allowing yield to be a random variable with beta probability distribution. In this case, the number of acceptable items in a lot follows a beta-binomial distribution, resulting in an unstable production system where process quality can no longer be monitored by a proportion control chart. In addition to model development under this scenario, the paper also presents explicit expressions for the special case where demand is Poisson and lead time is exponential so that the asymptote of demand during the lead time is exponential.

Can Learning-by-doing Hurt Profit? The Case of Outsourcing and Supplier Encroachment

Operations Management and Operations Research

Ms . Yaqin Sun [1], *Dr . Wenjing Shen* [1]

1. *Drexel University*

This paper considers an OEM's outsourcing decision when CM can learn to reduce production cost and when CM can enter the market. We want to study how this learning affects CM's encroachment decision. We will further discuss how OEM adjusts its outsourcing quantity when CM can encroach the end market.

Designing networks resilient to clique blockers

Operations Management and Operations Research

Mr . Haonan Zhong [1] *, Dr . Foad Mahdavi Pajouh* [1] *, Dr . Oleg Prokopyev* [2]

1. *University of Massachusetts Boston ,* **2.** *University of Pittsburgh*

The clique-blocker-resilient network design (CBRND) problem is a bi-level optimization problem extended from the minimum cost vertex blocker clique (MCVBC) problem in the literature. The problem is to find the minimum cost of creating a network such that the cost of blocking cliques via vertex removals is not less than a given constant. We addressed the computational complexity of this problem and proposed an integer programming (IP) formulation. We proposed a branch and cut algorithm to solve the IP in a lazy fashion. We also proposed an exact combinatorial branch and bound algorithm to solve this problem.

HEURISTIC REPLENISHMENT POLICIES FOR PERISHABLE GOODS THAT ARE SUBJECT TO SUBSTITUTION

Operations Management and Operations Research

Dr . Borga Deniz [1]

1. *Framingham State University*

Perishable goods have an important role in several sectors of business including grocery stores, restaurants, farms, pharmaceutical industry, blood banks. Products that are subject to fast obsolescence, such as high-tech consumer goods, can also be considered perishable. In this paper we study the replenishment of perishable goods when products at different ages have separate customer demand. In our model, for a product that has two periods of lifetime, we allow substitution between old and new items. Easy-to-calculate heuristic policies are proposed and compared via simulation.

Palm to Palm: Managing Resources

Operations Management and Operations Research

Mr . David Somoyah [1] , Mr . Alejandro Lucena Mir [2] , Mr . Neil Desnoyers [3]

1. Palm to Palm , 2. Africa Digna Foundation , 3. Saint Joseph's University

Palm to Palm, a Sierra Leone-based sustainable operations project, concluded 2019 having made having made significant progress in two areas: Production output and labor regulations. P2P's biggest accomplishment, spanning most of the year, was negotiating and implementing employee contracts that meet all labor regulations. The negotiation of the new contracts was driven by a threat from the Ministry of Labor to shut down production due to noncompliance with labor laws. The project also experienced significant increases in production output and corresponding revenue related to the prior year. Management continues to believe that there are better days ahead for the project.

RATIONALIZING YOUR SPECIFICATIONS

Operations Management and Operations Research

Prof . Donald Holmes [1], *Dr . Erhan Mergen* [2]

1. *Stochos ,* **2.** *Rochester Institute of Technology*

The objective of this paper is to discuss some issues around different type of specifications given by the customer. We will introduce some criteria and alternatives for dealing with these issues, both for bilateral and unilateral cases with or without the nominal (i.e., target) value given. We will also discuss the use of the Acceptance chart concept for some cases to monitor the process performance.

Reestablishing the ever-increasing need for skilled tradespeople in the United States

Operations Management and Operations Research

Dr . Jen Basile [1]

1. *Buffalo State College*

This study aims to research the ever-increasing need within the U.S. for skilled tradespeople after decades of pushing students towards bachelor's degrees. The national push for students to pursue college left vocational programs with poor images and the nation's factories with fewer skilled workers. High school students are often led to believe college is the only option, leaving the US with a shortage of apprentice level skilled workers in such fields as electricians, plumbers, machinists and other areas where certifications are available. Research is needed to determine how to return promotion of tradespeople to schools reinvigorating apprentice programs and certifications.

Reshoring for a sustainable manufacturing location decision in healthcare industry

Operations Management and Operations Research

Ms . Gawon Yun [1], *Dr . Douglas Hales* [1], *Dr . Mehmet Yalcin* [1]

1. *The University of Rhode Island*

With changes in competition and government pressure for domestic production, manufacturing firms have reevaluated and reshored manufacturing activities. Complexity in decision making remains high due to product and industry specific traits impacting the manufacturing process. with increasing quality and regulatory concerns from current offshored manufacturing, this study examines the factors and decision variables that impact reshoring decisions of medical device and pharmaceutical companies. Based on Dunning's OLI framework, this study tests a developed model using a survey approach. The result shows that reshoring in these industries are dominated by quality and regulatory requirements that involve complex validation and approval process.

SCHOOL BUS ROUTING WITH BELL TIME POLICY OPTIMIZATION: A MULTI-OBJECTIVE APPROACH

Operations Management and Operations Research

Mr . Leren Qian [1] *, Prof . Emanuel Melachrinoudis* [1]

1. *Northeastern University*

The School Bus Routing Problem (SBRP) is a comprehensive real-world problem which has been studied over decades. In this research, we propose multi-criteria school bell time optimization models under single load assumption for both heterogeneous and homogeneous fleet scenarios. We not only consider minimizing the number of buses to be used and the total service time of the buses, but also maximizing the preference of all constituents for the bell times while assigning optimal bell times (start and end time) to each school. Finally, experiments are conducted using a commercial solver on the proposed models and tested on benchmark data.

The Traveling Salesman Problem with Drop-off, Pick-up, and Job-times

Operations Management and Operations Research

Mr . Mohsen Mosayebi [1] *, Prof . Manbir Sodhi* [1]

1. The University of Rhode Island

By definition an autonomous agent is capable of unsupervised operation. This paper considers the scenario where a set of agents have to be distributed, by a traveler, over a set of nodes. Each agent completes a prescribed job on its own, and has to be retrieved at some later time. This problem is related to the Traveling Salesman Problem with Drop-offs and Pick-ups. The goal of the related routing problem is to minimize the total tour time, including waiting times. A mathematical formulation is presented. Computational experience in solving using both commercial solvers and heuristics is reported.

The Travelling Salesman Problem with Job-times and the variations

Operations Management and Operations Research

Mr . Mohsen Mosayebi [1], *Prof . Manbir Sodhi* [1]

1. *The University of Rhode Island*

This paper explores a problem related to the Travelling Salesman Problem where the traveler moves through n locations, visiting each location once to initiate one of n jobs, and returns to the origin. After initiation of a job, the traveler moves to the next location immediately and the job continues autonomously. This talk presents a mathematical model for solving this routing problem, and compares solutions obtained by commercial optimization solvers with heuristics developed specifically for the problem. Applications and future extensions of this work are explored.

TWO-DIMENSIONAL RANDOM POINTS MAY NOT BE HOMOGENEOUS

Operations Management and Operations Research

Dr . Jinchang Wang [1]

1. *Stockton University*

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 compare two methods of sampling by simulations. The simulation results and statistical analyses show that randomness in picking points does not warrant a uniform distribution of those points. 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.

Understanding Ordering Behavior in the Newsvendor Problem: An Experimental Application

Operations Management and Operations Research

Dr . Mike von Massow [1], Dr . Mustafa Canbolat [2]

1. *University of Guelph , * **2.** *SUNY The College at Brockport*

We present two experiments using the newsvendor model. We show that "demand chasing" is asymmetric in cases where the critical fractile is small. The response to over ordering is bigger than it is for under ordering. We find that the degree of demand chasing deceases as the critical fractile increases and that the difference between over and under ordering disappears. In the case where actual demand is not given when demand exceeds supply, the demand chasing phenomenon disappears for under ordering but not for over ordering. Understanding ordering behaviour can provide insight to managers to improve ordering performance.

Using 1-2-Opt Exchanges to Minimize the Number of School Bus Routes

Operations Management and Operations Research

Dr . Dmitriy Shaltayev [1] **_, Dr . Robert Hasbrouck_** [1]

1. *Christopher Newport University*

In this research we combine a number of heuristics to optimize the school bus routes. First, we use a modified Clarke-Wright heuristic to create an initial set of bus routes for a given distribution of bus stops and given number of students to be picked up at each stop. Next, we use 1-2-opt heuristic, where one point of a route is exchanged for two points on another route to minimize total number of routes. Finally, Tabu search is used on the set of resulting routes to minimize the longest route length.

Operations Management and Operations Research - Papers

A MODIFIED CONTINUOUS-REVIEW (s, Q) MODEL WITH BETA-BINOMIAL DISTRIBUTION FOR CONFORMING UNITS IN A LOT

ABSTRACT

The continuous review (s, Q) model is based on a series of assumptions among which are stochastic demand, constant lead time and perfect quality of replenishment items. Many variants of this model have appeared in the literature for a wide spectrum of operational realities. These variants include a class of models that relax the perfect quality assumption by treating the number of acceptable items in a lot as a binomial random variable. Such models are appropriate for stable processes in which the production yield (defined as the proportion of acceptable items in a replenishment lot) is not perfect but is a known constant, and process quality, therefore, may be monitored by a proportion control chart. In this paper we extend the basic framework of one of these stable models by allowing yield to be a random variable with beta probability distribution. In this case, the number of acceptable items in a lot follows a beta-binomial distribution, resulting in an unstable production system where process quality can no longer be monitored by a proportion control chart. In addition to model development under this scenario, the paper also presents explicit expressions for the special case where demand is Poisson and lead time is exponential so that the asymptote of demand during the lead time is exponential.

Keywords: Continuous Review Models; Uniform Yield Distribution.

1. INTRODUCTION

In his seminal work about the Japanese JIT (Just-in-Time) techniques, Schonberger [1982] indicated that significant cost savings in the form of decline in scrap and waste; reduction of rework; improved worker morale; reduced cycle inventories; and decreased buffer stocks accrue when the production system produces small lots of high quality. The same set of perspectives are

reinforced in Hall [1983] in the context of stockless production where a principle of continuous process improvement is fostered. Motivated by these operational realities, in the past several decades, researchers and practitioners in the sphere of continuous-review (s,Q) inventory systems have devoted significant times and efforts to examine the possible relationship between quality and lot size and its impact on the firm's overall performance. Initially, Moinzadeh and Lee [1987] studied the impact of defective items on the order quantity and reorder point of a continuous-review inventory model with Poisson demand and constant lead time. Nasri, Paknejad, and Affisco [1991] assumed that each lot contains a random number of defective items and derived explicit results for a (s,Q) inventory model with geometric lead time demand distribution. Paknejad, Nasri, and Affisco [1995] did the same for the cases of exponential and uniform distributions and investigated the effect of efforts aimed at reducing setup costs on the operating characteristics of the model. Pakenjad, Nasri, and Affisco [1999] studied the impact of investing to improve quality on lot size in a continuous review (s,Q) inventory system with exponential lead time demand in which an order of size Q, containing a random number of defective items, is placed each time the inventory position, on-hand plus on-order reaches the reorder point, s. Assuming that the investment function follows a logarithmic form, the authors also presented explicit results for the optimal order quantity, optimal reorder point, and optimal total cost per year. Paknejad, Nasri, and Affisco [2000] presented similar results for the case of power investment function.

A major component of the models in Nasri, Paknejad, and Affisco [1991] and Paknejad, Nasri, and Affisco [1995, 1999, 2000] is the assumption that the manufacturing process is an independent process with the obvious implication that the number of conforming units in each lot is a binomial random variable with parameters Q and $(1-\theta)$, where θ is the proportion of defective items in a lot and $(1-\theta)$ is the yield rate. Paknejad, Nasri, and Affisco [2006] considered another unique distribution for conforming items, also studied by Porteus [1986], which may arise from dependent processes. The authors presented an approximately optimal quality-adjusted (s,Q) model for this case.

The binomial assumption used in previous research is appropriate for stable processes in which the proportion of acceptable items in a replenishment lot, referred to as production yield or yield rate, is not perfect but it is a known constant, and process quality, therefore, may be monitored by

a proportion control chart. In this paper we extend the basic framework of one of the previously studied stable processes by allowing yield to be a random variable. Specifically, we assume that production yield follows a beta distribution leading to a beta-binomial distribution for the number of conforming units in a replenishment lot. The paper then presents explicit results for a special case where demand is Poisson and lead time is exponential so that the asymptote of demand during the lead time is an exponential distribution. Section 2 reviews the underlying stable system and assumptions. A modified continuous review (s,Q) model, where the proportion of non-defective units produced by the manufacturing process, yield, is a beta random variable so that the number of acceptable items in a lot follows a beta-binomial distribution, is developed in section 3. Finally, a brief summary and conclusion is presented in section 4.

2. REVIEW OF THE UNDERELYING MODEL ASSUMPTIONS, AND NOTATION

The key model studied in this research is the well-known continuous review (s, Q) inventory paradigm presented in many textbooks and studied by numerous researchers, including Hadley and Whitin (1963), Johnson and Montgomery (1974), Wagner (1975), Noori and Keller (1986), and Carlson [1982]. In this last paper the author views the demand per unit time, d, as a Poisson random variable with $E(d) = \Delta$. He also considers the lead time, w, to follow an exponential distribution with $E(w) = \lambda$. The author then shows that demand during the lead time, $D(w)=X$, is a geometric random variable which approaches an exponential distribution with $E(X) = \lambda\Delta$ and $Var(X) = \lambda^2\Delta^2$ as $\lambda\Delta$ increases. Under these settings, the author derives explicit expressions for the optimal pair of policy variables, lot size and reorder point, for two separate cases of shortage cost: (1) Based on the average number of shortages irrespective of magnitude, and (2) based on the expected number of shortages during the year.

Paknejad, Nasri, and Affisco [1999] considered the first type of shortage cost and extended Carlson's model under the following assumptions: Each lot contains a random number of defective items. Upon arrival, the purchaser inspects the entire lot using a 100% inspection policy. Defective units are immediately returned to the supplier at no extra charge. The system, however, incurs an additional cost for inspection of each lot. The following notation, which is similar to those in Carlson's paper [1982], were used.

A = expected demand per year,

Q = lot size,

s = reorder point,

d = demand per unit of time, a Poisson random variable with $E(d) = \Delta$,

w = lead time, an exponential random variable with $E(w) = \lambda$,

D(w) = lead time demand, an exponential random variable,

$\lambda\Delta = E[D(w)]$,

$\lambda^2\Delta^2 = Var[D(w)]$,

θ = proportion of non-conforming items in a lot, defect rate

c_1 = holding cost per unit per year,

c_2 = shortage cost regardless of the magnitude,

c_3 = ordering cost per order,

c_4 = inspection cost per lot,

y = number of conforming items in a lot of size Q, a random variable.

The authors showed that the total cost per year is a function of the mean and variance of y given

order size Q. When demand is Poisson and lead time is exponential, as referred to in Carlson

[1982], the asymptote of demand during the lead time is exponential. Considering this case and

assuming that y, the number of conforming units in a lot of size Q, is a binomial random variable

with parameters Q and $(1-\theta)$, the authors presented closed form expressions for the optimal order

quantity, Q^*, reorder point, s^*, and resulting expected total cost per year. Paknejad, Nasri, and

Affisco [2006] discussed another interesting case where the number of acceptable items is not

binomial. Specifically, they relax the assumption that the manufacturing process is an independent

process and develop an approximately optimal (s,Q) model for a unique state dependent case. In

this case the authors assumed, as in Porteus [1986] and Paknejad, Nasri and Affisco [2005], that while producing a particular lot, the production process may become "out of control" with a fixed probability, p, each time a unit is being produced. Once in "out of control" state, the production process continues to produce defective items until the entire lot is produced. Assuming that p is constant and close to 1, the authors provided explicit expressions for approximately optimal pair of policy variables, s^* and Q^*, and the corresponding expected annual cost.

The results in Paknejad, Nasri, and Affisco [1999] and those in Paknejad, Nasri, and Affisco [2005 and 2006] are based on the assumptions that the defect rate, θ, or probability of process moving "out of control", p, are known and constant. These assumptions are appropriate for stable processes that are in a state of statistical control. For unstable production processes, these parameters are not constant and should be viewed as random variables.

In the next section we assume that the yield rate, $\xi = 1 - \theta$, is a continuous random variable with known probability density function. Using this assumption, we develop a modified continuous review (s, Q) model with exponential lead time demand. We also present explicit results for the optimal pair of policy variables for a special case where ξ follows a beta probability density function and, therefore, the number of acceptable items in a replenishment lot is characterized by a beta-binomial distribution.

3. A MODIFIED CONTINUOUS- REVIEW (s, Q) MODEL

WITH RANDOM YIELD RATE

We now consider the relationship between lot size, reorder point, and quality in continuous-review inventory systems for processes that have not yet achieved the state of statistical control by

allowing the production yield, ξ=1-θ, to be a random variable. Motivated by the realization that many such processes exist for variety of manufacturing settings, researchers have started to focus on the mathematical investigation of these operational realities. Recently, Paknejad, Nasri, and Affisco [2018] began the investigation of perishable inventory models for this scenario in the context of Wilson formula with non-linear holding cost. This paper continues those efforts by examining the relationship between order quantity, reorder point, and quality in a continuous-review (s,Q) model for processes in which the proportion of conforming units produced by the manufacturing process, ξ, is random rather than constant. To do so, we use the following additional notation. Let:

ξ = 1-θ = yield rate, proportion of non-defective items in an order lot, ξ ε [0, 1], a continuous

random variable,

$f(\xi)$ = probability density function of ξ,

$E(\xi)$ = first moment of ξ,

$E(\xi^2)$ = second moment of ξ,

$\xi = \xi\, Q$ = number of non-defective items in a lot,

c(y) = total cost per cycle given that there are y non-defective items in a lot of size Q,

T = y/D = cycle time, time between two successive placement of orders,

E(.) = mathematical expectation.

Denoting the lead time demand, D(w), by x and using an approach similar to Johnson and Montgomery (1974), Noori and Keller (1986), and Paknejad, Nasri, and Affisco (1995), the total cost per cycle is

$$c(y) = c_4 + c_3 + c_2 \bar{b}(s) + c_1 \frac{y}{A}\left(s - \lambda\Delta + \frac{y}{2}\right) \tag{1}$$

where

$$\bar{b}(s) = \int_s^\infty (x-s)f(x)dx \tag{2}$$

The expected cycle time and cycle cost are

$$E(T) = \frac{E(y)}{A} \tag{3}$$

$$E(C) = c_4 + c_3 + c_2 \bar{b}(s) + c_1 \frac{E(y)}{A}(s - \lambda\Delta) + c_1 \frac{E(y^2)}{2A} \tag{4}$$

Dividing (4) by (3) gives the expected average annual cost, EA(C), as follows

$$EA(C) = \left(c_4 + c_3 + c_2 \bar{b}(s)\right) \frac{A}{E(y)} + c_1(s - \lambda\Delta) + \frac{c_1}{2} \frac{E(y^2)}{E(y)} \tag{5}$$

In what follows we assume that lead time demand, X, is an exponential random variable with E(X) = $\lambda\Delta$. We also assume that ξ follows a beta distribution defined on the interval $\xi \, \varepsilon \, [0, 1]$ with shape parameters α and β. Hence, the number of conforming items in a lot of size Q, y, follows a beta-binomial distribution, see Skellam, J. G. (1948). In this case, we have

$$\bar{b}(s) = \int_s^\infty (x - s) f(x) dx = \lambda\Delta e^{-\frac{s}{\lambda\Delta}} \tag{6}$$

$$E(y) = \frac{\alpha Q}{\alpha + \beta} \tag{7}$$

and

$$E(y^2) = \frac{\alpha Q\left[(1+\alpha)Q + \beta\right]}{(\alpha + \beta)(1 + \alpha + \beta)} \tag{8}$$

Using (6), (7), and (8) in (5), the expected total cost per year is

$$EC_{\text{exp.ltd,beta.yield}}(s, Q) = \left(c_4 + c_3 + c_2 \lambda\Delta e^{-\frac{s}{\lambda\Delta}}\right)\left(\frac{\alpha + \beta}{\alpha}\right)\frac{A}{Q} + c_1(s - \lambda\Delta) + \frac{c_1}{2}\left[\frac{(1+\alpha)Q + \beta}{(1 + \alpha + \beta)}\right] \tag{9}$$

To minimize (9), we solve

$$\frac{\partial EC_{exp.ltd,beta.yield}(s,Q)}{\partial Q} = -\left(c_4 + c_3 + c_2\lambda\Delta e^{-\frac{s}{\lambda\Delta}}\right)\left(\frac{\alpha+\beta}{\alpha}\right)\frac{A}{Q^2} + \frac{c_1}{2}\left[\frac{(1+\alpha)}{(1+\alpha+\beta)}\right] = 0 \qquad (10)$$

$$\frac{\partial EC_{exp.ltd,beta.yield}(s,Q)}{\partial s} = -c_2 e^{-\frac{s}{\lambda\Delta}}\left(\frac{\alpha+\beta}{\alpha}\right)\frac{A}{Q} + c_1 = 0 \qquad (11)$$

Solving (10) and (11) simultaneously, we have

$$Q^*_{exp.ltd,beta.yield} = \left(\frac{1+\alpha+\beta}{1+\alpha}\right)\left[\lambda\Delta + \sqrt{\lambda^2\Delta^2 + 2A\left(\frac{c_4+c_3}{c_1}\right)\left(\frac{\alpha+\beta}{\alpha}\right)\left(\frac{1+\alpha}{1+\alpha+\beta}\right)}\right] \qquad (12)$$

$$s^*_{exp.ltd,beta.yield} = -\lambda\Delta\ln\left(\frac{\alpha}{\alpha+\beta}\right)\left(\frac{c_1}{c_2 A}\right) \qquad (13)$$

The beta probability density function used in this paper is an ideal choice for yield distribution for variety of operational settings. For example, when $\alpha=\beta=1$, the beta distribution converts to the uniform distribution with scale and location parameters of 0 and 1, respectively. In this case, y is a discrete uniform random variable. Another interesting case arises if α is strictly positive ($\alpha>0$) while $\beta=1$. In this case, the beta distribution becomes a power function distribution with shape and scale parameters equal to α and 1, respectively.

4. CONCLUSION

This paper presents an extension of the widely used continuous review (s,Q) model to account for imperfect quality of items in a replenishment lot. Specifically, the paper assumes that yield rate, defined as the proportion of conforming items in each lot, is a continuous random variable following a beta distribution with shape parameters of α and β. Based on this assumption, the paper modifies an existing continuous review (s,Q) model for the quality factor where the number of conforming units in a lot follows a beta-binomial distribution. Explicit results for the optimal order

quantity and reorder point are given based on the assumption that the production process is unstable, and yield is random rather than constant.

Future research will focus on investigation of the impact of shape of yield distribution on the policy variables of the model.

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HEURISTIC REPLENISHMENT POLICIES FOR PERISHABLE GOODS THAT ARE SUBJECT TO SUBSTITUTION

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Abstract

Perishable goods have an important role in several sectors of business including grocery stores, restaurants, farms, pharmaceutical industry, blood banks. Products that are subject to fast obsolescence, such as high-tech consumer goods, can also be considered perishable. In this paper we study the replenishment of perishable goods when products at different ages have separate customer demand. In our model, for a product that has two periods of lifetime, we allow substitution between old and new items. Easy-to-calculate heuristic policies are proposed and compared via simulation.

Keywords: perishable inventory, simulation, substitution

Introduction

Perishable goods are products that deteriorate in a relatively short period of time, such as meat, dairy products, fresh produce, flowers, baked goods, blood, pharmaceutical products, and chemicals. It should be also noted that similar to perishable products some technological goods are subject to fast obsolescence, such as personal computers, computer parts (such as micro-processors, memory cards, graphic cards, data storage components), tablets, smart phones. These items lose their value rather quickly as the environment around them changes due to constant influx of better and faster high-tech products into the market. Because of this reason high-tech products that are subject to fast obsolescence can be considered as perishable, as well.

Managing perishable inventory is expensive. There are 15,000 different products in an average supermarket and 25,000 in a superstore according to the Food Marketing Institute (FMI), and retailers in the US have to deal with large amounts of past-their-prime items every year (Arumugam, 2012). According to the U.S. Department of Agriculture, food retailers and other businesses throw away $940 billion worth of expired food annually. (Kelso, 2018).

It is possible that perishable goods at different ages can be in the market at the same time, and old and new products can be substitutes for each other. Providing solutions for management of perishable inventory via mathematical models is a challenging task as a multi-dimensional inventory vector is needed to track the ages of goods in order to determine an optimal inventory policy. Additionally, incorporating substitution between old and new items into the model further complicates the situation. Therefore, we focus our efforts on heuristics solutions in this study.

In this paper, we consider a single perishable product with a lifetime of two periods in a multi-period, infinite horizon setting. The product becomes less valuable in the second period. Both new and old items face 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 shortage; old product demand is fulfilled similarly. In case of inventory shortage, unsold new items may be used to fulfill old item demand and vice versa. *Downward substitution* occurs when a new item is sold to a customer who demands old, and *upward substitution* occurs when an old item is sold to a

customer who demands new. If both downward and upward substitution are allowed, then we call such a policy *full substitution*.

One of the policies, *TIS*, brings the total on-hand inventory to an order-up-to level (S). The other policy, NIS, brings the new on-hand inventory to an order-up-level (S). These two policies are compared based on operational costs. We propose a number of heuristic policies to find the good NIS order level We compare policies based on long term system costs via discrete-time simulation.

Related Work in the Literature

Two comprehensive literature reviews of perishable inventory management research are 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. Most studies focus on the 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. In our model there are two demand streams: one for old products and one for new products. Even for the single demand stream case finding the optimal solution is quite difficult. For standard inventory management problems, the only information needed is the inventory position. However, in order to determine the optimal ordering policy for perishable goods you need to account for the amount of inventory of every age. Therefore, the problem's complexity grows as the lifetime of the product increases. 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 by a few researchers. 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. Civelek

et al. (2015) propose a critical level allocation policy under some practical replenishment policies and demonstrate that this policy produces a better performance compared to existing heuristics. Abouee-Mehrizi et al. (2018) study a multi-period stochastic perishable inventory system with multiple demand classes that require products of different ages. In their model a firm orders a product and sells it to multiple demand classes, each only accepting products with remaining lifetime longer than a threshold. In each period, after demand realization, the firm decides how to allocate the on-hand inventory to different demand classes with different backorder or lost-sale cost. They model the problem as a Markov decision process and characterize the optimal ordering, allocation, and disposal policies. They develop a heuristic that is within 4% of the optimal cost in their numerical examples. However, they do not consider substitution between products at different ages.

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 six replenishment heuristic NIS policies under 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;

$L_1^n = [(D_2^n - X_2^n), ds^n]^+$ is the amount of lost sales for old items;

$L_2^n = [(D_2^n - X_2^n), ds^n]^+$ is the amount of lost sales for new items;

$O^n = [(X_1^n - D_1^n), us^n]^+$ is the amount that outdates at the end of the period;

$X_1^{n+1} = [(X_2^n - D_2^n), ds^n]^+$ 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,

$$X_1^n + X_2^n = S.$$

NIS (New-Inventory-to-S): At the beginning of every period S new items are ordered. Therefore, for all n,

$$X_2^n = S.$$

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 $\pi_D = 0$).

Search for a Good NIS Order-up-to level: News-vendor-type Heuristic

We propose and evaluate six news-vendor-type heuristics for NIS order quantity. We did the numerical study for 400,000 periods after initial warm-up with 32 parameter settings with the following cost parameters: h = 1, m ∈ {2,5}, p_1 ∈{1,3}, p_2 ∈{4,9}, α_U ∈{3,7} and α_D ∈{2,6}. The demand has the uniform distribution between 0 and 25. The results are averaged over these 32 cost parameters. In the cost comparison cost of $\mathcal{N}$ is given for the sake of completeness and as a reference point.

Heuristic 1 (H1):

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:

$$CF_1 = \frac{p_2 + p_1}{p_2 + p_1 + h + m}$$

The results, which are averaged across 32 parameter settings, are summarized in the following table (Table-1):

	$\mathcal{F}$		$\mathcal{D}$		$\mathcal{U}$		$\mathcal{N}$	
	Cost	S	Cost	S	Cost	S	Cost	S
Heuristic-1	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-1: Heuristic-1 vs Optimal NIS

Heuristic 2 (H2):

In this heuristic we use p_2 as the cost of understocking and $h + m - p_1$ as the cost of overstocking in the traditional news-vendor setting. Therefore the critical fractile is:

$$CF_2 = \frac{p_2}{p_2 + h + m - p_1}$$

The results, which are averaged across 32 parameter settings, are summarized in Table-2.

	$\mathcal{F}$		$\mathcal{D}$		$\mathcal{U}$		$\mathcal{N}$	
	Cost	S	Cost	S	Cost	S	Cost	S
Heuristic-2	39.98	18.13	40.23	18.13	33.62	18.13	34.51	18.13
Optimal NIS	36.99	21.69	37.17	21.84	31.47	20.50	32.10	20.78
% difference	8.1%	-16.43%	8.24%	-17.02%	6.84%	-11.59%	7.51%	-12.78%

Table-2: Heuristic-2 vs Optimal NIS

Heuristic 3 (H3):

In this heuristic we use $p_2+p_1+\alpha_U$ as the cost of understocking and $h+m$ as the cost of overstocking in the traditional news-vendor setting. Therefore the critical fractile is:

$$CF_3 = \frac{p_2+p_1 + \alpha_U}{p_2+p_1 + \alpha_U + h + m}$$

The results, which are averaged across 32 parameter settings, are summarized in Table-3.

	$\mathcal{F}$		$\mathcal{D}$		$\mathcal{U}$		$\mathcal{N}$	
	Cost	S	Cost	S	Cost	S	Cost	S
Heuristic-3	40.08	18.19	40.41	18.19	32.83	18.19	33.87	18.19
Optimal NIS	36.99	21.69	37.17	21.84	31.47	20.50	32.10	20.78
% difference	8.37%	-16.43%	8.7%	-16.74%	4.33%	-11.28%	5.52%	-12.48%

Table-3: Heuristic-3 vs Optimal NIS

Heuristic 4 (H4):

In this heuristic we use p_2+p_1 as the cost of understocking and $h+m+\alpha_D$ as the cost of overstocking in the traditional news-vendor setting. Therefore the critical fractile is:

$$CF_4 = \frac{p_2+p_1}{p_2+p_1 + h + m + \alpha_D}$$

The results, which are averaged across 32 parameter settings, are summarized in Table-4.

	$\mathcal{F}$		$\mathcal{D}$		$\mathcal{U}$		$\mathcal{N}$	
	Cost	S	Cost	S	Cost	S	Cost	S
Heuristic-4	49.62	11.94	49.83	11.94	45.07	11.94	46.11	11.94
Optimal NIS	36.99	21.69	37.17	21.84	31.47	20.50	32.10	20.78
% difference	34.15%	-44.94%	34.05%	-45.35%	43.22%	-41.77%	43.62%	-42.56%

Table-4: Heuristic-4 vs Optimal NIS

Heuristic 5 (H5):

In this heuristic we use $p_2 + p_1 +\alpha_U$ as the cost of understocking and $h +m+\alpha_D$ as the cost of overstocking in the traditional news-vendor setting. Therefore the critical fractile is:

$$CF_5 = \frac{p_2+p_1 + \alpha_U}{p_2+p_1 + h + m + \alpha_D}$$

The results, which are averaged across 32 parameter settings, are summarized in Table-5.

	$\mathcal{F}$		$\mathcal{D}$		$\mathcal{U}$		$\mathcal{N}$	
	Cost	S	Cost	S	Cost	S	Cost	S
Heuristic-5	44.05	14.81	44.32	14.81	38.32	14.81	39.46	14.81
Optimal NIS	36.99	21.69	37.17	21.84	31.47	20.50	32.10	20.78
% difference	19.09%	-31.7%	19.23%	-32.19%	21.77%	-27.74%	22.93%	-28.72%

Table-5: Heuristic-5 vs Optimal NIS

Heuristic 6 (H6):

In this heuristic we use $p_2 + \alpha_U$ as the cost of understocking and $h + m - p_1$ as the cost of overstocking in the traditional news-vendor setting. Therefore the critical fractile is:

$$CF_6 = \frac{p_2 + \alpha_U}{p_2 + \alpha_U + h + m - p_1}$$

The results, which are averaged across 32 parameter settings, are summarized in Table-6.

	$\mathcal{F}$		$\mathcal{D}$		$\mathcal{U}$		$\mathcal{N}$	
	Cost	S	Cost	S	Cost	S	Cost	S
Heuristic-6	38.17	20.44	38.42	20.44	31.77	20.44	32.52	20.44
Optimal NIS	36.99	21.69	37.17	21.84	31.47	20.50	32.10	20.78
% difference	3.21%	-5.76%	3.37%	-6.44%	0.97%	-0.3%	1.32%	-1.65%

Table-6: Heuristic-6 vs Optimal NIS

Comparison of all six heuristics:

Based on the analysis above H6 is the best heuristic among all six, producing results within 4% of the optimal. H2 and H3 are within 9% of the optimal; H3 is better than H2 when downward substitution is not allowed. H1 and H5 fourth and fifth best heuristic respectively. H4 is the worst performing heuristic, its cost is within 35% to 45% of the optimal cost.

Conclusion and Future Research Direction

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 six heuristics to find a good NIS order-up-level based newsvendor-type logic. Based on the comparison of these heuristics we see that one of them performs within 4% of the optimal NIS which looks promising in case computational solutions are not readily available. As future research, more heuristic policies can be developed so that the gap with the optimal can be further reduced.

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Palm to Palm: Managing Resources

Introduction

Palm to Palm, a micro-scale sustainable operations project in Koidutown, Kono District, processes fruit of the oil palm tree into palm oil and palm kernel soap. These products are then sold throughout Kono District. The bulk of management's efforts in 2019 have been directed at negotiating with the Ministry of Labor and project employees to arrive at employee contracts that are satisfactory for the workers and, importantly, meet labor regulations as outlined by Ministry of Labor inspectors, with whom project management had significant contact throughout much of the year.

2019 Activities

Palm to Palm took a big step forward in 2019 managing human resources. A foreshadowing of 2019 activity in the area of human resources occurred during the second week of January when one of the project Co-Directors mentioned to the other two project principals that P2P will soon need to pay "…proper and minimum legal salaries." (N. Desnoyers, personal communication, 1/8/2019). Compensation issues, however, didn't immediately rise to the top of the priority list. That changed in early April when an Inspector from the Ministry of Labor paid a visit to P2P's processing plant. At the conclusion of the visit, the Inspector indicated to the local project manager a list of compensation and safety items that were required by law for the employees of production facilities. (D. Somoyah, personal communication, 4/5/2019). A few days later the project received a letter from the Ministry of Labor detailing the items to be addressed in order for P2P to begin operating in accordance with labor regulations (D. Somoyah, personal communication, 4/10/2019). The required items are as follows:

1. There are no protective gears for workers
2. No health medical provisions for workers
3. Poor working environment
4. Failure in meeting the minimum wage
5. No NASSIT (social security trust) contribution
6. Substandard salaries paid to workers

7. There is no Terms and Conditions for workers

8. Failure to register your Factory and failing to obtain factory license

9. No leave and leave emolument to workers

10. And there should be provision for Benefit/Gratuity

The letter ended with a warning that failure to address the items in the letter would result in a "…confrontation with the law." Two weeks later a second letter was received from the Ministry of Labor stating that no actions had been taken by P2P to address the list of items. This second letter warned the unless the project took prompt action on these items P2P would be shut down in early May (D. Somoyah, personal communication, April 26th, 2019). An impartial observer might declare that P2P's situation was dire.

After several meetings with one of more Ministry of Labor Inspectors and clarifications between the local manager and the Co-Director writing the contracts, draft contracts were sent (N. Desnoyers, personal communication, 5/21/2019) for the Inspector's review. Upon review of the draft contracts, the Inspectors agreed not to shut down the project on two conditions (D. Somoyah, personal communication, 5/27/2019):

1. P2P management work to finalize contracts with all workers that meet all necessary regulations.

2. P2P pay workers a bonus so that workers' total compensation for the first half of 2019 meets or exceeds required minimum salary. Funds for the bonus were sent at the end of June (N. Desnoyers, personal communication, 6/28/2019)

The final requirements as agreed between the local project manager, the project Co-Directors, and the Ministry of Labor called for the new worker contracts to include the following items (N. Desnoyers, personal communication, 9/14/2019):

1. Salary: Monthly salary for each worker at least SLL 500,000 (national minimum wage)

2. Medical Allowance: Each worker is to receive a monthly Medical Allowance of SLL 70,000.

3. Transport Allowance: Each worker is to receive a Transport Allowance of between SLL 40,000 and SLL 60,000 to cover the cost of transportation between home and the project processing plant.

4. Rent Allowance: Each worker is to receive a Rent Allowance of between SLL 30,000 and SLL 50,000 to cover the cost of rent.

5. NASSIT Employee contribution: 5% of each worker's salary is to be withheld and submitted as the employee contribution to NASSIT (national social security trust).

6. NASSIT Employer contribution: An amount equal to 10% of each worker's salary is to be submitted by P2P as the NASSIT employer contribution.

7. Vacation: Each employee is entitled to 26 days of vacation for the year, to be taken in "…no less than 2 bits and no more than 3 bits and not during busy season."

8. Benefit (separation payment): Each worker who has successfully completed at least one year of satisfactory work for P2P will receive a "benefit" (separation payment) from the project.

9. Workweek: The maximum number of days per week a worker will be required to work is six (6).

10. Safety: Each worker will be issued proper protective gear.

The contracts covered the period September 16, 2019 to August 31, 2020 and were signed on September 16, 2019 (D. Somoyah, personal communication, 9/16/2019).

Upon signing the contracts, the workers attempted to register with NASSIT so contributions in their names could be managed. Unfortunately, the NASSIT office informed the workers that they would be unable to register until P2P addressed the NASSIT arrears it owed. It seems that the project registered with NASSIT in 2014 but hadn't made contributions in the intervening years. The local manager negotiated with the NASSIT representative and an agreement was made whereby P2P would pay NASSIT arrears for the two employees that remained continuously employed by P2P from 2014 to 2019 (D. Somoyah, personal communication, 10/7/2019). A conference call was held between one of the project Co-Directors, the local manager, and a NASSIT official in an attempt to negotiate a further reduction in the amount of NASSIT arrears owed. The conversation did not result in a further reduction of the arrears (D. Somoyah, personal communication, 11/25/2019). P2P was successful, however, in setting up a plan with NASSIT to pay the arrears in installments starting in early December 2019 and ending in January 2020. By the time of writing, approximately half the arrears have been paid.

Meeting the compensation requirements (as embodied in the new employee contracts) stipulated by the Ministry of Labor came with a big drawback: The significantly increased compensation costs facing the project starting in September 2019 significantly increased P2P's operating losses. Implementing the new

contracts required one of the project's private donors to commit to offsetting operating losses through the end of 2019. P2P management believes that the project will be financially viable starting in January 2020 for three reasons:

1. January is the start of busy season, when production and corresponding revenues significantly increase.
2. Management is working to implement additional equipment that will lower the cost of a primary raw material.
3. Management is planning to expand product offerings.

The above information illustrates that P2P had a successful year from a human resources perspective, as by year-end the project was in compliance with all labor regulations.

2019 Outcomes

The project's primary outputs are and soap. 2019 has been a good year for P2P operations. Output of both palm oil and soap increased considerably from 2018 due to two primary factors:

1. P2P had access to a reliable and inexpensive method of transporting raw materials, most notably palm fruit heads, to the P2P processing plant.
2. Local weather in 2019 has been considerably better than the previous year.

As a result of producing and selling more of our products, P2P saw a substantial increase in revenue in 2019 compared to 2018.

Preliminary results for 2019 indicate that the project primary production outcomes are as follows:

1. Palm oil: P2P produced a little less than 400 "battas" of palm oil in 2019. Each batta contains five gallons, so this year's output was just under 2,000 gallons. It should be noted that most of the palm oil produced was not sold on the open market but instead used as an input for soap production.
2. Soap: Approximately 40,000 bars of soap were produced and sold, approximately 350% of the previous year's output. It should be noted that the vast majority of soap produced this year has been inexpensive laundry soap.

Increased production activity resulted in increased revenues. The project brought in approximately SLL 90M (~$10,000) in revenue during the year. The fact that local currency revenue is notably larger than P2P's previous record but dollar-denominated revenue is approximately equal to previous dollar-denominated record values illustrates that there continues to be significant inflation present in Sierra Leone. Another note that should be made about project revenue is that, as stated earlier, most of the palm oil produced was used as inputs in the soap production process. This fact has resulted in difficulty quantifying revenues because the project struggles with transfer pricing.

Conclusion

Palm to Palm continued to make progress in 2019. P2P production levels (and corresponding revenue) increased significantly from the prior year. The project's major accomplishment during the year was implementing employee contracts that conformed to all labor regulations – including minimum monthly salary. The impetus behind negotiating new worker contracts came from the Ministry of Labor when the ministry threatened to shut the project down for labor violations. After negotiations between project management, the employees, and Inspectors for the Ministry of Labor, new contracts where signed and implemented in mid-September that put the project in compliance with all labor regulations. The significantly increased cost associated with the implementation of the new contracts resulted in significant operating losses for the last four months of the year. Addressing these operating losses is a major concern for project management in the new year.

RATIONALIZING YOUR SPECIFICATIONS

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Abstract

The objective of this paper is to discuss some issues around different type of specifications given by the customer. We will introduce some criteria and alternatives for dealing with these issues, both for bilateral and unilateral cases with or without the nominal (i.e., target) value given. We will also discuss the use of the Acceptance chart concept for some cases to monitor the process performance.

Key words: Process specifications, bilateral and unilateral specifications, nominal value, process capability, acceptance charts.

Introduction

Specifications are stated in a variety of forms. The usual "bilateral" specifications are given in terms of the Upper Specification Limit (USL), Lower Specification Limit (LSL) around the Nominal (i.e., the target value). "Unilateral" specs, on the other hand, come in several varieties that we will discuss in this paper. A capable process can be defined as one that is narrow enough to allow all process output to fall within the specification limits and is also centered on the process nominal, if there is a nominal (see, for example, Holmes and Mergen (2015)). For example, the process may be narrow enough (i.e., it has small variation) but may not be centered properly, which might cause some outputs to fall outside the specification limits; or the process could be properly centered but it may have excess variation so some outputs may exceed specifications.

Thus, we have two issues to deal with in capability analysis: i. the width issue, and ii. the center issue.

Discussion

We need to remember that specifications are set by the customer requirements, rather than by supplier process capabilities. The quality level of a process is determined by comparing the process output with the customer specifications. Thus, the identity of the customer should be defined clearly; i.e., who makes the final decision that an output is acceptable or not? The customer may be internal or external to the organization.

Specification limits imply an acknowledgement that process outputs will vary; i.e., obtaining identical results from a process is nearly impossible. In addition, close attention must be paid to the differences between the three sets of limits: 1). Specification limits (customer defined – what the customer wants); 2). Natural process (tolerance) limits (process defined – what the process is doing); and 3). Control limits (which deals with checking process stability, i.e., in-control or not). Failure to understand the differences between those may lead to communication problems and erroneous decisions for the process.

We also need to remember that output near the specification limits is of lower quality than that which is far away from the specification limits, given that there is a nominal value given by the customer. Thus, the average value of the process output should be as close as possible to the nominal value.

There are some discussions that emphasize the difference between *Design* and *Acceptance* specifications. *Design* specifications describe output requirements. We will discuss this type. *Acceptance* specifications have to do with sampling plans that are used to decide whether a lot of output should be accepted.

In the discussion below, we will look at different cases.

Case 1. For bilateral specifications where a nominal value is given:

If the customer provided the specifications, e.g., bilateral specifications with a nominal value, meeting specifications only is not good enough today to retain the customers. You must meet the specifications and your process must be on or near the nominal with small variation around the nominal. In other words, the distance between the process average and the nominal value must

be small, and the process standard deviation must be such that the process can comfortably avoid producing output outside the specifications (see Figure 1 below).
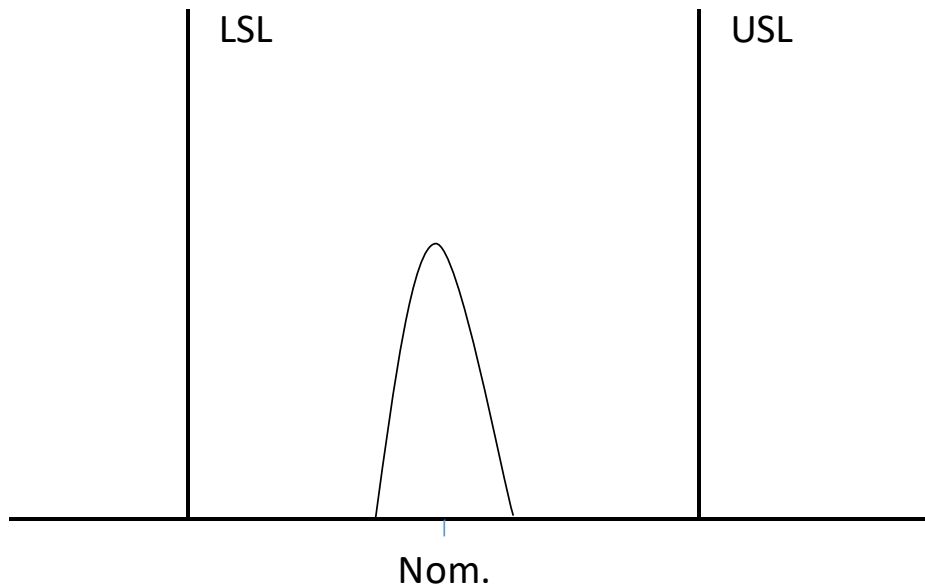
Figure 1. Bilateral specifications with nominal.

Case 2. For bilateral specifications where specifications are not available:

Here the issue is how to build the specifications that do not exist. You need to talk to your customer and find out what the customer needs. Also, check your process to find out what the process can do (its capability) and what it is doing now (its current performance).

If your process is in control (i.e., stable), you can be assured that most of the output will fall ± 3 standard deviations around the average. Then, for example, you can propose the specification limits to the customer as "average ± 4 standard deviations" so that you can comfortably meet them. If the customer agrees, then establish the specifications at that level.

If this is not agreeable to the customer, then you need to decide:
i. Do you want the business?

ii. How much would it cost to improve the process to the level that is satisfactory for the customer?

iii. Can you convince the customer to open up the specifications?

If your process is not in control (i.e., not stable), you can only describe your past performance and make little if any predictions about the ability of your process to produce the same way in the future. In this case, you would better to allow considerably more than $\pm$ 4 standard deviations around the average.

Case 3. For given bilateral specifications with no nominal:

This case has more flexibility for the producer; your process center can wander about as long as no output is outside of specification limits (see Figure 2). If the capability standard deviation of your process is small enough, you can consider using *"Acceptance Charts"* to monitor the process, where the capability standard deviation is one that is independent of changes in average values. The capability standard deviation could be estimated, e.g., using $\frac{\bar{R}}{d_2}$ or $\frac{\bar{S}}{c_4}$. Another alternative would be to use the mean square successive differences (MSSD) approach (see, for example, Neumann, et al. (1941), Hald (1952), Holmes and Mergen (1995, 2004) Acceptance charts are designed to be used when we want to answer the question *"Is the process producing output satisfying the customer specifications?"* In other words, we would like to have protection against the case where the process average may shift so much that it will start producing some non-conforming output. There are some processes which, due to their nature, are expected to have unavoidable shifts in their average value, but which are still able to satisfy customer established specifications, such as some chemical processes. This situation occurs when the standard deviation of the process, at the various average values of the process, is very small relative to the tolerance width, i.e., the difference between the upper and lower specification limits. In usual statistical process control terms, such a process is not in-control (i.e., process average wanders, not stable) but may be able to produce acceptable product. Freund (1957) was the first one who proposed these charts. See also, for example, Duncan (1986), Montgomery (1996), Holmes, Mergen Uysal (2019), Holmes and Mergen (2009, 2002) for more detailed explanation and building of the acceptance charts.
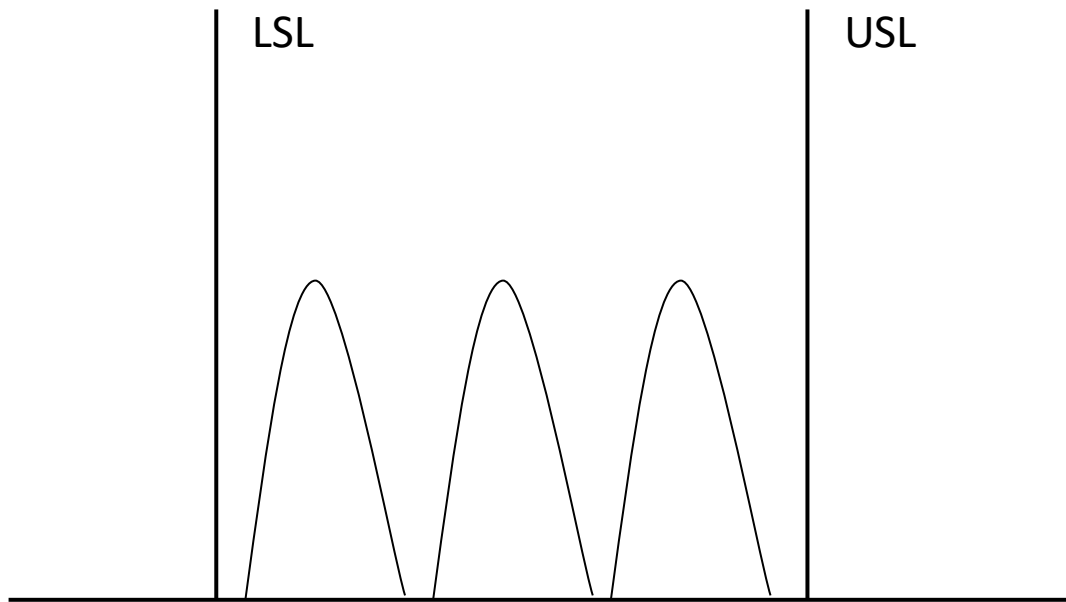
Figure 2. Bilateral specifications with no nominal

If the specification limits do not exist, follow the procedure described in Case 2 above.

Case 4. Unilateral specification with no nominal:

This is the most commonly used unilateral specification. The customer may provide either the upper (USL) or the lower specification limit (LSL). You have the freedom to place your process average anywhere you wish, as long as the specification limit given by the customer is not violated. Generally, it is economically best to place the center of your process as close to the given specification limit as possible without violating it. For example, you may place the process center USL – 4 standard deviations to generate very little output that violates the upper specification limit (use LSL + 4 standard deviations for the case of lower specification limit).

As you can guess, there is an advantage to having an in-control (i.e., stable) process here. For in-control processes, the standard deviations are smaller than for out-of-control processes and you can demonstrate the economic advantage of being in-control. In other words, having a stable process average and small standard deviation will enable you to set the process center as close as possible to the given limit so that you can minimize your process costs while meeting the customer specification.
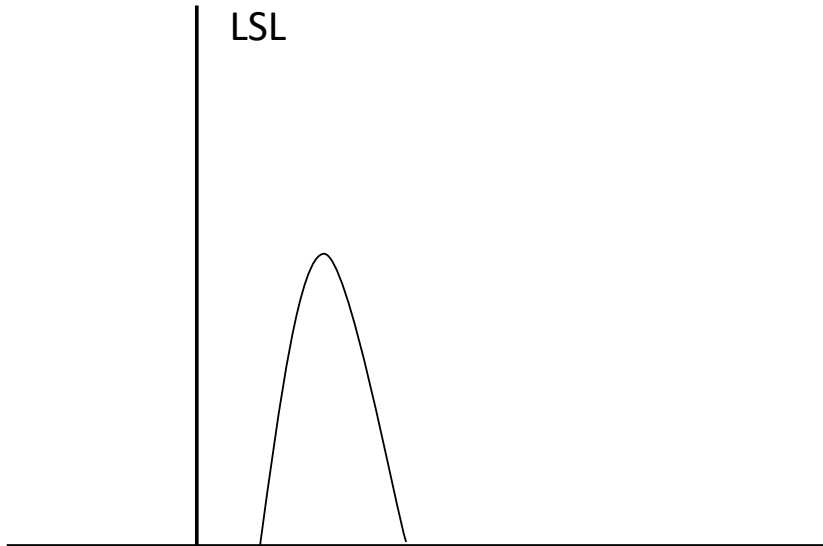
Figure 3. Unilateral specification (e.g., LSL) with no nominal

As discussed under Case 3, you may also consider using Acceptance Charts in this situation too. Keep in mind that there would be only one acceptance limit in this case.

Again, if the specification limit does not exist, use the approach of Case 2 above.

Case 5. Unilateral specification with nominal given:

In this situation, you have lost a degree of freedom; you not only meet the specification but also center your process on the nominal value (see Figure 4). As you can guess, this requires controlling your process center on nominal and with a small (even smaller) standard deviation. Since the customer provides a nominal value for your process center to be on, Acceptance Charts would not be an option in this situation.
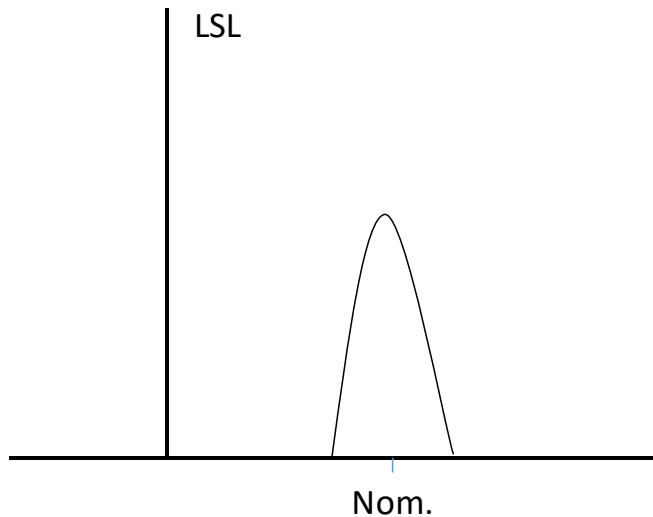
Figure 4. Unilateral specification (e.g., LSL) with nominal.

Again, if the specification limit and the nominal value do not exist, use the approach of Case 2 above.

Case 6. Nominal + 0 and Nominal – XX type specification:

This type of specification has little to recommend itself, except to emphasize that you need to have a thorough discussion with the originator of the specification to be sure that the meaning is clear. The way the specification is given, no matter where you place the process center; there will be output that will violate the given specification. For example, nominal – 0.05 will imply that there is a lower specification limit and Nominal + 0 implies that nothing should be above the nominal value. If your process center is placed on the nominal, then roughly 50% of the output would be above the nominal, which will not be desirable given the specification is defined (Figure 5). Thus, this would imply that the producer should have a nominal value that is below the specified nominal; or else they would be producing 50% defective output. This, in turn, will lead to the customer getting output that, on average, is below the nominal value. Therefore, these issues need to be included in the discussion with the customer.
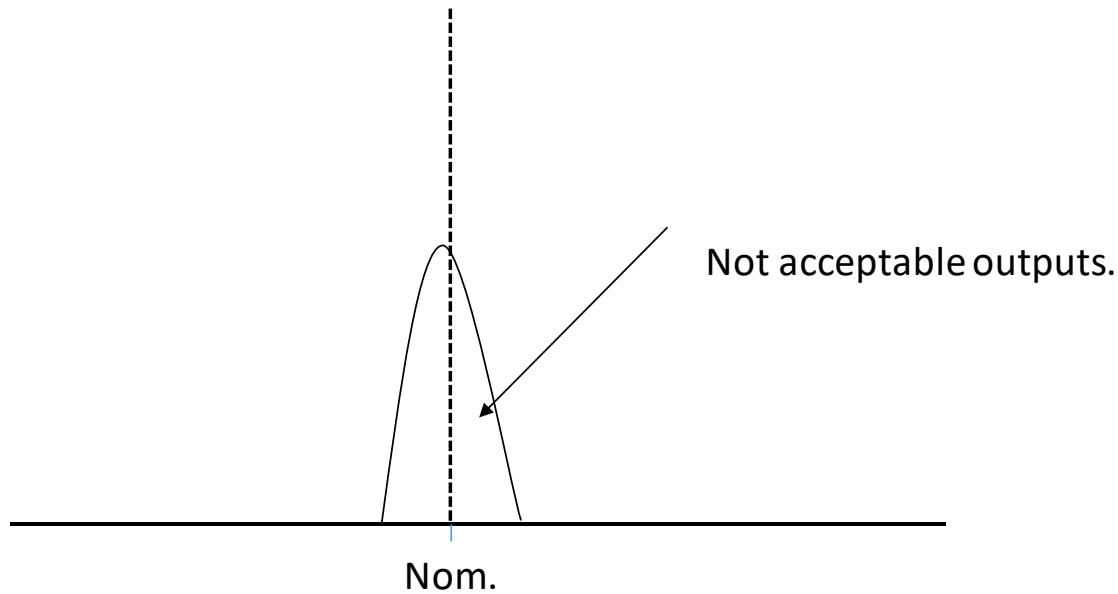
Figure 5. Nominal + 0 and Nominal – XX type specification.

Such specifications may be OK for the customer but should not be used for the process. That is to say, in this case, there are two sets of specifications: one for the customer; and one for the process.

Once these issues have been resolved, one of the cases we have considered above will be appropriate.

Conclusion:

In this paper, we discussed several different scenarios with respect to the way the specifications are given. Guidelines and the methods provided in the paper should be of practical significance for monitoring the process capability, i.e., meeting the customer requirements and at the same time minimizing the process cost.

In a future study, we will look into the capability indices that could be used under the cases, which we discussed in this paper.

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SCHOOL BUS ROUTING WITH BELL TIME POLICY OPTIMIZATION:

A MULTI-OBJECTIVE APPROACH

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Abstract

The School Bus Routing Problem (SBRP) is a comprehensive real-world problem which has been studied over decades. Among all the sub-problems of SBRP, the school bell time adjustment sub-problem has drawn little research attention. However, change in the school bell time could be a cost-efficient and practical approach to improve the school bus transportation system. In this research, we propose multi-criteria school bell time optimization models under single load assumption for both heterogeneous and homogeneous fleet scenarios. We not only consider minimizing the number of buses to be used and the total service time of the buses, but also maximizing the preference of all constituents for the bell times while assigning optimal bell times (start and end time) to each school. Finally, experiments are conducted using a commercial optimization solver on the proposed models and tested on benchmark data.

Keywords: school bus routing, multi-objective optimization, bell time adjustment

1. Introduction

The school bell time is the start time in the morning and the close time in the afternoon for each school. The school bus transportation system needs to determine the schedule for a route picking students from their homes to school, as well as delivering them back, all based on the prior bell time information. School district administrators are responsible for designing the school bus routes, determining the bell times and assigning a bus to each route. Multiple criteria from different perspectives, such as cost, student health issues and family preference are supposed to be considered.

The transportation cost is one of the main issues. As the number of students from each school and each locality increases, the number of buses required to service each route is increasing and the cost to transport keeps increasing accordingly. The transportation system for the Boston Public School (BPS) system is a typical example. Data from BPS transportation system show that transportation costs reached $110 million or 11% of the district's budget in year 2016, up by $33M from FY11, a 7.5% annual increase [3]. The problem can be traced down to the increased number of buses (around 640) for 25,000 students. This increasing budget of Boston Public School Bus System was the motivation forcing the community to search for better methods to reduce the annual budget. Utilizing each bus multiple times for multiple schools whose bell times are optimally assigned can help reduce the transportation cost by a large amount and better utilize buses.

The satisfaction from the groups affected by the bell time schedule is another important factor. As Bertsimas et al. [2] mentioned "School districts typically struggle with balancing many competing objectives, including student health, special education programs, parent and staff schedules, state and federal regulations, and public externalities". Obviously, it is impossible to establish a policy to make everyone happy. Nevertheless, a fair model which could maximize the overall system satisfaction would be helpful for the administrators of the school districts while making decisions. These considerations call for an optimization model that can reduce transportation costs and improve the constituents' satisfaction level.

2. Literature Review

School bus routing problem (SBRP) has been a research topic studied for many years since its first appearance by Newton and Thomas [11] in 1969. The school bus system design process is decomposed by Desrosiers et al. [4], into five sub-problems: data preparation, bus stop selection, bus route generation, school bell time adjustment and route scheduling. A review contains 29 SBRP-related publications produced by Park and Kim [12]. Most recently, Ellegood et al. [6] published an updated review, which has very similar classification methods including 64 new publications examining SBRPs. Among these papers, we may notice that very few determine the school bell time adjustment, while nearly all treat the school start and end time, or time window, as inputs to the problem. Only the following four studies in the last ten years dealt with bell time adjustment or its modified version.

Most recently, Bertsimas et al. [2] developed a multi-phase heuristic algorithm, handling bus stop assignment, route generation, school bell time adjustment and bus scheduling sub-problems. The stop assignment is considered independently from the route generation problem. A randomized greedy insertion heuristic is designed to generate multiple sets of feasible trips for each single school before these feasible trips are put together to form different possible paths in order to find a combination with minimum paths, thereby minimizing the number of buses in the whole system. Thus, a network formulation is formulated, and it could be solved to optimality in two hours using commercial solvers such as Gurobi. Finally, a similar network formulation is designed for bus assignment based on the selected scenario derived from last step. Relied on the results from this heuristic approach, a Generalized Quadratic Assignment Problem (GQAP) is introduced to determine the bell time selection and solved by simple local improvement heuristic. Besides, the bell time preference and other policies are analyzed and discussed.

Eguizabal et al. [5] designed a model minimizing operating costs and travel time based on different situations and various inputs including number of buses, max route journey time and time window duration (in this study, all schools have the same time window). First, routing problems are solved separately using the model established by Bektas and Elmastas [1] which is modelled as a capacitated and distance constrained open vehicle routing problem and presented in an integer linear optimization, using number of routes and max journey time as input. As a result, several feasible routes for each school are obtained. Then a script written in Python is

used to link these routes into path connecting all schools as possible alternatives. Finally, the optimal solution for each situation is found by comparing these alternatives (min cost and min travel time). In this study, the starting time for each school varies, leading to the opportunity to decrease the transportation cost. It is a bell time adjustment problem in essence though the open time window for all the schools are the same.

Mandujano et al. [9] established a two-step model to optimize the public schools' locations and transportation separately for rural areas public schools in Brazil. From the first step, school locations and the pupil sizes are determined which are the inputs for the second step. An integer model is formulated and solved by IBM CPLEX. In the second phase, the shift (morning or afternoon) for the school is determined along with solving the routing problem, considering the school day lasts 4 hours and schools operate in two shifts in Brazil. An integer model is proposed and solved using a heuristic. The shift here could seem as a modified version of bell time. However only two shifts are considered and tested.

Fügenschuh [7] presented an integer programming model, minimizing the number of vehicles and total driving time by adjusting the school starting times. In this model, the students can change bus transferring from one trip to another. Several approaches including preprocessing techniques (starting time propagation, variable fixing, Big-M reduction and lifting), Big-M-free reformulation and k-path cut are presented to improve the LP relaxation in order to shorten the gap between lower and upper bound solved from CPLEX.

To the best of our knowledge, no formal mathematical model in the literature has been formulated for the bell time adjustment sub-problem, which is the focus of this paper.

3. Problem Definition

School bell time adjustment problem defines the school bell time as a variable. As the input of the problem, bus routes information, candidate school start (and close) time window and other related policies and elements such as user preference shall be provided or derived from the other sub-problems.

In the most common situations, only single load is allowed for most urban school districts transportation system. In other words, students from different schools cannot sit on the same bus trip. However, in some rural areas, the policy could be different since students are all located remarkably decentralized in the rural area so that the single load policy would be unnecessary and cost inefficient. Mandujano et al. [9] and Miranda et al. [10] both studied the rural area schools in Brazil by using mixed loads policy. In this paper, single load rule is considered because the most complicated cases of school bus routing problems happen within urban school districts. Meanwhile, transfers among different buses are not allowed under the single load policy. Table 1 presents a list of assumptions that our model is based on.

Table 1. Model Assumptions

- The bus routes for each school are given.
- Multiple available bell time options for each school are given.
- No vehicles break down during the time of service i.e. during picking up and dropping off students.
- A bus will service no more than one route per school but may service routes of multiple schools having different bell times (single load assumption).
- No transfer among the buses is allowed.

A simple example of a school bus system with three schools and eight routes is illustrated in Figure 1. The bus running time along each route can be computed based on some average speed and time at each stop. Similarly, the running time for a bus from the bus yard to the start point of a route, or from a school to the start point of a route, can be computed or approximated by the Euclidean distance, given the location information of the bus yard, schools and the start points of all routes. The bell time is set as a variable to be assigned to each school. For example, in Figure 1, there are three possible bell times that can be assigned to the three schools, 7:30, 8:30 or 9:30 am.
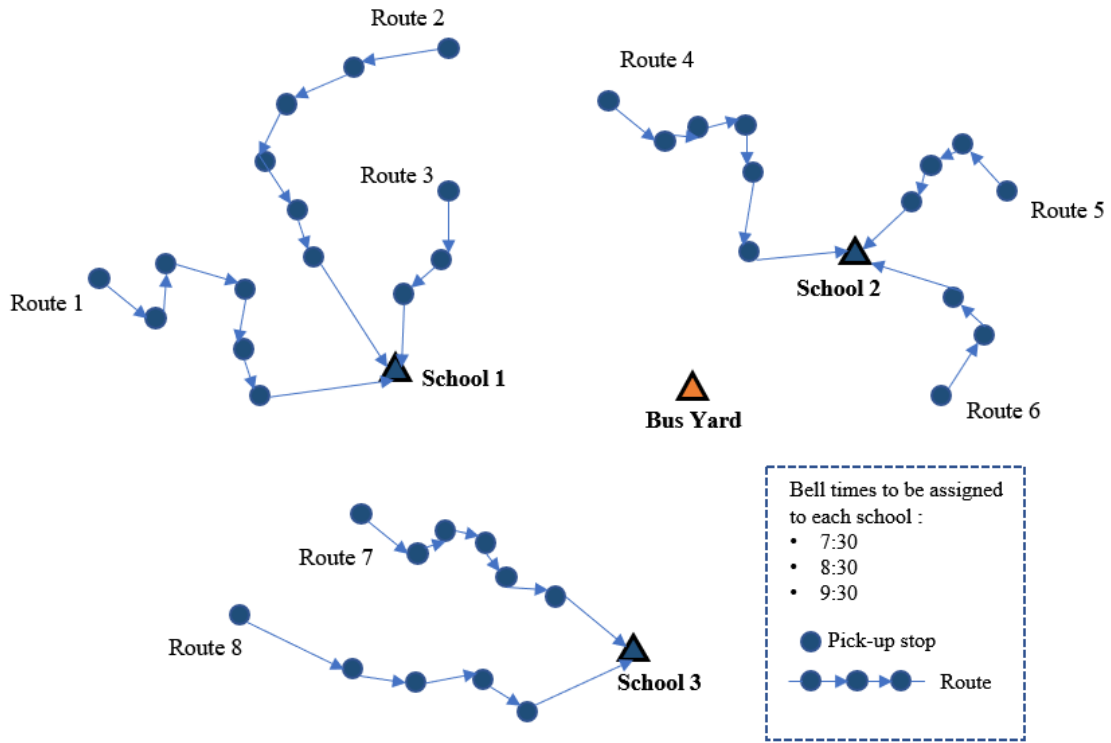
Figure 1. An example problem
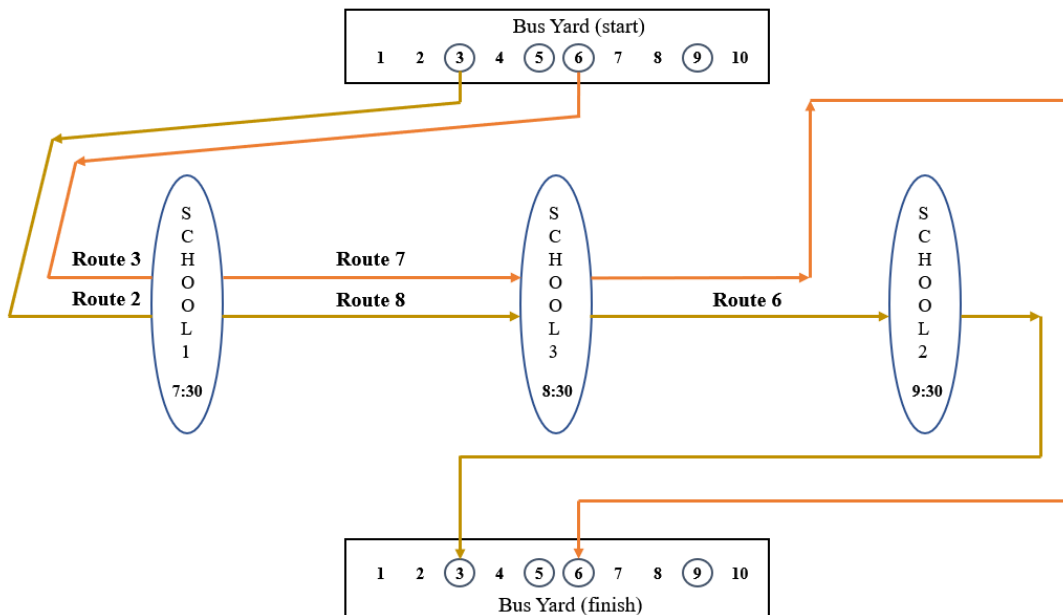
Figure 2. Bus assigned to each route
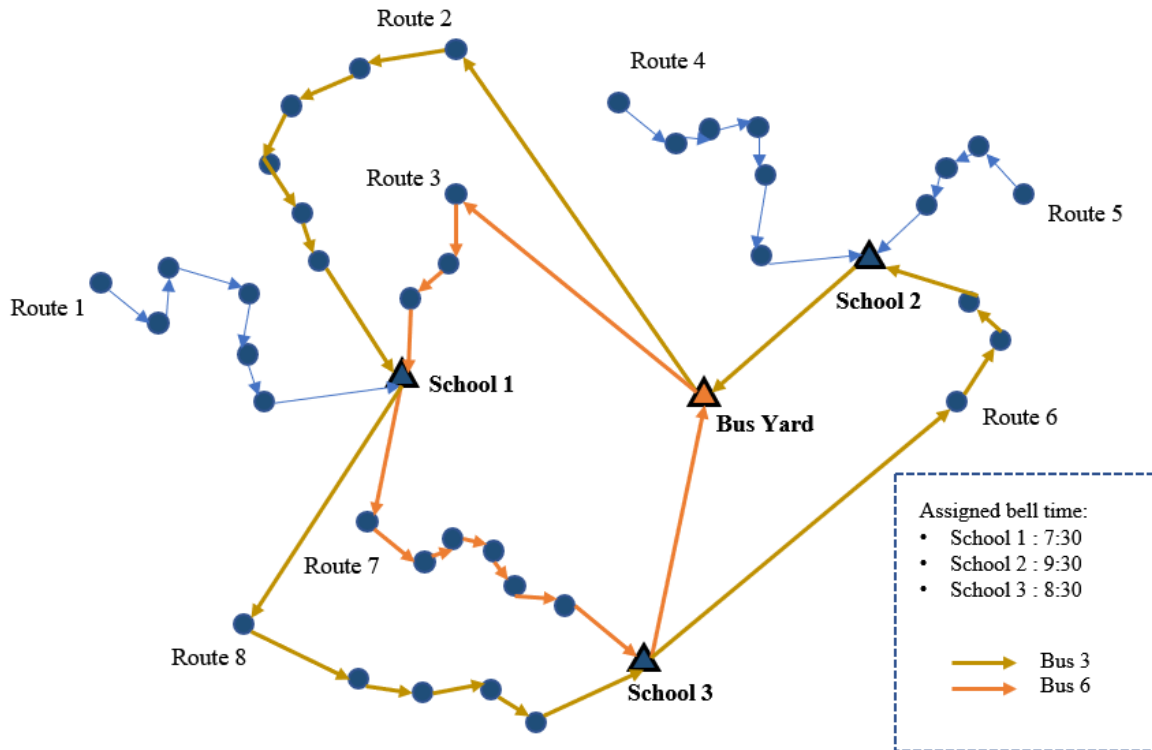
Figure 3. A partial solution for the example

Figure 2 provides a flow chart showing a feasible solution of bus assignments to the routes. Ten school buses are available in this example in the bus yard of which two buses (3 and 6) have been used for this small scale problem. Given the bell time for each school, as shown in Figure 2, Bus 6 starts from the bus yard heading to the start point of Route 3. As we assumed, the information of Route 3, as well as the other routes, are all given as the input. Route 3 will end at School 1 as its terminal. Then Bus 6 will service Route 7 terminated at School 3 whose bell time is assigned as 8:30. After arrival, Bus 6 will end its morning assignment and return to the finish bus yard. Similarly, Bus 3 after leaving the bus yard, services Route 2 first for School 1, then Route 8 for School 3 and then Route 6 for School 2 whose bell time has been assigned at 9:30. As a result, from Figure 3, we can see the partial final solution (only two buses flow are showed in the figure).

4. Solution Procedure – Heterogeneous Fleet

In the heterogeneous fleet model, all buses are the same with the same capacity and other characteristics. The problem can be formulated as a MILP model, using 3 different main binary decision variables to determine the bus assigned for a route started from a school, the bus assigned from a school return to the depot and the bell time assigned to each school. An auxiliary continuous variable is used to describe the idle (waiting) time of the bus after serving a route. The model takes three criteria as the objectives into consideration, (a) minimizing the number of buses, (b) minimizing the total service time of all the buses, and (c) maximizing the preferences of the families of students for bell times as a factor to improve satisfaction level of families.

4.1 Mathematical Notations

Sets and Indices:

B: set of buses, $i \in B$

S: set of schools, $s \in S$

Js: set of routes j for school s, $s \in S$; also, j is the starting node of route j

J: set of routes j

K: set of bell time indices $k \in K$.

A single bus yard exists at node $\{0\}$ which holds all buses. The model can easily be modified to accommodate multiple bus yards and is in the future scope of the paper.

Input Parameters:

c_i: capacity of bus i, $i \in B$

n_j : total number of students picked up on route j, $j \in Js$ and $s \in S$

r_j : Travel time of route j, $j \in Js$ from its starting node to arrival at school s

t_{sj}: travel time from school s to starting node of route j, $j \in Js$

t_{0j}: travel time from depot to the starting of route j

t_{s0}: travel time from school s to the depot

b_k: school start time for bell time index k, $k \in K$

α: minimum time interval for arrival before a school starts (the value of 15 minutes is used below)

M: a big number

w_{sk}: weight preference of school s, s ∈ S for bell time k ∈ K

Decision Variables:

$$X_{isj} = \begin{cases} 1, & \text{if bus i serves route j after a route of school s} \\ 0, & \text{otherwise} \end{cases} \quad j\notin Js$$

$$Z_{sk} = \begin{cases} 1, & \text{if school s, } s \in S \text{ is assigned bell time } k, k \in K \\ 0, & \text{otherwise} \end{cases}$$

$$X_{is0} = \begin{cases} 1, & \text{if bus i leaves school s it served last to go back to the bus yard} \\ 0, & \text{otherwise} \end{cases}$$

For the special cases of s=0 we have,

$$X_{i0j} = \begin{cases} 1, & \text{if bus i leaves the bus yard to serve its first route j} \\ 0, & \text{otherwise} \end{cases}$$

Auxiliary Variables:

U_j = idle time of the bus after serving route *j*

4.2 Mathematical Formulation

Objective Functions:

Min $\sum_{i \in B} \sum_{j \in J} X_{i0j}$ ... (1)

Min$\sum_{i \in B} \sum_{j \in J} t_{0j} X_{i0j} + \sum_{i \in B} \sum_{s \in S} t_{s0} X_{is0} + \sum_{i \in B} \sum_{s \in S} \sum_{j \in J} t_{sj} X_{isj}$

$+ \sum_{j \in J} U_j$ ... (2)

Max $\sum_{s \in S} \sum_{k \in K} w_{sk} Z_{sk}$ ... (3)

Subject to

$\sum_{i \in B} X_{i0j} + \sum_{i \in B} \sum_{s \in S} X_{isj} = 1,\ j \in J \backslash j \notin Js$ and $s \in S$ ...(4)

$\sum_{k \in K} Z_{sk} = 1,\ s \in S$ ...(5)

$\sum_{j \in J \backslash j \notin Js} X_{i0j} + \sum_{j \in J \backslash j \notin Js} \sum_{s \in S} X_{isj} \leq 1,\quad i \in B$ and $s \in S$ ...(6)

$\sum_{s \in S} X_{is0} \leq 1,\ i \in B$ ...(7)

$\sum_{j \in Js} X_{i0j} + \sum_{m \in s} \sum_{j \in Js} X_{imj} = \sum_{j \in J \backslash j \notin Js} X_{isj} + X_{is0},\ i \in B$ and $s \in S \backslash s \neq m$ ...(8)

$[\sum_{k \in K} b_k Z_{sk} + \sum_{i \in B}(t_{sj} + r_j + M)X_{isj} + \alpha - \sum_{k \in K} Z_{mk} \ b_k] \le M$, $j\in J\backslash j \notin Js$ and {s, m≠s}   …(9)

$[-\sum_{k \in K} b_k Z_{sk} - \sum_{i \in B}(t_{sj} + r_j - M)X_{isj} - U_j - \alpha + \sum_{k \in K} Z_{mk} \ b_k] \le M$, $j\in J\backslash j \notin Js$ and {s, m≠s}   …(10)

$n_j (X_{i0j} + \sum_{s \in S} X_{isj}) \le c_i$, $i \in B$, $j\in J\backslash j \notin Js$ and $s \in S$ …(11)

$X_{isj} \in \{0,1\}$, $i \in B$ and $s \in S$ and $j\in J\backslash j \notin Js$ …(12)

$X_{is0} \in \{0,1\}$, $i \in B$ and $s \in S$ …(13)

$Z_{sk} \in \{0,1\}$, $s \in S$ and $k \in K$ …(14)

$U_j \ge 0$, $j \in J$ …(15)

Objective function (1) minimizes the number of buses required to transport the students to and from the schools. Objective function (2) minimizes the dead head time for all buses. This includes deadhead time of a bus after serving a school and going to the beginning of the next route, idle bus time from one school to another and trips from and to the bus yard. Objective function (3) maximizes the preferences of the families for bell times based on the assigned weight. Constraint (4) ensures that every route is served by a bus. Constraint (5) ensures that every school is assigned a bell time. Constraint (6) maintains that a bus is assigned to at most one route of a school. Constraint (7) ensures that if a bus is used, it will return to the depot from some school. Constraint (8) is a flow balance constraint. It states that if a bus is serving a route of a school then the bus either comes from the bus yard or from another school. Constraint (9) ensures that if a bus serves school m after school s it should have enough time to serve a route of school m and arrive at least α time before the bell time. Constraint (10) is used to compute the bus idle time for each individual route while all bus idle times are summed up in objective function (2) to compute the total idle time. Constraint (11) is the bus capacity constraint. Finally, constraints (12) to (14) declare the binary variables and constraint (15) declares non-negativity on the continuous variables.

The model assigns bell times to each school such that a bus can serve multiple schools and hence reduce the number of buses required to pick up and drop off students to and from the schools. The model also focuses to reduce the deadhead time from bus yards to schools and the waiting time at

each school. Doing this would reduce the total service hours of each bus thus reducing costs for schools.

5. Solution Procedure – Homogeneous Fleet

In the homogeneous fleet model, the fleet is homogeneous, which means all buses in the school bus system are the same. Then the problem could be formulated as a MILP model with at most two indexes in main decision variables. The homogeneous model could be solved more efficiently compared to the heterogeneous model which contains three indexes in main variables.

5.1 Mathematical Notations

Sets and Indices:

S: set of schools, $s \in S$

Js: set of routes j for school s, $s \in S$; also, j is the starting node of route j

J: set of routes j

K: set of bell time indices $k \in K$.

A single bus yard exists at node $\{0\}$ which holds all buses. The model can easily be modified to accommodate multiple bus yards and is in the future scope of the paper.

Input Parameters:

r_j : Travel time of route j, $j \in Js$ from its starting node to arrival at school s

t_{sj}: travel time from school s to starting node of route j, $j \in Js$

t_{0j}: travel time from depot to the starting of route j

t_{s0}: travel time from school s to the depot

b_k: school start time for bell time index k, $k \in K$

α: minimum time interval for arrival before a school starts (the value of 15 minutes is used below)

M: a big number

w_{sk}: weight preference of school s, $s \in S$ for bell time $k \in K$

Decision Variables:

$$X_{sj} = \begin{cases} 1, & \text{if route j is served after school s} \\ 0, & \text{otherwise} \end{cases} \quad j \notin J_s$$

$$Z_{sk} = \begin{cases} 1, & \text{if school s, } s \in S \text{ is assigned bell time } k, k \in K \\ 0, & \text{otherwise} \end{cases}$$

$$X_{j0} = \begin{cases} 1, & \text{if route j is served before go back to the bus yard} \\ 0, & \text{otherwise} \end{cases}$$

For the special cases of *s=0* we have,

$$X_{0j} = \begin{cases} 1, & \text{if route j is served as the first route after leaving depot} \\ 0, & \text{otherwise} \end{cases}$$

Auxiliary Variables:

U_j = idle time of the bus after serving route j

5.2 Mathematical Formulation

Objective Functions:

$\text{Min} \sum_{j \in J} X_{0j}$ … (1)

$\text{Min} \sum_{j \in J} t_{0j} X_{0j} + \sum_{s \in S; j \in Js} t_{s0} X_{j0} + \sum_{j \in J} \sum_{s \in S} t_{sj} X_{sj} + \sum_{j \in J} U_j$ …(2)

$\text{Max} \sum_{s \in S} \sum_{k \in K} w_{sk} Z_{sk}$ … (3)

Subject to

$X_{0j} + \sum_{s \in S} X_{sj} = 1, \quad j \in J \backslash j \notin Js \text{ and } s \in S$ …(4)

$\sum_{k \in K} Z_{sk} = 1, s \in S$ …(5)

$\sum_{j \in Js} X_{0j} + \sum_{m \in S} \sum_{j \in Js} X_{mj} = \sum_{j \in J \backslash j \notin Js} X_{sj} + \sum_{j \in Js} X_{j0}, s \in S \backslash s \neq m$ …(6)

$[\sum_{k \in K} b_k Z_{sk} + (t_{sj} + r_j + M)X_{sj} + \alpha - \sum_{k \in K} Z_{mk} \ b_k] \leq M, \quad j \in J \backslash j \notin Js$ and $\{s, m \neq s\}$ …(7)

$[-\sum_{k \in K} b_k Z_{sk} - (t_{sj} + r_j - M)X_{sj} - U_j - \alpha + \sum_{k \in K} Z_{mk} \ b_k] \leq M, \quad j \in J \backslash j \notin Js$ and $\{s, m \neq s\}$ …(8)

$X_{sj} \in \{0,1\}, s \in S$ and $j \in J \setminus j \notin J_s$ …(9)

$X_{jo} \in \{0,1\}, j \in J$ …(10)

$Z_{sk} \in \{0,1\}, s \in S$ and $k \in K$ …(11)

$U_j \geq 0, j \in J$ …(12)

Objective function (1) minimizes the number of buses required to transport the students to and from the schools. Objective function (2) minimizes the dead head time for all buses. This includes deadhead time of a bus after serving a school and going to the beginning of the next route, idle bus time from one school to another and trips from and to the bus yard. Objective function (3) maximizes the preferences of the families for bell times based on the assigned weight. Constraint (4) ensures that every route is served by a bus. Constraint (5) ensures that every school is assigned a bell time. Constraint (6) is a flow balance constraint. It states that if a bus is serving a route of a school then the bus either comes from the bus yard or from another school. Constraint (7) ensures that if a bus serves school m after school s it should have enough time to serve a route of school m and arrive at least α time before the bell time. Constraint (8) is used to compute the idle time. Finally, constraints (9) to (11) declare the binary variables and constraint (12) declares non-negativity on the continuous variables.

6. Experimental Results

The model was tested with available benchmark data provided by Kim et al. [8]. However, their benchmark data were adequate for the bus scheduling problem only, instead of being applicable for the bell time adjustment problem as well. In other words, they made the bell times fixed parameters rather than variables. In order to make the benchmark data suitable for the bell time adjustment problem, some adjustments were made based on their data. First, schools are disjointed with the fixed bell times. Instead, the original bell times in the benchmark data became available bell times to be assigned to each school. Besides, all available bell times are adjusted to be non-overlapping. This was accomplished by partitioning the total time into consecutive small equal length periods, and each period became an available bell time to be selected if there is data plotted into that period. The period length used is 20 minutes, according to the original benchmark data. Figure 4 shows the partition:
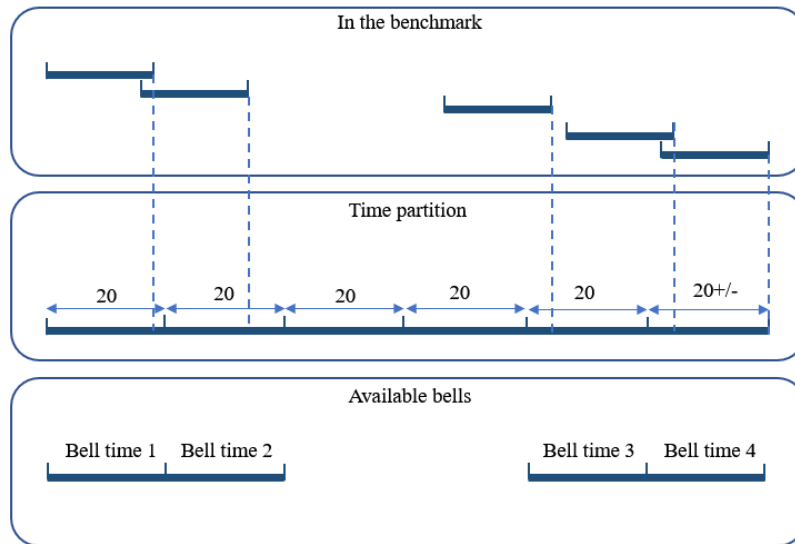
Figure 4. The example of bell time partition for generating available bell times

The multi-criteria model is solved with the weighted sum method, i.e. solving the weighted sum of the objectives as a single objective problem. In this approach, weights are assigned to the objectives with their sum being equal to 1. As the weights are varied, non-dominated solutions are generated. The prototype mixed integer linear programming model was solved using the Gurobi solver. The methods described in this paper were implemented in Python 3.6 and a personal computer running MacOS as operational system with 16 GByte RAM and a 2.5 GHz Dual-Core Intel i7 CPU. As MILP solver, Gurobi 8.0.0 was used.

In Table 2 and 3, computational results are displayed obtained after solving the heterogeneous model and homogeneous model using the heterogeneous fleet benchmark data and the homogeneous fleet benchmark data, respectively. The computational time is measured in seconds. The gap (%) between lower and upper bound is displayed in the last column. After an hour of computation, the solver was forced to stop. Gap equal to "0" means the problem is solved to optimality in the time specified. On the other hand, if the gap is not applicable "N/A", the model cannot find a feasible solution within the one-hour time limit. As the two tables show, both models can be solved by the solver to optimality for medium size problems with up to 10 schools, 60 routes and 3,000 students. As was expected, the homogeneous fleet model could be solved to optimality for slightly larger size problems within the specified one-hour time limit.

Experiment Hetero	School#	Route#	Student#	Time (s)	Gap (%)
hetero_test_1	1	7	335	0.00	0
hetero_test_2	2	13	596	0.00	0
hetero_test_3	3	21	1012	0.15	0
hetero_test_4	4	24	1199	0.62	0
hetero_test_5	5	32	1610	9.53	0
hetero_test_10	10	58	3002	3600	43.4
hetero_test_20	20	120	6012	3600	N/A
hetero_test_30	30	187	9415	3600	N/A
hetero_test_40	40	239	12136	3600	N/A
hetero_test_50	50	286	14352	3600	N/A
hetero_test_60	60	345	17350	3600	N/A
hetero_test_70	70	408	20723	3600	N/A
hetero_test_80	80	469	23686	3600	N/A
hetero_test_90	90	514	25736	3600	N/A
hetero_test_100	100	562	28175	3600	N/A

Table 2. Results for heterogeneous fleet benchmark problems

Experiment Homo	School#	Route#	Student#	Time (s)	Gap (%)
homo_test_1	1	3	143	0.00	0
homo_test_2	2	13	611	0.00	0
homo_test_3	3	20	975	0.01	0
homo_test_4	4	23	1154	0.19	0
homo_test_5	5	29	1448	1.07	0
homo_test_10	10	49	2405	2002.69	0
homo_test_20	20	106	5097	3600	53.8
homo_test_30	30	161	8155	3600	62.3
homo_test_40	40	234	11528	3600	73.4
homo_test_50	50	309	15238	3600	69.5
homo_test_60	60	372	18551	3600	76.3
homo_test_70	70	430	21554	3600	75.2
homo_test_80	80	461	23066	3600	77.4
homo_test_90	90	514	25736	3600	80.1
homo_test_100	100	562	28175	3600	81.3

Table 3. Results for homogeneous fleet benchmark problems

7. Conclusion

In this paper, we provided two models describing the school bell time adjustment and bus routing for both heterogeneous and homogeneous fleet scenarios, given the bus routes information. The models take the preference of bell times into consideration while minimizing the number of buses and service time. The SBRP sub-problems are known to be NP-hard though they can be solved directly by solvers for medium size datasets. For larger size datasets, heuristic approaches can be applied to find good solutions in a reasonable amount of time.

Future research directions include proper heuristic design to improve the efficiency of search for the upper bounds, and decomposition and relaxation methods to provide lower bounds. In addition, mixed loads policy would be helpful in the complex transportation network system to save costs.

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TWO-DIMENSIONAL RANDOM POINTS MAY NOT BE HOMOGENEOUS

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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 compare two methods of sampling by simulations. The simulation results and statistical analyses show that randomness in picking points does not warrant a uniform distribution of those points. We should be alerted that 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 needed in an 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, if we randomly pick families on the randomly selected streets, for example, 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? Does randomness warrant uniformity and homogeneity? If not, what kind of methods are valid, and what kind of methods are not valid?

In this article, we examine two methods of randomly generating points. We do computer simulations on a circle. A circle represents the two-dimensional area, since if a method does not generate uniformly distributed points in the 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 in each method, and carry out statistical analyses on the uniformness of the generated points.

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 points 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], and 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 T.

For a two-dimensional area, uniformness or homogeneousness of the points is defined statistically. Let *S* denote a two-dimensional area. 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.

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 tiny square *q* which is smaller than the area S. If the points in S are homogeneously distributed, then number of points in every *q* in S would be same or similar no matter where *q* is.

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 20 by 20, which is put at various places 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, no matter where q is.

3. METHODS FOR RANDOMLY GENERATING POINTS IN AREA S

Among many methods of generating random points in the area within circle S, the two methods we will examine 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 $-100 \leq x \leq 100$, and randomly pick y such that $-100 \leq y \leq 100$.

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

The simulations are carried out in EXCEL Spreadsheets. Hundreds of thousands of points are randomly generated in circle S by either of the above methods. We count numbers of points in the small square q placed at different places 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 ratio 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 the benchmark 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 no matter where *q* is. 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	X²+Y²=r²		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

The above tables have showed the following results of simulations and statistical analysis:

- 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 Method 1 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 Method 2 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. Randomness in the one-dimensional space guarantees homogeneousness. But in the two-dimensional space, randomness doesn't warrant homogeneousness.

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 homogeneous. 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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Service and Healthcare Management - Abstracts

A Socio-Technical Analysis of Access to Mental Health Services by Older Adults in Rural Communities

Service and Healthcare Management

Dr . Rhoda Joseph [1]

1. *Pennsylvania State University Harrisburg*

Rural communities, particularly older adults, have inadequate access to mental health services. The U.S. geriatric population is expected reach 72 million by 2030 (CDC, 2013). Given the historic slow growth in the number of geriatric psychiatrists since 1990, there will be a continued lack of qualified professionals available to older adults. This problem will be particularly pronounced in rural communities. In older adults, mood disorders such as depression, dementia, late onset bipolar disorder, and late onset schizophrenia are the most common mental illnesses (AAGP, 2015). This study uses secondary data to examine barriers and solutions to access mental health services.

Accountable Care Organizations and Hospital Performance

Service and Healthcare Management

Dr . C. Christopher Lee [1], *Dr . Heechang Shin* [2]

1. *Central Connecticut State University ,* **2.** *Iona College*

This study explored the impacts of accountable care organizations (ACO) on hospital performance. We proposed profitability, efficiency, and quality variables to measure hospital performance. We hypothesized hospitals participating in ACO were higher than non-ACO hospitals in terms of the three performance variables. Operating margin, ROA, and ROE measured profitability. Capacity productivity and manpower productivity measured efficiency. Hospital overall ratings, patient experience ratings, readmission rates, and serious complications measured quality. We collected data from the 2017 AHA hospital survey data for profitability and efficiency variables, and the 2017 Medicare data for the quality variables. Evidence showed mixed results on three hypotheses.

ASSOCIATION BETWEEN PHYSICIAN PRESCRIBING BEHAVIOR AND PHARMACEUTICAL COMPANY PAYMENTS

Service and Healthcare Management

Prof . Janice Winch [1]

1. Pace University

The Sunshine Act of 2010 established the Open Payments database that reveals the pharmaceutical industry's payments to physicians. These payments data and the Medicare part D prescription data are housed at Centers for Medicare and Medicaid Services (CMS) website. A longitudinal study of these two databases shows that the percent of physicians receiving industry payments has decreased over the years since the implementation of the Sunshine Act. This paper also shows the association between payments and the prescription of the paying manufacturer's drugs.

Blockchain In Healthcare: How Smart Contracts Can Change Prescriptions

Service and Healthcare Management

Prof . Afrooz Moatari-Kazerouni [1]

1. *University of Lethbridge*

Healthcare sector is lagging behind when it comes to adopting with technology advancements. Blockchain being one of the current leading technologies, within this research, the blockchain technology is examined in the context of smart contracts for replacing paper prescriptions. The idea of utilizing blockchain for allowing doctors, clinics and patients to create smart contracts for simpler transactions is explored. The current method of organizing data is inefficient to what could be potentially resolved by implementation of blockchain technology. The solution of blockchain could prevent medical mistakes and misplacements of healthcare data within the current system.

Coordinating care in inpatient units using buffer management

Service and Healthcare Management

Dr . Danilo Sirias [1]

1. *Saginaw Valley State University*

Silo thinking is a major challenge when managing inpatient units. People tend to focus on their own departmental tasks, at the micro-level, because they do not have the right tools to consider the impact on patient flow at the macro level. A suggested strategy to improve coordination and reduce the negative impact of organization silos is Buffer Management (BM), a tool from the Theory of Constraints (TOC). A case study of a Neonatal Intensive Care Unit (NICU) will be presented to illustrate the use of BM to reduce length of stay and decrease costs.

Daily Food Selection for a Healthier Generation - A Linear-Programming Optimization Model

Service and Healthcare Management

Dr . Chin-Yen Alice Liu [1]

1. Texas A&M University-San Antonio

There is an increasing evidence of the critical role of nutrition in overall health, which is encouraging many individuals to think of a healthy diet as a priority. However, eating a healthy diet can be difficult to incorporate into everyone's daily life especially under the cost constraints. In this study, we use the Linear Programming (LP) model to help individuals choose foods they prefer to eat while still meeting their nutritional goals and satisfying different tastes, which can encourage them more likely to stick with such a diet plan and increase the likelihood of a successful outcome.

Effect of Rotation on Factor Analysis for Parenting Stress in Japanese Working Mothers

Service and Healthcare Management

Ms . Michika Kato [1] **_, Prof . Tetsuo Yamada_** [1] **_, Dr . Eri Ohto-Fujita_** [2] **_, Prof . Seiko Taki_** [3]

1. _The University of Electro-Communications_ , **2.** _Tokyo University of Agriculture and Technology_ , **3.** _Chiba Institute of Technology_

Recently, concern about parenting stress factors in working mothers is increasing because of the causes of decreasing birth rate in Japan. However, detecting parenting stress would be complicated because it might be related to unconscious factors. Therefore, factor analysis and cluster analysis were adopted for detecting ten potential stress factors and propose to obtain practical solutions for Japanese working mothers (Kato et al., 2019). However, the factor analysis was implemented without rotation. This research aims to analyze the effect of rotation on factor analysis for parenting stress in Japanese working mothers.

Personalized Treatment for Breast Cancer Patients: Evaluating Performances of Machine Learning Methods

Service and Healthcare Management

Ms . Melike Hazal Can [1], *Dr . Ibrahim Zeid* [1], *Dr . Sagar Kamarthi* [1], *Dr . Stephen Agboola* [2], *Dr . Kamal Jethwani* [2], *Dr . Ramya Palacholla* [3]

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Breast cancer is the most common cancer diagnosed among women worldwide. In this study, we investigated machine learning methods to formulate a model that accurately predicts the response to a given neoadjuvant chemotherapy for breast cancer patients, while considering the individual variability in baseline patient and tumor characteristics. We evaluated model performances in predicting tumor response to a given treatment regimen by several calibration measures. These algorithms can address the challenges posed by patient heterogeneity, and assist clinicians in personalizing treatment plans. We aim to enhance the clinical decision making processes to find the best treatment for breast cancer patients.

Service Supply Chain Capacity Planning using a Python-Coded Decision-Support System with Simulation-Based Optimization

Service and Healthcare Management

Dr . Canan Corlu [1], Prof . John Maleyeff [1], Ms . Chenshu Yang [1], Ms . Tianhuai Ma [1], Ms . Yanting Shen [1]

1. *Boston University*

Computer scientists determine network capacities by calculating the "knee" of the hockey stick function found in all queuing systems. The knee is the optimal server utilization found visually as the point on the waiting time versus service utilization function just before its slope increases disproportionately. A simulation was developed using Python code that mimics a service facility. It shows that the knee will vary based on arrival types, service variation, and number of servers. It is embedded in a decision support system that tells users both the number of servers and the service time needed to operate at the knee.

Spatiotemporal Urban Ambulance Pre-assignment Problem

Service and Healthcare Management

Dr . EunSu Lee [1], **_Ms . Natalia De La Fuente_** [1], **_Dr . Melanie McDonald_** [1]

1. _New Jersey City University_

Pre-assignment is one of the typical operational strategies for an ambulance in service for quick response to a call. By doing so, the ambulance can be assigned in advance for a call to a predicted area in order to avoid traffic congestion depending on the frequency and type of calls. This study proposed a model minimizing total annual travel time from ambulance stations to incidents while considering historical call volume. The propositioned model can accomplish noteworthy results of coverage compared to the classic used of ambulance stations. It will be beneficial especially in where the most vulnerable population resides.

Substance Use Disorder Outcome Predictions for Decision Support: A Holistic Data Analytics Approach

Service and Healthcare Management

__Mr . Murtaza Nasir__ [1]*, Dr . Nichalin Summerfield* [1]*, Dr . Margaret Knight* [1]*, Dr . Asil Oztekin* [1]

1. *University of Massachusetts Lowell*

Substance use disorder treatment has been an increasingly important issue in the last few decades, and with the recent opioid epidemic, it is getting more critical to better understand and tackle the problem. Each day, 130 people in the US die due to complications from substance use. In this work, we propose a novel data analytics approach to devise decision support tools for care providers using machine-learning models. Using the models, we also highlight potentially important factors and their dynamic relationships for the various outcomes. We also show that our model can provide useful information to augment decision making processes.

THE IMPACT OF HOSPITAL READMISSION REDUCTION PROGRAM ON REDUCING THE READMISSION RATES: A DATA ANALYSIS APPROACH USING PATIENT AND HOSPITAL SPECIFIC FACTORS

Service and Healthcare Management

Dr . Fatma Pakdil [1] _, Prof . Steve Muchiri_ [1] _, Prof . Nasibeh Azadeh-Fard_ [2]

1. *Eastern Connecticut State University ,* **2.** *Rochester Institute of Technology*

This study aims to analyze the impact of Hospital Readmission Reduction Program (HRRP) on the nationwide optimization efforts of LOS and readmission rate using the Nationwide Readmission Database (NRD) between 2010 and 2016 provided in the Healthcare Cost and Utilization Project (HCUP) by the Agency for Healthcare Research and Quality (AHRQ). The trend of readmission rates has been declining after the establishment of HRRP in 2012. Our analysis based on specific variables show that the reduction rate of readmission rates vary for patients with different age groups, gender, length of stay, insurance type, hospital location and teaching status.

Service and Healthcare Management - Papers

ASSOCIATION BETWEEN PHYSICIAN PRESCRIBING BEHAVIOR AND PHARMACEUTICAL COMPANY PAYMENTS

Janice K. Winch

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Abstract

The Sunshine Act of 2010 established the Open Payments database that reveals the pharmaceutical industry's payments to physicians. These payments data and the Medicare part D prescription data are housed at Centers for Medicare and Medicaid Services (CMS) website. A longitudinal study of these two databases shows that the percent of physicians receiving industry payments has decreased over the years since the implementation of the Sunshine Act. This paper also shows the association between payments and the prescription of the paying manufacturer's drugs.

Keywords: Drug industry, Sunshine Act, Open Payments, Prescribing behavior

Introduction

The Physician Payments Sunshine Act provision from the Affordable Care Act of 2010 requires pharmaceutical, biologic and medical device manufacturers to report payments that were made to physicians and teaching hospitals. The purpose of the Act was to illuminate potential conflicts of interest when physicians accept payments that are used for promoting the company products. The Act requires the manufacturers to report payments of at least $10 or at least $100 per year made to an individual or a teaching hospital. Called *Open Payments*, these payment data were made available to the public on the Centers for Medicare and Medicaid Services (CMS) website starting with August of 2013. At the time of writing, the most recent year of the available data was 2018.

Since the advent of Open Payments, numerous studies have used the data to characterize the payments to physicians in various specialties: emergency physicians (Fleischman, Ross, Melnick, & Venkatesh, 2016), urologists (Maruf et al., 2018), cardiothoracic surgeons (Ahmed et al., 2017), and otolaryngologists (Morse, Fujiwara, & Mehra, 2018).

Several studies have examined the association between payments and physician prescribing behavior. Using 2013 Open Payments data and Medicare Part D Prescriber data, DeJong et al. (2016) found the association between the number of days of meal payments promoting four drugs and the prescription rate of the promoted drugs relative to alternatives. Ornstein, Tigas, & Jones (2016) and Jones & Ornstein (2016) focused on five common medical specialties, establishing a positive association between the payment amount received from companies promoting the most-prescribed brands of drugs and the prescribing rate of those drugs, and also finding that speaking payment recipients prescribed brand name drugs at a higher rate than those receiving other types of payment. Sharma, Vadhariya, Johnson, Marcum, & Homes (2018) compared the prescription of six expensive new drugs relative to less expensive alternatives between the physicians who received payments targeting those drugs versus those who did not. The result was a significant association for the three out of the six drugs examined. All these studies were cross sectional studies, using the payment data and the prescription data from the same year.

Association between payment and prescription spanning more than a year was addressed in Winch & Carter (2018). This study examined payments by two large pharmaceutical manufacturers, AstraZeneca and Pfizer in 2015 and observed that the physicians who received drug-related payments in 2015 prescribed more of the payer's drugs in 2016 and that those who received non-food payments prescribed more than those who received only food payments. In this paper, we extend the study to many more manufacturers and to years spanning 2014 – 2017. We examine the top eighteen payers to detect an association in the prescription level of the manufacturer's drugs based on the types of payments physicians received from the manufacturer. This is done for each possible pair of the payment year and the prescription year out of the four years. The research question is: Is there an association between the payments received and prescribing behavior across the years?

In the next section, we describe the data sets and data processing methods. This will be followed by the Results and the Summary sections.

Methods

Data

The study used the following publicly available databases from CMS: Medicare Part D Prescriber Data from 2014 to 2017 and Open Payment database from 2014 to 2017 (CMS, 2019a, CMS, 2019b). The years of 2014-2017 were the only years in which completed and updated data were available for both Open Payments and Medicare Part D Prescriptions.

From Medicare Part D Prescriber Data, the data used were the detailed data sets that provided the quantity and the dollar amount of prescription for each doctor-drug pair each year. The unit of observation was the doctor-drug pair. The doctors were identified by their National Provider Identifier (NPI), name, specialty, and the address. The number of rows dedicated to each doctor was the number of distinct drugs the doctor prescribed to Medicare Part D beneficiaries in the year. The doctor-drug pair with fewer than 11 claims were not included in the detailed data sets.

The Open Payment data used were General Payments data which listed manufacturers' payments to teaching hospitals and healthcare providers. It consisted of payments that were not related to medical research. The unit of observation was the payment. The physician recipients were identified by their Profile ID's. It categorized the nature of each payment and the drugs and medical devices to which the payments are related. For each payment, manufacturers were required to identify the recipient of the payment, the drug or device that the payment pertains to, and the category of payment. There were fourteen available categories: (1) charitable contribution, (2) compensation for services other than consulting, including serving as faculty or as speaker at event other than continuing education program, (3) compensation for serving as a speaker for accredited continuing education program, (4) compensation for serving as a speaker for a non-accredited continuing education program, (5) consulting fee, (6) ownership or investment interest, (7) education, (8) entertainment, (9) food and beverage, (10) gift, (11) grant, (12) honoraria, (13) royalty or license, and (14) travel and lodging.

Study Population

The study population was limited to healthcare providers who were categorized as a doctor of medicine or osteopathy (MD's or DO's) with practice locations in the United States. In addition, since we used Medicare Part D Prescriber Data for the prescribing behavior of physicians, we

limited the study to the doctors who appeared in the Medicare Part D data in years 2014, 2015, 2016, and 2017. There were 421,796 such physicians. Since Medicare Part D data used NPI's and Open Payments data used Physician Profile ID's, we matched the NPI's and Profile ID's based on the physician's full name, practice location address, and specialty.

Payments

We included only the payments that were for physicians and pertained to drugs, not those that pertained to devices or supplies. The number of payments and the payment amounts were very skewed, and fewer than half of the physicians received any payment. Food and beverage payments accounted for over 90% of the number of payments, but about 25% of the total payment amount. Because of these data characteristics, we chose to characterize the physicians by the type of payments received instead of the number or the amount of payments received. Specifically, for a given manufacturer and year, we classified the physicians into the following three groups:

1. no-pay group: physicians who did not receive any drug-related payments from the manufacturer,

2. food-only group: physicians who received only payments categorized as food and drinks, and

3. other-pay group: physicians who received payments in categories other than food and drinks, possibly in addition to food and drinks.

Prescriptions

In the Medicare Part D detailed data, the quantity of prescription was given in terms of the number of claims, 30-day fill counts, days of supply, and drug cost. We used 30-day fill counts for the prescription count.

Manufacturers

To study the relationship between payments of pharmaceutical companies and the prescription of the payer's drugs, the drug prescription data in Medicare Part D prescriptions needed to be matched to the manufacturers. Medicare Part D data did not list the manufacturers of the prescribed drug. The sources used to identify the manufacturer of each drug included the National Drug Code

Directory, the manufacturers listed in the Open Payments data, and information from the manufacturers' web pages.

The manufacturers of drugs were not always well-defined because some drugs were jointly marketed by two or more companies. In such cases, we chose to attach to the drug the company that made more payments for the drug. In addition, payments related to some drugs were reported sometimes under a subsidiary and sometimes under a parent company. For example, Genzyme is a subsidiary of Sanofi-Aventis, but for the same drug, sometimes Genzyme is listed and sometimes Sanofi-Aventis is listed. We chose to attach the parent company in such cases.

We chose to analyze the prescription and the payment data for each manufacturer separately to see if consistent patterns appear. There are over 400 manufacturers that reported drug-related payments each year, but a small percent of these manufacturers made a bulk of the payments. Out of these manufacturers, we identified top eighteen payers whose cumulative payments to physicians comprised over 50% of the total industry payments in 2017. Specifically, the manufacturers were sorted based on the total drug-related payment amounts paid to physicians in 2017. The chosen manufacturers were in the top 20 in both the total payment amounts and the number of payments. The total payment amount of these manufacturers was $487 million, 62% of the overall total of $790 million.

For each manufacturer, we created a separate data set joining the payments and the prescription for each year for each physician. Data processing and analyses were conducted using R and Microsoft Excel.

Results

First, Figure 1 shows the general trend in the percent of physicians who received industry payments. The percent of doctors who received any payment decreased from 46.8% to 41.8% from 2014 to 2017. The percent of doctors who received food payments was steady over the years, but the percent of doctors who received other payments decreased from 17.7% to 11.5% from 2014 to 2017.

The type of payments received could be associated with future prescribing behavior, perhaps activities associated with the payment increasing prescription of the related drugs. In Winch & Carter (2018), we saw the prescription level in 2016 was associated with the type of payment group (no-pay, food-only, or other-pay) in 2015 for two pharmaceutical companies. But

the association could be shown in reverse chronological direction, perhaps activities associated with the payment in 2015, such as a speaking engagement, being followed by higher prescription in 2016. Hence, for each year's payment activities, we want to study the prescribing behavior in both the past and future as far as allowed by the available data.

Figure 1: Percent of physicians receiving industry payments from 2014 to 2017.
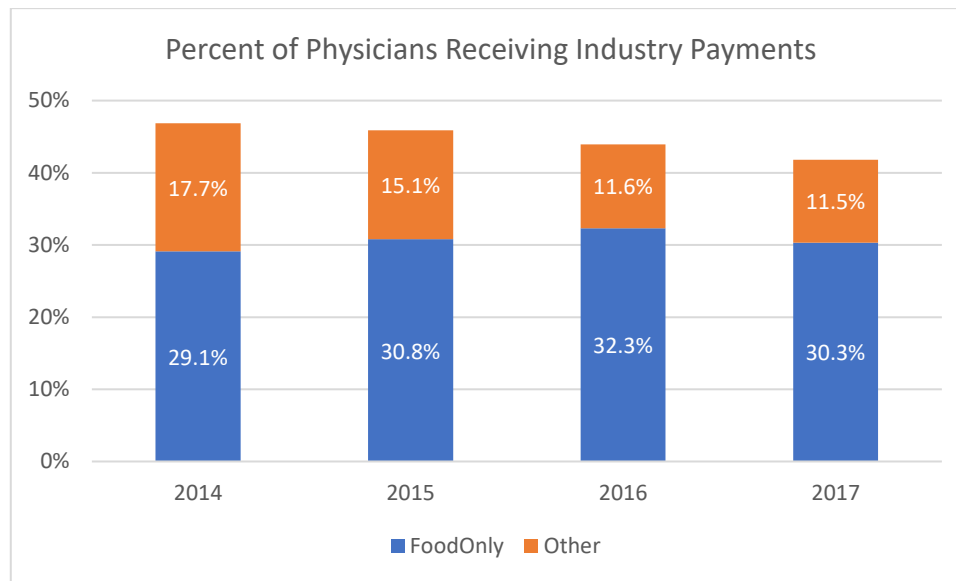
For each of the 18 selected manufacturers, we computed the following. For each physician and for each of the four years, 2014 – 2017, we classified the physician into one of the three payment groups based on the payments received from the manufacturer and computed the amount of that manufacturer's drugs (measured in 30-day supplies) the physician prescribed to the Medicare Part D beneficiaries.

For each pair of years (s, t) where s = 2014, 2015, 2016, 2017 and t = 2014, 2015, 2016, 2017, we computed the median prescription level of given manufacturer's drug in year t for each payment group in year s. In addition, we computed the percent of physicians in each payment group who had at least one prescription from the manufacturer. We hypothesized that the prevalent pattern will be that the median prescription level and the % of prescribers will be lowest for the no-pay group and the highest for the other-pay group.

For a given manufacturer, we will use the following notation to describe the results:

$P_N(s,t) =$ Percent of physicians in the no-pay group in year s that prescribed at least one 30-day supply of the manufacturer's drug in year t,

$P_F(s,t) =$ Percent of physicians in the food-only group in year s that prescribed at least one 30-day supply of the manufacturer's drug in year t,

$P_O(s,t) =$ Percent of physicians in the other-pay group in year s that prescribed at least one 30-day supply of the manufacturer's drug in year t,

$M_N(s,t) =$ median count of the manufacturer's drugs prescribed in year t by physicians in the no-pay group in year s,

$M_F(s,t) =$ median count of the manufacturer's drugs prescribed in year t by physicians in the food-only group in year s,

$M_O(s,t) =$ median count of the manufacturer's drugs prescribed in year t by physicians in the other-pay group in year s.

For illustration, Table 1 shows the result for AbbVie. For example,

$$P_N(2014,2014) = 21.4\%, \; P_F(2014,2014) = 59.7\%, \; \text{and } P_O(2014,2014) = 73.8\%$$

$$M_N(2014,2014) = 0.0, \; M_F(2014,2014) = 26.0, \; \text{and} < M_O(2014,2014) = 49.0.$$

Notice both the % of prescribers of AbbVie drugs and the median prescription level of AbbVie drugs increase with the payment group, from no-pay to food-only to other-pay, for every pair of payment year s and prescription year t. In general, the pattern is

$$P_N(s,t) < P_F(s,t) < P_O(s,t) \tag{1}$$

$$0 = M_N(s,t) < M_F(s,t) < M_O(s,t) \tag{2}$$

for every pair, s and t. Thus, there was an association between payments and the prescription in both directions, both past and future payments being associated with any given year's prescriptions.

Table 1: Prescription of AbbVie drugs based on payment groups.

Payment Year (s)	Payments Received	Count of Physicians	Percent of AbbVie Prescribers in Year (t)				Median Count of AbbVie Prescription in Year (t)			
			2014	2015	2016	2017	2014	2015	2016	2017
2014	No Pay	380,817	21.4%	20.8%	20.6%	20.2%	0.0	0.0	0.0	0.0
	Food Only	38,739	59.7%	59.5%	59.1%	58.1%	26.0	25.2	24.0	24.0
	Other	2,240	73.8%	73.3%	74.6%	75.5%	49.0	50.9	51.0	51.2
2015	No Pay	381,871	21.9%	21.2%	20.9%	20.5%	0.0	0.0	0.0	0.0
	Food Only	37,353	56.3%	56.6%	57.1%	56.6%	19.0	19.0	20.0	19.7
	Other	2,572	59.7%	62.1%	62.8%	62.2%	21.0	23.0	24.0	23.0
2016	No Pay	384,414	22.5%	21.8%	21.4%	21.0%	0.0	0.0	0.0	0.0
	Food Only	35,703	52.3%	52.7%	54.1%	54.3%	13.0	13.0	14.0	15.0
	Other	1,679	60.6%	63.0%	64.7%	65.6%	21.0	24.0	26.0	25.0
2017	No Pay	385,545	22.8%	22.1%	21.7%	21.2%	0.0	0.0	0.0	0.0
	Food Only	34,664	50.4%	50.9%	52.3%	53.3%	11.0	11.0	12.0	13.0
	Other	1,587	61.5%	63.3%	65.3%	66.1%	23.0	25.8	29.0	30.0

Table 2 summarizes the result for all the 18 manufacturers examined. The pattern in (1) was found in most of the other manufacturers. However, the pattern in (2) was not so prevalent in other manufacturers. Only six of the other 17 manufacturers showed this pattern in all or most of the (s, t) pairs. This was because the median prescription count was frequently 0 in two or more payment groups. The other patterns that were observed are shown in (3) and (4).

$$M_N(s,t) = M_F(s,t) = M_O(s,t) = 0 \tag{3}$$

$$0 = M_N(s,t) < M_O(s,t) < M_F(s,t) \tag{4}$$

The median prescription of the no-pay group was always 0. This is true whether the year of the payment was before or after the year of the prescription.

Summary

This paper extends existing research on the association between industry payments by studying the interactions between physicians and a number of manufacturers separately across the years.

Table 2: Prescription of drugs based on payment groups for top payers.

Company	$P_N(s,t) < P_F(s,t) < P_O(s,t)$ for every pair of years?	$0 = M_N(s,t) < M_F(s,t) < M_O(s,t)$ for every pair of years?
AbbVie, Inc.	Yes	Yes
Allergan Inc.	Yes except for 4 pairs where $P_N(s,t) < P_O(s,t) < P_F(s,t)$	Yes except for 6 pairs where $0 = M_N(s,t) < M_O(s,t) < M_F(s,t)$
Amgen Inc.	Yes	$M_N(s,t) = M_F(s,t) = M_O(s,t) = 0$
AstraZeneca Pharmaceuticals LP	Yes except for 3 pairs where $P_N(s,t) < P_O(s,t) < P_F(s,t)$	Yes except for 1 pair, where $0 = M_N(s,t) < M_O(s,t) < M_F(s,t)$
Boehringer Ingelheim Pharmaceuticals, Inc.	Yes	Yes
E.R. Squibb & Sons, L.L.C.	Yes	$M_N(s,t) = M_F(s,t) = M_O(s,t) = 0$ for 7 pairs, $0 = M_N(s,t) \leq M_F(s,t) < M_O(s,t)$ for the rest
Genentech, Inc.	Yes	$M_N(s,t) = M_F(s,t) = M_O(s,t) = 0$
Janssen Pharmaceuticals, Inc	Yes	$0 = M_N(s,t) \leq M_F(s,t) < M_O(s,t)$ for 10 pairs, $0 = M_N(s,t) < M_F(s,t) < M_O(s,t)$ for 6 pairs
Lilly USA, LLC	Yes	$0 = M_N(s,t) = M_F(s,t) < M_O(s,t)$ for all pairs
Merck Sharp & Dohme Corporation	$P_N(s,t) < P_O(s,t) < P_F(s,t)$ for every pair	$0 = M_N(s,t) = M_O(s,t) < M_F(s,t)$ for all pairs
Novartis Pharmaceuticals Corporation	Yes except for 4 pairs where $P_N(s,t) < P_O(s,t) < P_F(s,t)$	$0 = M_N(s,t) \leq M_F(s,t) < M_O(s,t)$ for 13 pairs, $0 = M_N(s,t) < M_O(s,t) < M_F(s,t)$ for 3 pairs
Novo Nordisk Inc.	Yes	Yes
Otsuka Pharmaceutical Co., Ltd.	Yes	$M_N(s,t) = M_F(s,t) = M_O(s,t) = 0$ for 6 pairs, $0 = M_N(s,t) = M_F(s,t) < M_O(s,t)$ for 10 pairs
Pfizer Inc.	Yes except for 2 pairs where $P_N(s,t) < P_O(s,t) < P_F(s,t)$	Yes except for 1 pair where $0 = M_N(s,t) < M_O(s,t) < M_F(s,t)$
Sanofi-Aventis U.S. LLC	$P_F(s,t) \approx P_O(s,t)$ for most pairs	Yes except for 4 pairs where $0 = M_N(s,t) < M_O(s,t) < M_F(s,t)$
Shire Plc	Yes except for 6 pairs where $P_N(s,t) < P_O(s,t) < P_F(s,t)$	$M_N(s,t) = M_F(s,t) = M_O(s,t) = 0$
Sunovion Pharmaceuticals Inc.	Yes	$M_N(s,t) = M_F(s,t) = M_O(s,t) = 0$ for most pairs
Takeda Pharmaceutical Company, Limited	Yes	$0 = M_N(s,t) = M_F(s,t) < M_O(s,t)$ for 11 pairs, $0 = M_N(s,t) < M_F(s,t) < M_O(s,t)$ for 5 pairs

This paper sought to identify prevalent patterns in the association between industry payments and prescription behavior by classifying each physician into payment groups based on receiving no payments, receiving only food payments, and receiving other types of payments. Examining highest-paying manufacturers revealed the prevalent pattern that a higher proportion of physicians who received some payment tend to prescribe the paying manufacturer's drug regardless of the timing of the payment. The positive relationship of prescription to the payments both in the earlier year and the later year suggests that the payments are not strictly antecedents to prescriptions. The prescriptions may sometimes be antecedents to payments.

The limitations of this study include the following. The prescriptions examined in this paper include only the prescriptions to Medicare Part D beneficiaries, so the results apply only to this patient population. In this paper, we compared the prescription of all of the manufacturer's drugs to all of the drug-related payments by the manufacturer. This may have obfuscated some relationships between the specific drugs that were marketed and their prescriptions. In the future, it may be helpful to limit the analysis to the drugs to which the payments were related.

A future study could expand the result to control for other factors such as physician and manufacturer characteristics. The payment and prescription levels can vary significantly based on physician specialty. The manufacturer's drugs that are on the market, their patent status, the status of the competing drugs may all contribute to payment levels and the prescription levels.

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EFFECT OF ROTATION ON FACTOR ANALYSIS FOR PARENTING STRESS IN JAPANESE WORKING MOTHERS

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ABSTRACT

Increasing concern has centered on parenting stress factors in working mothers recently because it is considered one of the causes of decreasing birth rate in Japan. The declining birth rate could be caused by increasing the un-married rate and progress of late marriage. The late or un-marriage could be related to the difficulty in the lack of work-life balance, which is associated with oppressive burden parenting, housework, or responsibility in their workplace. Thus, analyzing the working mother's stress factors could contribute to easing the sharp decreasing birth rate in Japan. However, parenting stress in working mothers would be complicated and intertwined. It is related to changing their lifestyles, and even the change might be unconscious. Therefore, factor analysis and cluster analysis were adopted in our previous research to analyze Japanese working mothers' parenting stress deeply. For further analysis, this research rotated the data of factor analysis. First, the data from surveys that Parenting Stress Index (PSI), which is designed to evaluate the magnitude of stress in the parent-child system, and an original survey were analyzed by factor analysis. Second, the result of factor analysis was rotated by varimax rotation and promax rotation. Five stress factors were defined, and solutions were provided as a result of rotation of the data. Last, it was showed that this statistic procedures enabled us to understand the trend of parenting stress factors and their solutions.

Keywords: Statistic procedure, Parenting Stress Index (PSI), Work-life balance, original survey, sample size

INTRODUCTION

As Japan's extreme birth rate decreases, more research is needed to improve the situation of this Japan. Some research shows that low birth rates are strongly associated with increasing unmarried rates and late marriage progress [1]. It is said that late marriage is based on the Japanese women's challenge and struggle to handle both work and childcare on their own [2]. Reflecting the gender gap in Japan, women tend to feel more parenting stress than men, and this makes it difficult for Japanese women to maintain work-life balance. The "pressure" is not only overt parental pressure such as delivery, eating, disciplining, but also indirect pressure following these life events. This unrealized pressure increases the causes of stress. Both types of stress factors, should be identified in order to provide adequate support for parenting. Consequently, the Parenting Stress Index (PSI) [3] and the methodological method is implemented. Shinohara and Taki [4] conducted a survey based on the Japanese version of PSI and their original survey, evaluating the findings through t-testing and biased analysis. A possibility has been suggested from their research that stress was not only caused by heavy parenting pressure, but also by ordinary and enjoyable everyday events and activities. However, there was a limitation of Shinohara's research, which used t-test and discriminant analysis because the indicator for access the stress was only from standard PSI indicator. In addition, with the development of current statistic procedures, more complicated relationship among invisible factors could be detected. Factor analysis is to summarize the interrelationships among the variable in a concise but accurate manner as an aid in conceptualization [5] and cluster analysis is clustering groups based on similar characteristics [6], [7]. In particular, combining the factor analysis and the cluster analysis is useful statistic procedure. Based on the past research [7], factor analysis and cluster analysis were implemented in our last research [8] and ten stress factors were detected and succeeded in suggesting solutions. Rotation is to minimize the complexity of the factor loadings to make the structure simpler to interpret. In our last research [8], the initial factor analysis data was not rotated. Therefore, the data of factor analysis was rotated for further analysis. This research aims providing indicators to detect stress factors more precisely using PSI and original survey, and data rotation in factor analysis.

METHOD

In this section, the analysis procedure and the steps are described. Similar to our past research [8], this research proposed an analysis method using factor analysis to specify potential stress factors of 28 Japanese full-time or part-time working-mothers. In this study, a free software R was used for factor analysis and the PSI and original surveys which was developed by Shinohara [4] was conducted for

assessment of stress status of Japanese working-mothers. There are two sections in the proposed method. In the first section, the results of Parent Parenting Stress Index (PSI) [3] and original survey were analyzed using factor analysis to detect potential stress factors. Next, the second section is proposing solution. In the first section, there are four steps. The first step is the decision of factor numbers. The second step is calculation of score of factors. The third step is rotation of the date that acquired in the second step. The fourth step is estimation of potential stress factors.

For detecting potential factor more precisely, the result of survey was analyzed with factor analysis. Principal axis factoring (PAF) and maximum likelihood factor analysis (MLFA) are two of the most popular estimation methods in exploratory factor analysis and iterative principal axis factoring which is a type of PAF was adopted in this study. Two methods of rotation were adopted in this study, varimax rotation and promax rotation. Rotation as any of a variety of methods used to further analyze initial principal component analysis (PCA) or exploratory factor analysis (EFA) results with the goal of making the pattern of loadings clearer [9]. Varimax method is an orthogonal rotation method that minimizes the number of variables that have high loadings on each factor. This method simplifies the interpretation of the factors [10]. Promax rotation is an oblique rotation, which allows factors to be correlated. This rotation can be calculated more quickly than a direct oblimin rotation, so it is useful for large datasets. The free software R was used for the analysis [10].

The PSI developed by Abidin [3] in the U.S. and is widely used measure of parenting stress. The PSI is based on a relational concept of stress due to both the stress-provoking characteristics of the child and individual characteristics of parents together with situational/demographic variables related to the parenting role [3]. Japanese version of PSI, which based on original version was used in this research. The Japanese version is consisted of 78 questions with two subscales, which is child subscales and parent subscales and a Total Stress scale. The child subscales are Distractibility/Hyperactivity, Adaptability, Reinforces Parent, Demandingness, Mood, Acceptability and the parent subscales are Competence, Isolation, Attachment, Health, Role Restriction, Spouse/Parenting Partner Relationship (Table 1, 2). In addition, the original survey is 9-item questionnaire and was developed by Shinohara and Taki [4] to specify other potential stress factors, which is not covered by PSI [11]. This research was admitted by the Ethics committee of Chiba Institute of Technology [11]. Through iterative principal axis factoring, five factors were extracted and rotated.

Incidentally, the limitation of this research should be referred. The sample of number is 28 and the amount of PSI and original survey questions is 87. The free software R did not function for factor analysis because it is said that minimum sample size should include from 3 to 20 times the number of variables for

Table 1. Subgroup of a Child Domain in Japanese version PSI and related question numbers

Subscale	Question numbers
C1 Reinforces parents	6, 7, 8, 9, 10, 13, 19, 22
C2 Mood	11, 12, 14, 15, 27, 34, 35
C3 Acceptability	16, 17, 18, 20, 21
C4 Distractibility/Hyperactivity	1, 2, 3, 4, 5
C5 Hang around parents	26, 28, 33, 40, 41
C6 More problems/worries	36, 37, 38, 39
C7 Sensitive to stimuli	29, 30, 31, 32

Table 2. Subgroup of Parent Domain in Japanese version PSI and related question numbers

Subscale	Question numbers
P1 Role restriction	51, 52, 53, 54, 55, 56, 57
P2 Isolation	69, 70, 71, 72, 73, 74, 77
P3 Spouse	64, 65, 66, 67, 68
P4 Competence	24, 25, 42, 43, 45, 46, 47
P5 Depression	58, 59, 60, 61
P6 Sad/uneasy feeling after leaving hospital	23, 44, 62, 63
P7 Attachment	48, 49, 50
P8 Health	75, 76, 78

conducting factor analyses [12]. Therefore, the variables, which is the number of questionnaires should be reduced. PSI has 78 questions with two subscales which are child domain and parent domain, and one question was picked randomly from each subgroup. Combining these picked questions with the nine questions of original survey, this research was succeeded in acquiring the results of factor analysis.

RESULTS

In this section, the results of data analysis using factor analysis and rotation are described. Table 3 shows the parenting stress in Japanese working mothers with varimax and promax rotation and the factor loadings of 24 selected survey items. Items are referred to with abbreviated labels because of copyright restrictions. Before rotation, five factors were extracted, which accounted for 50.23% of the total variance. Variables with patterned weights less than 0.40 were excluded to facilitate interpretation of the factors because higher factor loading indicate that a valuable is closely associated with the factor. The initial solution results in correlations of a variable with several factors or in a variable that has no strong correlations with any of the factors (Table 3). After rotation, the loadings are rescaled back to the proper size so that we could acquire clearer results. For example, the highest factor loading is 0.507 in factor 2 in the first solution. On the contrary, the highest factor loading was 0.908 after varimax rotation and 0.996 after promax rotation respectively. Moreover, the trend of factor loadings was similar between varimax and promax. However, the highest factor loading in factor 5 was 0.739 after varimax and 0.372 after promax so that the results of varimax rotation was adopted for providing explanation in this research because of this clearer factor value.

The final factors were identified after varimax rotation and it shows parenting stress is caused by 1) Feeling lack of affection towards children, 2) Uncontrollable time management because of her child or husband, 3) Parent's poor health condition, 4) Less opportunity spending time as a family, 5) Frustration

by comparing with other children. Each factor relates to different category and it could contribute to define potential stress factors for parenting by varimax rotation.

DISCUSSIONS

This section discusses the result of varimax rotation and promax rotation. The first factor, *Feeling lack of affection towards children*, consisted of six items, which are Q1, 48, 58 in PSI and Q 80, 81, 87 in original survey. These questions in PSI showed parent's negative feeling toward their children. In addition, it appeared that the feeling is based on financial anxiety by Q80 in original survey.

From these results, it was found that the lack of affection does not mean that the mother dislikes or hates their child. Some mothers feel guilty at the same time and others have anxiety for cost of childcare. The motherhood myth still persists in Japan [13] and Japanese people believe that affection toward child comes naturally and the myth make mothers suffer. To improve the situation, women should know before or just right after delivery that the affection is disturbed by various factors and it is natural for all women.

The second factor, *Uncontrollable time management because of her child or husband*, is consisted of four items, Q 6, 26, 51 and 64 in PSI. The highest factor loading is 0.908 in Q26. The question shows that the mother spares her time for her child who needs more time to learn something than other children. Other questions also support the concept because Q51 shows that the mother devotes her time and Q64 shows enough support is not provided by her husband. Thus, the second factor could be defined related to time management.

To improve the situation, time management skill could be required, or schedule and scheduling [14] should be reconsidered. It is just the same as the workplace. Working mothers cannot work like before delivery.

The third factor, *Parent's poor health condition*, is consisted of three items, Q 24, 69 and 75 in PSI. The highest factor loading of Q75 is 0.752 and it shows the poor health condition recent a half year. Q24 shows lack of confidence as a mother, and Q69 shows feeling of loneliness. Poor health condition could accelerate the negative feeling.

The first solution for the third stress factor is receiving medical treatment immediately and it should be prioritized. Mental and physical health is fundamentally linked [15], so feeling loneliness would be improved simultaneously.

Table 3. Result of Parenting Stress in Japanese Working Mothers with Varimax and Promax

Sub group #	Question #	Items	Initial solution					Varimax					Promax				
			Factor1	Factor2	Factor3	Factor4	Factor5	Factor1	Factor2	Factor3	Factor4	Factor5	Factor1	Factor2	Factor3	Factor4	Factor5
Child Domain																	
C1	Q6	Rarely make parent feel good	0.258	-0.142		0.305			0.407			0.106		0.444		-0.118	
C2	Q11	Child's screaming	0.341	0.507	-0.239	0.279	0.255	0.360	0.157		0.588	0.268	0.238	0.241	0.554	-0.137	0.238
C3	Q16	Chid is different from other children	0.341	0.112	0.124	-0.129	0.634					0.739					0.750
C4	Q1	Hyper child	0.267	0.313			-0.301	0.470			0.100	-0.166	0.471	0.116			-0.223
C5	Q26	Learn slow	0.757			0.649		0.268	0.908		0.279	0.140	0.152	0.996	0.263	-0.176	
C6	Q36	Health problem	0.382	-0.131	0.478		0.255		0.345	0.348	-0.199	0.422		0.207	-0.213	0.338	0.372
C7	Q29	Annoyed parent with simple things	0.326	0.449	0.169	0.117	0.138	0.344	0.119	0.300	0.290	0.250	0.243		0.275	0.263	0.184
Parent Domain																	
P1	Q51	Devote parent's time	0.601		0.334	0.351	-0.274	0.264	0.711	0.295	-0.118		0.218	0.683	-0.111	0.199	-0.162
P2	Q69	Feel alone	0.309	0.338	0.560	0.123	0.271	0.154	0.181	0.608	0.139	0.408			0.145	0.609	0.322
P3	Q64	Less support by husband	0.341	-0.433	0.494	0.476	-0.105	-0.230	0.757	0.332	-0.224		-0.285	0.703	-0.177	0.269	
P4	Q24	I feel that I am very good/not very good at being a parent.	0.179	0.480	0.388	0.145	-0.370	0.406	0.113	0.566	0.140	-0.231	0.343		0.179	0.557	-0.350
P5	Q58	Feel guilty as a parent	0.628	0.326	0.172	-0.143		0.600	0.201	0.218		0.318	0.570	0.121	-0.101	0.170	0.240
P6	Q23	Lack of confidence as a parent	0.205	0.236	0.264	0.227	0.367		0.179	0.310	0.277	0.386	-0.116	0.124	0.279	0.287	0.346
P7	Q48	Take a time having warmth feeling as a parent	0.562	0.549	-0.160		-0.314	0.814	0.164		0.215		0.795	0.212	0.164		-0.152
P8	Q75	Health issue recent six months	0.204	0.207	0.752				0.159	0.752		0.218				0.788	0.118
Original Survey																	
	Q79	Suffering from sleep deprivation	0.243		0.344	-0.178	-0.209	0.186	0.128	0.267	-0.370		0.226		-0.379	0.282	
	Q80	Childcare costs more than I expected	0.688			-0.722		0.674		-0.136	-0.567	0.447	0.792	-0.168	-0.702	-0.142	0.432
	Q81	I get stressed out with parenting	0.430	0.481	0.333	-0.341	-0.209	0.679		0.432	-0.141	0.120	0.682	-0.204	-0.183	0.445	
	Q82	Feeling stress in working	0.260	-0.227	0.197		-0.101		0.311		-0.251				0.266	-0.256	
	Q83	Feeling stress spending whole day at home	-0.375	0.277	0.245			-0.170	-0.300	0.349	0.209		-0.230	-0.348	0.262	0.419	
	Q84	Often going out as a family	0.196	-0.582	0.262	-0.229		-0.183	0.216		-0.620	0.185	-0.101	0.102	-0.646		0.195
	Q85	There is my parents' or parents-in-law's house near my home		0.482		0.243	0.361			0.147	0.578	0.242			0.587	0.131	0.235
	Q86	Having relationship with local community		0.158		0.221			0.137		0.241			0.179	0.250		
	Q87	Having dinner as a family	-0.222	-0.398	0.168	0.229		-0.467	0.178		-0.132	-0.140	-0.468	0.176			-0.127

The fourth factor, *Less opportunity spending time as a family*, is consisted of three items, Q11 in PSI, and Q84 and 85 in original survey. The factor loading of Q84 is -0.620 and it is negative but highest impact. It means there is a less opportunity to go out as a family. Q11 shows one of the reasons which is hardness of handling her child. It could make parent hesitate to go out. Q85 indicates another reason is the existence of parents or parents-in-low's home. Support from grandfathers or grandmothers is helpful for mothers, and the support could deprive opportunity spending time as a family, however it could create new stressful situation.

To improve the situation of less opportunity spending time as a family, the first step is not considered communication as a special event. Even short conversation would bring better relationship in a family [16].

The fifth factor, *Frustration by comparing with other children,* is related Q16, 36 in PSI. The highest factor loading is 0.739 in Q36 and it shows Mother who feels that her child is different from other children could be frustrated. Also, Q16 shows poor child's health condition. As mentioned in the third factor, the stress situation could be more complicated when the issue combines to health issue.

Avoiding comparing your child with other children would reduce parenting stress. However, it is uneasy because people tend to compare with other people when they are in depressed feeling [17]. Receiving medical treatment for their child could be effective if a child has a health issue.

SUMMARY AND FUTURE WORKS

In this study, five potential stress factors and its solution were acquired through factor analysis and rotated the data. It is found that two out of five factors are linked between PSI and original questions. Based on our last research [8], some solutions were suggested for improving stressful situation. This research is also succeeded in suggesting solutions and showing the role of original survey. By developing more variable questions in original survey for further areas of study for future research on parenting stress of working mothers, more detailed suggestion could be expected.

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SPATIOTEMPORAL URBAN AMBULANCE PRE-ASSIGNMENT PROBLEM

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Abstract

Pre-assignment is one of the typical operational strategies for an ambulance in service for quick response to a call. By doing so, the ambulance can be assigned in advance for a call to a predicted area in order to avoid traffic congestion depending on the frequency and type of calls. This study proposed a model minimizing total annual travel time from ambulance stations to incidents while considering historical call volume. The propositioned model can accomplish noteworthy results of coverage compared to the classic used of ambulance stations. It will be beneficial especially in where the most vulnerable population resides.

Keywords: Ambulance Service, Public Health, Pre-assignment, Spatial Analysis

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SPATIOTEMPORAL URBAN AMBULANCE PRE-ASSIGNMENT PROBLEM

Introduction

In New Jersey counties, an ambulance has an average of 13 minutes to reach the scene of an emergency. In fact, no county in the Garden State averages a response time less than 9 minutes, according to the September 2019 report from the NJ Department of Health and Office of Emergency Medical Services (2019). Figure 1 shows the response time by each county. This data was retrieved by the NJ Department of Health and Office of Emergency Medical Services (2019). In fact, the analysis conducted by Hsia et al. (2018) confirmed that EMS responding to low income areas had a lower likelihood of meeting national benchmarks of 8 minutes and 15 minutes compared to EMS responding to high income communities and showed that mean EMS response time, on-scene time and transportation time were longer in low income communities, even after observable differences were controlled.
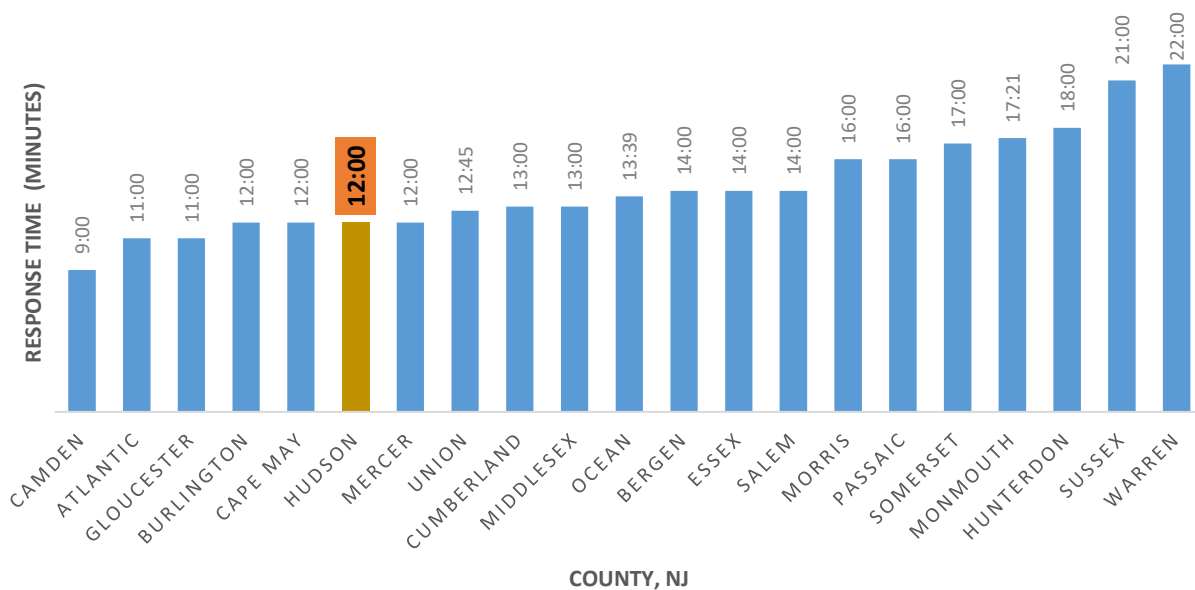
Figure 1. EMS Response time by County, September 2019 (OEMS, 2019).

This study seeks to help the region and health care department to develop and implement new strategies that can be used in delivering ambulance services to citizens. Therefore, this study intends to find if there are any gaps in the ambulance system, when it comes to covering low income areas. This study investigates the distribution of response time based on existing ambulance system, by minimizing travel time between the ambulance service location and the census tracts. This study will propose a potential service ambulance location across the city to reasonably respond to the 911 calls within 9 minutes.

Literature Review

Response time is important when dealing with emergency cases. Swift responses characterized by minimal delays improve the quality of outcome of emergency and incident response activities. On the other hand, delays deter or decrease the quality of services when it comes to risk mitigation and emergency response. Low income areas face the challenges of getting

swift response to their 911 calls from the local ambulances. This has led to many fatalities in the recent past. The purpose of the current literature is to show how local ambulances could use optimized distribution model to minimize response time. Consequently, this section reviews some of the models that are used to minimize response time in emergency services.

Pérez et al. (2015) explained reducing response time using linear programming model to locate ambulances. Finding the right locations is one of the biggest problems because it is difficult to choose the best place to locate emergency facilities. According to Perez et al. (2015), given the different location of users, costs, and demand of transport in the area under consideration, the number of services required, the geographical location, and the capacity of each location are the basic things to consider when seeking to optimize the quality of services and operations in emergency response and disaster management. Thus, to solve the problem that affects many response teams in the world, Pérez et al. (2015) have developed a method that is based on linear programing to locate ambulances. Their study concluded that near programming models based on p-medians and set covering approach helped to shorten the distance between the user and the ambulance. They also found out that the method helped to reduce the response time.

Aringhieri et al. (2007) proposed a three-step method that can help to improve ambulance location and reduce response time during emergencies. The first step in this method analyzed the real time data on the system to understand its behavior. The second step involves using integer linear programming, while the third method involves finding new locations. Aringhieri et al. (2007) concluded that the integer method could help to improve emergency responses by reducing response, but the method was subject to further discussion.

Firooze et al. (2018) used a mixed integer linear programming program and says: "The conditions are the ambulance is on its way to serve a demand, the ambulance is serving a demand or the ambulance is returning to the station on it was out from or to a new one". The objective function of the study was to minimize the summation of response time and relocation time that they will be using for the case and penalty costs according to the results. They also want to ensure the number of ambulances dispatched from a station should not exceed its capacity in any time period. They used some variables and parameters to formulate the equation and found the constraints called ambulance availability constraints in terms of linear mathematical optimization modeling. They also determined the length of each time period which helped to determine the time of response in order to assure that all calls will be received.

Firooze, et al. (2018) found that by increasing the number of ambulances from three to four, the objective function is expected to improve. This study focused on emergency vehicle location and relocation problem with the purpose of dealing with emergency demands considering service time, response time and return time" (Firooze et al., 2018). The model could be solved in a rational time in small-, middle- and large size distances, whilst, in the extra-large-size test problems, the average solution time was higher relatively. They focus on reducing the time of response to cover all possible demands.

Liu, Yang, and Hao (2017) conducted a case study in the City of Shanghai, China. The study utilized a mixed integer programming with the CPLEX software. The study compared the results with the emergency system of Songjiang emergency center. They determined that the travel time with the patient that will be sent to the nearest hospital to receive the appropriate service which should not exceed in thirty minutes (Liu et al., 2017). This study showed that the demand coverage rate and response time can be efficiently improved through relocating the current facilities without additional vehicle resources. Liu et al. (2017) concluded that the time of the response should be less than eight minutes at least 60% with a liability of 90%. The study of Liu

et al. (2017) used the shortest travel time from ambulance stations to the demand points and from demand to hospital on the basis of Euclidean distance. They used a running average speed of an ambulance of 55km per hour, without considering the different types of speed of different routes, but this speed is consistent with the traffic conditions for most of the Shanghai urban streets. They focused on reducing the time of response to cover all possible demands.

Noble's (1973) results showed that more than one ambulance in the pre-assignment lists influences location decisions and consequently the system performances. The capacity of ambulances, their maximal workload, also impact the decisions, but mostly pre-assignment ones. Indeed, when the system capacity is tight, pre-assignment lists adjust accordingly thus providing a better estimate of system performance and workload balance.

The difference between the proposed study and the existing literature is that the existing literature mostly focuses on analyzing the functioning of the entire emergency response systems in developed areas, while the current study examines emergency response in Jersey City, studying the income levels, with fewer facilities. For this reason, the approaches used in the existing literature might not work for this study. Therefore, this research will help fill the gap left by the existing literature when it comes to addressing emergency services in low income areas.

Model Development

This study proposes adding a new location using historical call locations using a mixed integer linear program (MILP). The study proposes pre-assigned ambulance locations. New locations are needed in order to improve medical emergency services and manage efficient public health systems. Thus, the decision variable of the study is the number of calls as follow:

X_{ij} : Number of 911 calls in 2017 from Census Tract j assigned to ambulance location i

$Y_i : \begin{cases} 1 = \text{If an ambulance is being dispatched in Census Tract } i \\ 0 = otherwise \end{cases}$

The objective function is to minimize annual total travel time to response to all call volumes per year (1). Using sum of total annual trips from census tract (i) to ambulance location (j) multiply by minimum travel time from ambulance location (i) to census tract (j). Minimum travel time (T_{ij}) is distance (D_{ij}) from i to j divided by the assumed travel speed in route (S_{ij}). On the assumption of 25 miles per hour (MPH) over the region in response to the local traffic between ambulance location i and location of demand j which is the centroid of census tract.

$$Min \ Z = \sum_{i=1}^{I} \sum_{j=1}^{J} X_{ij} T_{ij} \qquad (1)$$

where:

j: Location of 911 demand (centroid of Census Tract), $j = \{1, 2, …, J\}$

i : Potential ambulance location (centroid of Census Track), $i = \{1, 2, …, I\}$

T_{ij}: Travel time in minutes from census track of ambulance location (i) to census track of demand (j)

$T_{ij} = D_{ij} / S_{ij}$

D_{ij}: Distance per ambulance to census tract (i) to census track (j)

S_{ij}: Travel speed 35 miles per hour

The ambulance response time from i to j should be less than lower bound response time (LB_RT) minutes to reflect local policy and requirement (2). Each ambulance cannot serve more than maximum calls (MAXCALLS) per year due to capacity of an ambulance (3). In addition, there should be less than a certain number of pre-assigned ambulances (MAXAMB) in the region to receive a call due to budget plan (4). The demand of Census Tract should be served by any ambulances (5). The number of calls assigned to an ambulance service should be integer (6). All variables should not be negative (7).

$$T_{ij} \leq \text{LB\_RT} \tag{2}$$

$$\sum_{i=1}^{I} X_{ij} \leq \text{MAXCALLS} \cdot Y_i, for \ \forall j = \{1,2,\ldots,J\} \tag{3}$$

$$\sum_{i=1}^{I} Y_i \leq MAXAMB \tag{4}$$

$$\sum_{i=1}^{I} X_{ij} = CALL_j, for \ \forall \ j = \{1,2,\ldots,J\} \tag{5}$$

$$X_{ij} \ is \ integer \tag{6}$$

$$T_{ij}, X_{ij} \geq 0 \tag{7}$$

Case Study

Jersey City

The study will focus on the emergency ambulance system in Jersey City. The Jersey City region is located in the North Eastern part of the State of New Jersey. The city is located in Hudson County. Jersey City has a population of about 16,736 per square mile. On the other hand, the land covered per square mile is approximately 14.79. The eastern waterfront is located in a strategic position where it faces the Hudson River (Washko & Heightman, 2012). This is also a place where the waterfront meets the Upper New York Bay. The city has eleven neighborhoods: Bergen-Lafayette, Downtown, Greenville, Hackensack Riverfront, Journal Square, Liberty Park, Lincoln Park, McGinley Square, The Heights, The Waterfront, and West Side.

In order to understand the ambulance services in Jersey City, we have to study the characteristics of the city, as well as the socio-economic facts. Jersey City has the largest population in Hudson County and the second largest in the state of New Jersey (World Population Review, 2019). The city is part of the New York metropolitan area, and it is known for its distribution, busiest transportation and manufacturing center due to the port region. The data provided is essential to understand any gap between ambulance services and Jersey City's population. Population density is high in the middle of the region and downtown near the waterfront (Figure 2-A). The map also demonstrates how most of the calls are originated from the highly populated census tracts.

In Jersey City, paramedics are delegated to ensure that all individuals that are part of the ambulance service delivery are fully licensed. Moreover, the main focus should be to ensure the safety of citizens and save as many lives as possible. Furthermore, the law requires that anybody that needs to donate ambulances to the region must get permission from the health department before they are allowed to offer such services to the society. This helps to promote professionalism

during operations (World Population Review, 2019). Previous studies suggest that the response time of ambulance services in low income areas take longer, leading to disparities in prehospital delivery of care over time (Hsia et al., 2018). This information is crucial to understand if there is any link between poverty levels and ambulance services (See Figure 2-B). This study also collected median income and population from each census tract in the period of 2017 (Data USA, 2019). In Jersey City, households have a median annual income of $66,264, which is more than the median annual income of $60,336 across the entire United States (Data USA, 2019). As well, in 2017, the location of Census Tract 74 shows the highest Median Household Income in Jersey City with a value of $185,439, followed by Census Tract 76 and Census Tract 77, with respective values of $181,923 and $152,325 (Data USA, 2019). On the other hand, the place with the lowest value of $16,600 is from Census Tract 44.
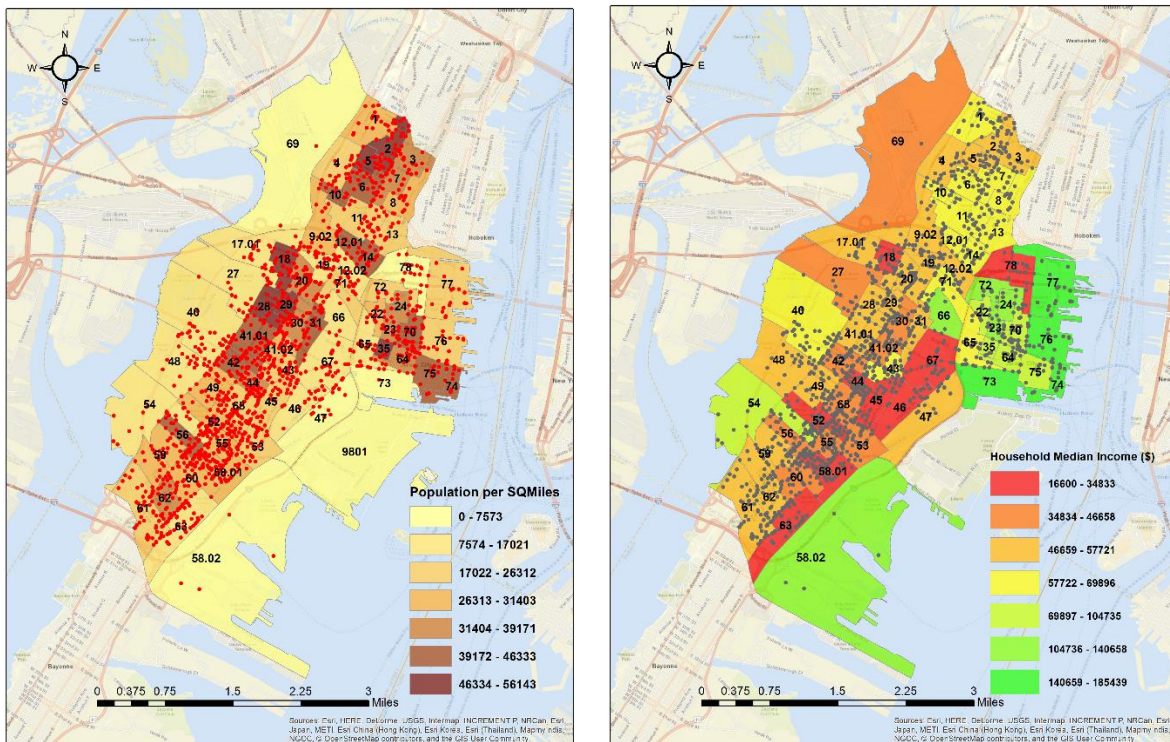
(A) Population Density   (B) Household Income

Figure 2. 911 Calls with population density of 2010 (A) and household income of 2017 (B) by Census Tract in Jersey City.

The population of Jersey City, NJ is highly diverse. The composition is as follows: 29.5% Hispanic or Latino, 26.3% Asian Alone, 22.2% Black or African American Alone, 19% White Alone, 2.36% two or more races, 0.389% other race alone, and 0.225% American Indian and Alaska Native Alone (Data USA, 2019). As for poverty levels by ethnicity, Data USA (2019) concluded that groups living below the poverty line in Jersey City, NJ is Hispanic, followed by White and Black (Data USA, 2019). The following data was retrieved from Data USA (2019) with information about poverty levels by ethnicity in Jersey City (see Figure 3).

According to the Office of Emergency Medical Services, New Jersey Department of Health, following the 90th percentile methodology, the response time in September 2019 was 9

minutes and 11 seconds in Jersey City (NJ Department of Health & Office of Emergency Medical Services, 2019). There are many studies that indicate that a gap in the response time between low income areas and high-income communities is still affecting the citizens.
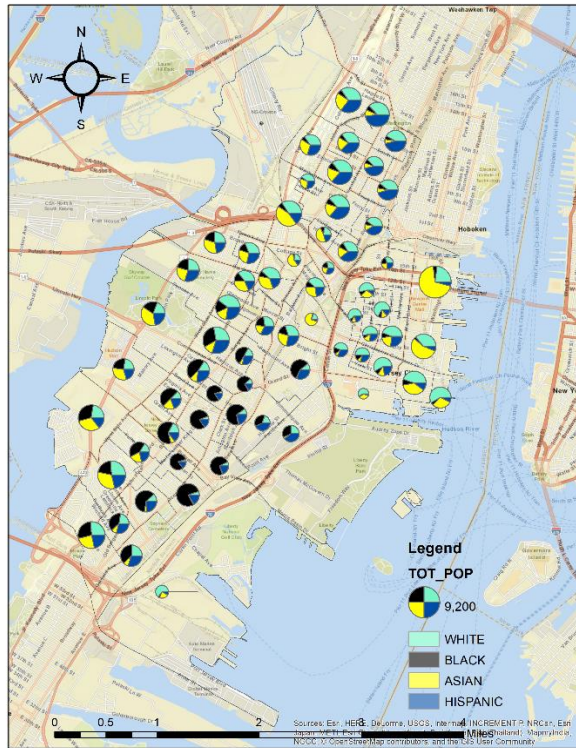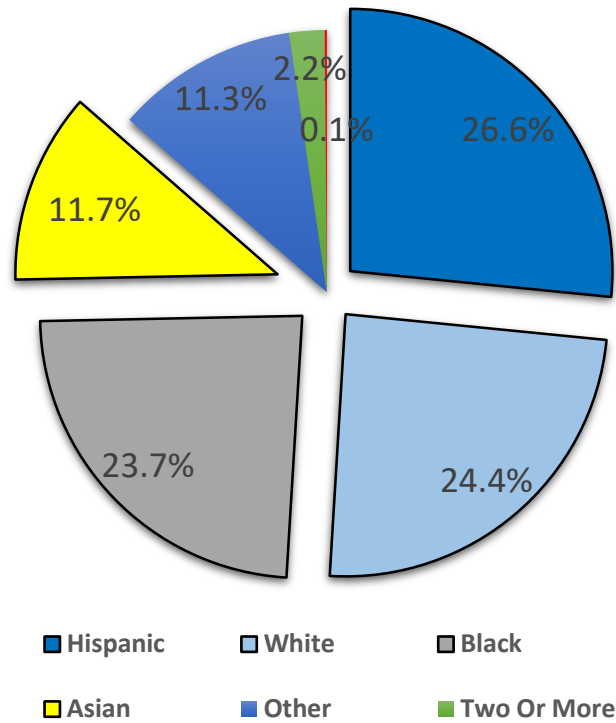
        (A) Ethnicity   (B) Poverty Level (Data USA, 2019).

Figure 3. Jersey City Poverty Levels by Ethnicity: Ethnicity (A) and the Poverty Level of Ethnicity (B).

Data Description

Jersey City counts with 67 Census Tracts. The Census Tracts were downloaded from Jersey City Open Data. The data set includes x- and y-coordinates, census tract ID and 911 calls. The 911 calls correspond to the 2017 period and only include emergency calls (Jersey City Open Data, 2019). The number of 911 calls for ambulances on the census tracts were visualized in Figure 1.

      The Jersey City Medical Center operates a fleet of 50 ambulances, about 25 in service each day (Quigley, 2019). This study assumes that the travel speed responding to an emergency call is 25 MPH over the entire city regardless of road types since the speed limit in the city boundary is 25 MPH in general. According to the State of New Jersey, an ambulance can "Exceed the maximum speed limits so long as he does not recklessly endanger life or property" (State of New Jersey, 2019). According to the official site of the State of New Jersey:

> *New Jersey law sets top speed limits for any given road, street, highway, or freeway. The speed limit, unless otherwise posted, is 25 mph in school zones, business, or residential districts; 35 mph in certain low density business and residential districts; 50 mph on all other roadways; 55 mph on certain state*

highways (as posted) and all interstates; and 65 mph on certain state highways (as posted). (State of New Jersey, 2019)

Results and Discussion

While solving the problem using LINGO 18.0 from LINDO® Inc., the study used sensitivity analysis in regard with the number of locations to respond to any 911 calls in five minutes. The system measures the yearly total travel time in minutes. The number of ambulances in the system is 40, which is the exact number of ambulances operated in 2017. The shortest travel time from ambulance stations to demand points is calculated on the basis of Euclidean distance.

Figure 4 shows recursive operations characteristics based on the number of ambulances pre-assigned to some census tracts in the region. The study shows that when five ambulances are in operations, the areas will be served in five minutes, resulting in 4679.4 travel time in minutes in total for a year. As the number of ambulances in operations increases, the yearly total travel time decreases. The results show that the number of ambulances will provide faster response service to the residents; however, depending on the budget of the city and ambulance, the health planner should decide the service level.
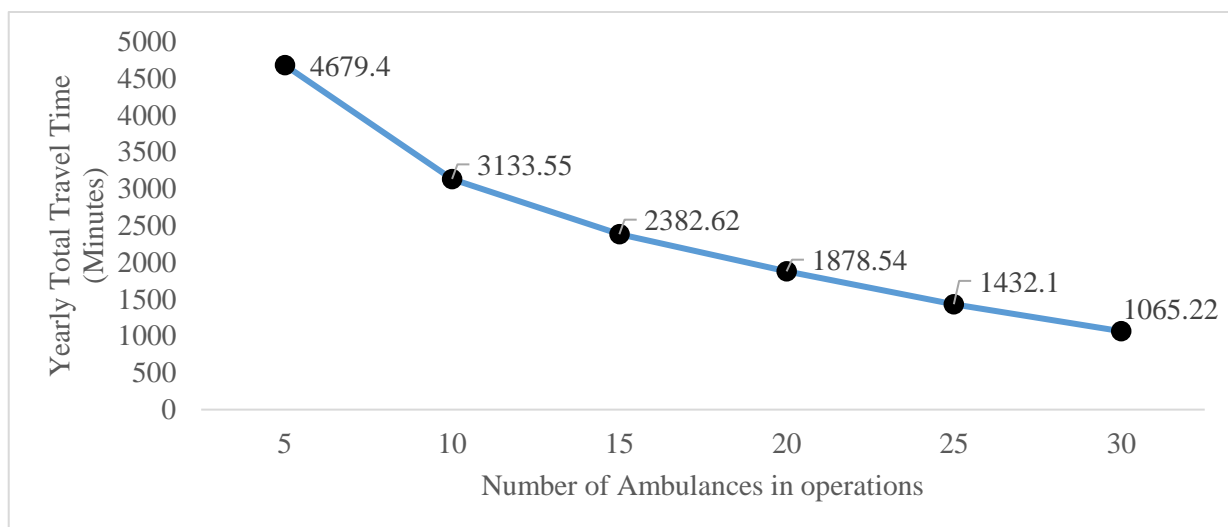
Figure 4. Recursive operations characteristics based on the number of ambulances in operations.

Furthermore, Figure 5 shows the spider lines between ambulance location and census tracts which the ambulance will serve. Figure 5-A also displays the average response time to the 911 calls of 2017. Average response time is slow near the waterfronts including Hudson River on the East and Hackensack River on the West. The areas of slow response time will have extra ambulances in motion to quickly response to the any future calls.

Figure 5-B shows the standard deviation of the response time in the regions. Even if the average response time is high, if the standard deviation is high, the service is not predictable. Thus, high average response time with narrow standard deviation is desirable. In addition to the waterfronts, the standard deviation in the middle of the region is also broad. Thus, the ambulance locations in the middle and near the waterfront area will improve the service overall.
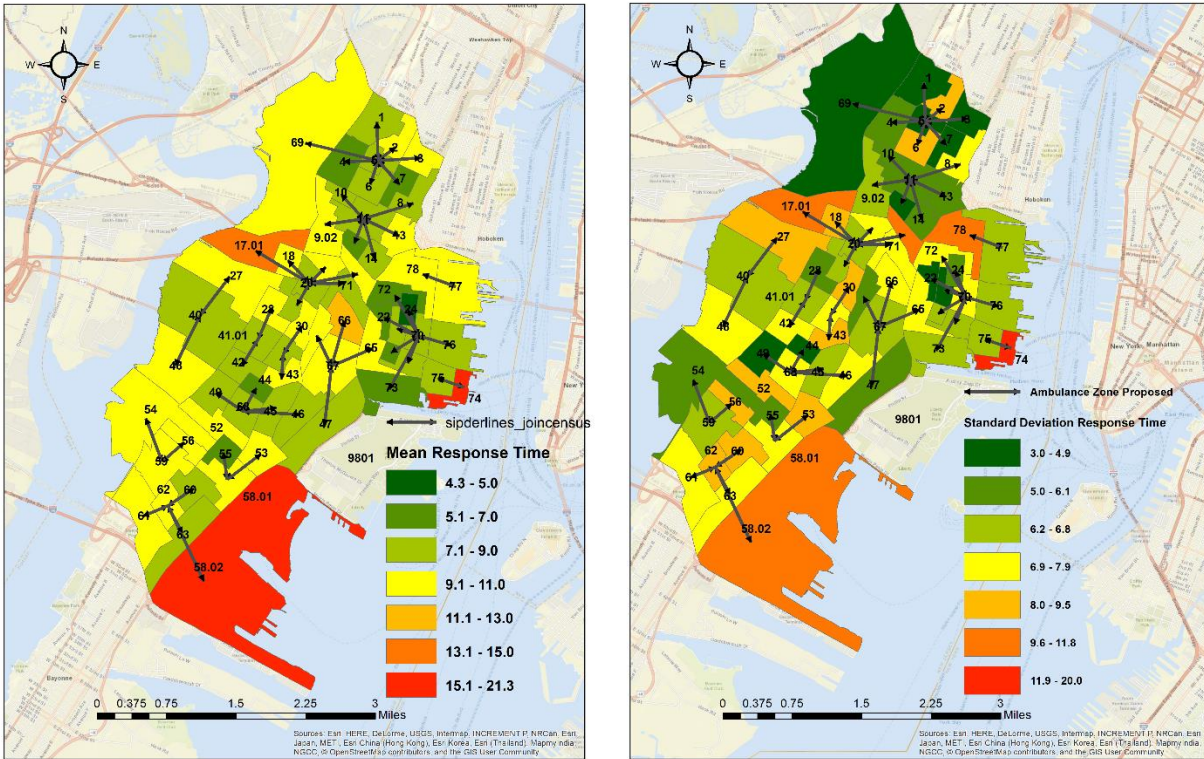
(A) Average   (B) Standard Deviation

Figure 5. Proposed 15 ambulance zones in response to the current average response time (A) and standard deviation (B) based on the 911 calls of 2017.

Conclusion

This study proposed a model minimizing total annual travel time from ambulance stations to incidents while considering historical call volume. After studying and analyzing the ambulance locations for the Emergency Medical Services (EMS) in Jersey City, New Jersey, the study has concluded that the ambulance base locations affect the EMS performance significantly. The study proposes that locations will decrease average response time and narrow standard deviation of response times in Jersey City. In addition, it will be extremely beneficial especially in where the most vulnerable population resides and the outskirts of the area.

The propositioned model can accomplish noteworthy results of coverage compared to the classic used of ambulance stations. However, the results are based upon the real demands in only one-year data from 911, excluding any other calls. The cost of the ambulance station set up and the ambulance vehicle utilization is not under the scope. Likewise, the speed assumed for the ambulance response is on a straight line 25mph, not taking in consideration that are different types of routes.

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Strategy and Organizational Behavior - Abstracts

EXPLORING THE WORK-FAMILY RELATIONSHIP THROUGH A HISTORICAL PERSPECTIVE

Strategy and Organizational Behavior

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This paper introduces a historical model of the relationship between work and family. The model summarizes the movement through three eras of production which resulted in different role relationships between work and family: (1) role solidarity of the pre-industrial era, (2) role segmentation of the industrial era, and (3) role overlap of the post-industrial era. The model shows that the public/private ideology associated with the role segmentation of the industrial era stands strong in the post-industrial era. It is argued that the incongruence of the public/private ideology and the role overlap of the post-industrial era has contributed to work/family conflict.

KNOWLEDGE FLOWS IN ALLIANCES: AN ANTECEDENT TO PARTNER ACQUISITION

Strategy and Organizational Behavior

Dr . Simona Ileana Giura [1]

1. *SUNY Oneonta*

Strategic alliances lead to knowledge transfers in alliance related areas (intended knowledge transfers) while also leading to knowledge spillovers in alliance unrelated areas (unintended knowledge transfers). We argue that high unintended knowledge transfers lead to acquisition of alliance partners while intended knowledge flows deter the acquisition of alliance partners.

Repairing with Foresight: A Framework for Understanding Psychological Contract Breach and Repair in Organizations

Strategy and Organizational Behavior

Prof . Kristen DeTienne [1] **_, Dr . Marc-Charles Ingerson_** [1]

_1._ _BYU_

In this paper, we propose that psychological contract breaches and violations co-occur within the offended employee. We show how managers can use foresight in understanding how certain managerial accounts address the breach and violation with the offended employee. Four major types of accounts are examined: refusals, excuses, justifications, and apologies. We build this theory by offering a typology that points to which accounts are better when it comes to validating a breach and reducing the moral intensity of the violation. We conclude by examining the implications and research imperatives of this new model of interpersonal and organizational communication in institutions.

THE DYNAMIC AND PROCESSUAL SCHEMA FOR TRANSFORMING VALUE PROPOSITION TO VALUE PERCEPTION

Strategy and Organizational Behavior

Dr . Tung-Shan Liao [1], Mr . Shi-wen Tung [1]

1. College of Management, Yuan Ze University

This study aims to explore a dynamic processual framework of the service process for the understanding of how a firm delivers its value proposition and directs customers to perceive its value offerings. The major findings include: (1) a firm's service process should be designed to convey the value proposition; (2) a customer's value perception is derived from the changes of her/his emotion states and her/his evaluation on these changes in the service process; and (3) the manipulation of "dominance" is a potential source of a firm's dynamic management capabilities in managing the service process that urge customers' emotion stimulation.

THE USE OF THE BALANCED SCORECARD AS A TOOL FOR ORGANIZATIONAL DEVELOPMENT AND CHANGE

Strategy and Organizational Behavior

Prof. Robert Yawson [1], *Dr. Amy Paros* [1]

1. *Quinnipiac University*

This paper discusses the Balanced Scorecard (BSC) as a tool for Organizational Development and Change. The purpose of using BSC, the underlying assumptions, expected outcomes, and limitations of its use are discussed in the context of its epistemology and actual organization experience with its use. The paper concludes by analyzing, from the author's perspectives, the value of BSC as a tool for an OD intervention and organizational leadership decision making. Is the BSC still relevant for future usage?

Strategy and Organizational Behavior - Papers

KNOWLEDGE FLOWS IN ALLIANCES: AN ANTECEDENT TO PARTNER ACQUISITION

Abstract

Strategic alliances lead to knowledge transfers in alliance related areas (intended knowledge transfers) while also leading to knowledge spillovers in alliance unrelated areas (unintended knowledge transfers). We argue that high unintended knowledge transfers lead to acquisition of alliance partners while intended knowledge flows deter the acquisition of alliance partners.

Key Words: Acquisitions, Alliances, patent, knowledge transfers.

Introduction

Alliances and acquisitions are motivated by similar reasons such the accessing external complementary resources that reside in other firms (Wang & Zajac, 2007), knowledge that is costly and difficult to create internally. While both alliances and acquisition have received attention in the literature, they are usually looked at in parallel, and not how one drives the other. While limited, there is some research that argues that alliances act as an antecedent and enable firms to manage various uncertainties in the acquisition process (Agarwal, Anand, & Croson, 2005; Lin, Peng, Yang, & Sun, 2009; Yang, Lin, Peng , 2011; Porrini, 2004), such as those related to valuation (Balakrishnan & Koza, 1993) and environmental volatility (Folta, 1998; Kogut, 1991).

Alliances are voluntary agreements that lead to knowledge transfers in areas related to the scope of the alliance due to coordination and closeness between the partners. However, alliances also lead to knowledge leakage in areas unrelated to the scope of the alliance due to the same causes that lead to increased undesired intentional knowledge transfers. In alliances, the partners get restricted access to knowledge, while in acquisitions, the acquirer gets complete control over the knowledge of the acquired firm.

Our research addresses the following question: How does transfer of knowledge impact acquisitions of alliance partners? We address the above question using a sample of 639 R&D alliances and measures based on patent data. We find that knowledge transfers unrelated to the

scope of the alliance (unintentional knowledge flows) leads to the decision to acquire. While we hypothesis about the negative effect of related knowledge (intentional knowledge flows) on the decision to acquire the partner, we did not find support for that.

The remainder of the paper is organized as follows. In the next section we discuss our theory and hypotheses. Following that, we move on to the empirical analysis and describe the data sources, the sample construction, and the measures and methods used. Next we present the results. Finally, we offer concluding remarks and discuss the limitations of this study.

Theory and hypothesis

There are many reasons why a firm might acquire its alliance partners. Prior research has argues that pre acquisition alliances can increase post acquisition coordination (Hagedoorn & Sadowski, 1999) and post acquisition performance (Porrini, 2004). In this paper, we argue that transfer of knowledge in areas unrelated to the alliances leads to partner acquisition while the transfer of knowledge in areas related to the alliance deter partner acquisition.

Alliances create value for the partner firms by allowing the firms to access complementary resources and skills from other firms (Anand & Khanna, 2000; Dyer, Kale, & Singh, 2001; Kale, Singh, & Perlmutter, 2000; Williamson, 1991). In alliances, the partners address matters in innovative ways that are less likely to be found in the partner firms in the absence of an alliance. Firms are a bundle of unique tangible and intangible resources (Penrose 1959), that give the firm its competitive position and advantage (Rumelt 1984). The Resource Based View informs us that the reason firms form alliances is to have access to resources that otherwise would not be available to them and to create new resources.

R&D alliances provide advantages for the partner firms such as allowing firms to learn from their differences and complementarities. However, there are also costs and hazards such as the cost of coordination, and the hazard of unintended knowledge transfers (knowledge transfers outside the scope of the alliance). Unintended knowledge transfers to the partner can be in the form of knowledge leakage or in the form of appropriation of valuable technologies. These unintended knowledge flows are caused by the fact that alliances are organizational forms that are incomplete contracts between firms. Humans have bounded rationality (Simon, 1947) and as a result it is impossible to write in a contract all the possible future interactions. While only the knowledge that serves the common scope of the alliance is meant to be transferred that is not always the case. And while cooperation is the main reason for alliance formation, there is also

competition between the partners as these might be part of the same industry (Hamel, 1991). The competition between the alliance partners has significant impacts on the dynamics of the learning process and creates tension. If humans were rational rather than bounded rational, contracts would be perfect and would stipulate all possible ways in which a firm could appropriate knowledge from its partner in an alliance. Therefore, unintended knowledge transfer to the partner would not be a problem if perfect contracts could be written. However, as Williamson (1975) observes, perfect **contracts are impossible to write** and despite all efforts and costs, a contract does not fully specify what each party must do under every possible situation.

Alliance partners have to find the balance between keeping an open knowledge exchange while also preventing unintended leakage of knowledge. Doz (1996) argues that firms enter alliances with shared, explicit expectations but also less explicit, private expectations. Firms know when they enter a collaboration that there will be some unintended knowledge leakage, but how much and how it will affect the success of the alliance and of each firm post-alliance is unknown.

Given that unintended knowledge transfers happen, we argue that too much leakage diminishes the competitive advantage of the firm and therefore the firm is more likely to acquire its partner or let itself be acquired by their partner.

We argue that acquisition decisions can be determined by knowledge spillovers:

Hypothesis 1: The higher the transfer of alliance unrelated knowledge, the higher the likelihood of acquisition.

When compared to other market forms of knowledge transfers, alliances have advantages such as transferring valuable tacit knowledge between firms (Aggarwal, Siggelkow, & Singh, 2011). Alliances have these advantages because they use multiple coordination mechanisms, such as a board of directors overseeing alliance activities, and committees assigned to specific tasks (Reuer & Devarakonda, 2016; Kumar & Nti, 1998) but also enhanced social contact between the members of the firms (Kogut & Zander, 1992). As these members come in repeated contact with each other, the transfer of tacit knowledge is facilitated through an enhanced understanding of each other's routines, communication modes, and cognitive schema. There is an expectation that related knowledge transfers will happen in alliances and if they don't happen and one of the firm has a strong desire to access the other's knowledge, it might acquire it. However, if the transfer of

related knowledge is high, the alliance has achieved its scope and the likelihood of an acquisition is small.

Hypothesis 2: The higher the transfer of alliance related knowledge, the lower the likelihood of acquisition.

Data and Sample

To empirically test our hypotheses, we constructed a data set comprising of patenting activities of alliance partners in a wide range of industries. We construct our data set from two main sources: the Securities Data Company (SDC) Database on Joint Ventures and Alliances and the NBER patent database (Hall, Jaffe, & Tratjenberg, 2001). The SDC database contains information on all types of alliances and is compiled from publicly available sources, including SEC filings, industry and trade journals, and news reports. Since firms are not required to report alliance activities, coverage is still incomplete. However, this database currently represents one of the most comprehensive sources of information on alliances. Following previous research (Sampson, 2007) two steps were taken to increase the reliability of the SDC data. First, all deals for which the alliance announcement date is estimated, rather than known, are removed from the sample, since these alliances may never have materialized. Second, data is collected starting 1988 since SDC coverage of alliances is more comprehensive from that year (Oxley & Sampson 2004). Our sample consists of alliances involving collaborative R&D activities exclusively, which commenced between 1988-1996, inclusive. Alliances that involve a combination of R&D activities with manufacturing and/or marketing activities have been eliminated. There are two reasons why we went only up to 1996, inclusive with our alliance collection data. First, in constructing our knowledge measure we looked at patenting activity 10 years after the alliance. Second, the last year for which we have patent data from NBER is 2006. However, this period of time has also the advantage of not containing any significant technological changes, thus avoiding any phenomena such as patent races (Valentini 2011). We restrict ourselves to two partner alliances, where both partners are US private or public firms. The US firm restriction is important since this is necessary to maintain consistency, reliability, and comparability, as patenting systems across nations differ in their application of standards, system of granting patents, and value of protection granted.

After matching SDC with NBER, we have 639 alliances. Our sample size also matches well with previous studies. For example, Oxley and Wada (2009) have a sample of 536 licensor-licensee pairs and Sampson (2007) has a sample of 463 alliances.

Patents are not always assigned by USPTO to the firm subsidiaries in which the innovations take place. Therefore, looking at corporate firm level patent portfolios becomes important. We construct a patent portfolio for firms based on patents assigned to the parent firm as well as all of its subsidiaries. We first use the Directory of Corporate Affiliations to identify all subsidiaries of the firms in the sample. The Directory contains information on the subsidiaries and affiliates of both public and private U.S. firms. We then drew all patents from the NBER database assigned to the parents as well as their subsidiaries and aggregated the identified patents at the corporate level.

Measures

Dependent Variable. Our focus is whether alliance partners are being acquired because of transfers of knowledge flows. Thus, we coded our dependent variable as a dummy (1 "partner acquisition," 0 "no partner acquisition"). Out of the 639 alliances, 57 alliances end up in acquisitions.

Patent measures. We use a number of variables derived from patent data, mainly measures based on patent citations, as a proxy for knowledge flows between the partners (Gomes-Casseres *et al.*, 2006; Mowery *et al.*, 1996; Oxley and Wada, 2009). All US patents have to include citations to all existing patents that are relevant to that technology, and thus patents provide a trace of an organization's knowledge creation activities (Gittelman and Kogut, 2003; Vasudeva and Anand, 2011).

Similar to Oxley and Wada (2009), in constructing our measures of related and unrelated knowledge flows, we used 118 technology classes defined in the International Patent Classification System which provide us with more fine-grained measures of knowledge flows than the 49 aggregated technological sub-categories used in Jaffe (1986).

The SDC database on alliances reports a scope for the alliance at the 4 digit SIC code. According to Schilling (2009) SIC coding in SDC is highly accurate In identifying related and unrelated knowledge flows, we have to identify knowledge flows that are within the scope of the 4 digit SIC code of the alliance (related knowledge flows) and knowledge flows outside the scope of the alliance (unrelated knowledge flows). Unfortunately, the USPTO classification of patents does not provide an SIC correspondent of each patent. We therefore employ a concordance developed by Silverman that that links the International Patent Classification (IPC) system to the U.S. Standard Industrial Classification (SIC) system at the four-digit SIC level.

This concordance has been used in previous literature (Silverman 1999; McGahan & Silverman 2001; Luque 2000; Mowery & Ziedonis 2001).

This correspondence between patent classes and SIC provides the foundation for the distinction between related and unrelated knowledge transfers in alliances. First, we established the patent classes that correspond to the SIC code of the alliance based on the patent portfolios constructed at the corporate level for each firm in the alliance. All patents that belong these technological classes are considered alliance related patents. The patents that belong to technological classes that are outside the scope of the alliance (outside the SIC code of the alliance) are considered alliance unrelated patents. For a detailed explanation of the measure, consider the following example outlined in Table 1.

In Table 1, firm *i* patents in technological classes A and B, while firm j patents in technological classes A and C. The scope of the alliance is an SIC code that corresponds to patent class A. Therefore our related patent class is A while B and C are unrelated patent classes. Before the alliance, firm *i*'s patents in the related technological class A have one citation to firm *j*'s patents that are in the related technological class A. After the alliance, firm *i* has increased the number of patent citations to firm *j* in related areas to 3. The difference of 2 partner citations in related areas after the alliance as compared to before the alliance represents the related knowledge that firm *i* receives from firm *j*. Similarly, firm *j* has increased the number of citation to firm *i* in the related areas from 2 to 5, indicating that it has received 3 units of related knowledge from firm *i* after the alliance as compared to before the alliance. Moving forward to technological class B, in which before the alliance firm *i* patents but firm *j* doesn't patent, the number of citations from firm *i* to firm *j* has not increased after the alliance. However, firm *j* has started patenting in technological class B after the alliance and its patents in this class cite firm *i*'s patents twice. Therefore these 2 units of knowledge acquired by firm *j* constitute flows in unrelated areas. Similarly, before the alliance firm *j* patents in technological class C, while firm *i* doesn't patent in this class. After the alliance, firm *j* maintains the same number of citations to firm *i* in class C as before the alliance, while firm *i* starts patenting in this class and has one citation to firm *j* patents. This 1 unit represents unrelated knowledge received by firm *i* from firm *j*.

Our method for calculating related and unrelated knowledge flows builds on Oxley and Wada's (2009) study of knowledge transfers in licensing arrangements. Using a sample of 536

licensing contracts between US and Japanese firms, Oxley and Wada (2009) examine the effect of the ownership structure governing the licensing agreement (i.e. equity JV versus non equity alliance) on knowledge flows in related and unrelated areas. Knowledge flows in related areas were measured as increases in citations to the licensor's patents by the licensee in those technological classes specifically covered by the licensed patents. Correspondingly, knowledge flows in unrelated areas were measured as the increase in citations to the licensor's patents by the licensee in technological classes outside those covered by the licensed patents. Based on these measures, Oxley and Wada (2009) argue that knowledge flows in unrelated areas (i.e. flows in technological classes outside those covered by the licensed patents) are likely to be the result of leakage rather than intentional knowledge sharing. In support of this point, they find that licensing contracts governed by equity arrangements are associated with lower knowledge flows in unrelated areas compared to non equity arrangements.

Independent Variables

Prealliance Related Knowledge. In order to implement the above measures, we have to capture Prealliance Related Knowledge and Postalliance Related Knowledge for each firm (i.e. in Table 1 - number of patents in technological class A that falls within the declared SIC scope of the alliance). We chose to look at applied for patents rather than granted patents since the application date is the earliest time when we can identify a new technology (Rosenkopf and Almeida, 2003). The total number of patent citations to the partner in the alliance related areas was counted in the patents applied for in the 10 years before the alliance. This count constituted the Prealliance Related Knowledge.

Postalliance Related Knowledge. Similar to the prealliance related knowledge, we counted the postalliance citations from firm i to firm j in patents applied for 10 years after the alliance in alliance related technological classes.

Related Knowledge Flows (R_i). As $Firm_i$ acquires technological knowledge from its partner $Firm_j$ in an alliance we should see a higher rate of citation of $Firm_j$'s patents in new patents applied for by $Firm_i$ (Mowery *et al.*, 1996). Increases in the cross citations in the alliance related technological classes (i.e. patent class A in Table 1) constitute our final measure of related knowledge flows. This measure captures the extent to which one partner builds on the partner's technology in areas within the scope of the alliance.

Total Related Knowledge Flows ($TR_{ij}=R_i + R_j$) is the related knowledge flow in the alliance that is transferred from partner i to partner j summed with the related knowledge transferred from partner j to partner i. Thus total related knowledge gives the sum of flow for both partners, and is used to test the complementarity relationship between related and unrelated knowledge flows at the dyad level.

Prealliance Unrelated Knowledge. The total number of patent citations was counted for the patents applied for in the 10 year before the alliance from firm i to firm j in the alliance unrelated technological classes (i.e. classes B and C in Table 1).

Postalliance Unrelated Knowledge. Similar to the prealliance unrelated knowledge, we counted the postalliance citations from firm i to firm j in patents applied for 10 years after the alliance in the unrelated classes.

Unrelated Knowledge Flows (UR_i). Increases in the cross citations in the unrelated technological classes constitute our final measure of unrelated knowledge flow for each firm. This measure captures the extent to which one firm builds on the technology of its partner, even though this is outside the scope of the alliance.

Total Unrelated Knowledge Flows ($TUR_{ij}=UR_i + UR_j$) is the total unrelated knowledge flow in the alliance from partner i to partner j and from partner j to partner i.

Control variables

Total Number of Prealliance Patents in Related Areas. An essential control variable based on patent data is the total number of patents in related areas. We measure prealliance patents in related areas by counting both partners' patents in a 10 year window before the alliance with a one year lag in the areas pertaining to the alliance scope. Similarly, we measured **Total Number of Prealliance Patents in Related Areas** by counting the number of partners' patents in areas outside the alliance scope.

Technological overlap. Following prior research, we use the measure of technological overlap developed by Jaffe (1986) based on the angular separation of the patent class distribution vectors of the partner firms in the 10 years previous to the alliance announcement. The distribution vectors (F_i ; F_j) are defined over the 118 technological classes. The extent of the overlap among partner firms' areas of technological expertise is then:

Technological Overlap $= \frac{F_i F_j'}{\sqrt{(F_i F_i')(F_j F_j')}}$, where F_i is the patent class distribution vector for

firm i and F_j is the patent class distribution vector for firm j.

Technological Overlap varies from zero to one. A value of zero indicates no overlap in partner firms' areas of technological expertise and the closer the value is to one, the greater the overlap. This measure is not sensitive to the total number of a firm's patents within a class.

Industry dummies. We include industry dummies to control for industry specific effects not captured by the other explanatory variables. Firms in different industries have different patenting propensity due to differences in the importance of patent protection, technological advancement etc (Mansfield, 1986).

Year dummies. Since the propensity to patent may also vary across time (Pavitt, 1984), we control for the year when the alliance was announced.

Alliance Experience. To capture a firm's prior alliance experience (Hoang and Rothaermel 2005) we counted from SDC the total number of formed alliances before the alliance in our sample.

Firm Diversity. We control for a firm's diversity of knowledge. Firm Diversity is measured as $= 1 - \sum_{l=1}^{n} a_{lm}^2$, where a_{lm} is the proportion of citations patent l makes to patents in technological class m (Trajtenberg, Henderson, & Jaffe, 1997) .

Total Partners' Knowledge Importance is measured as the total number of citations the partners' patents received. This is measure of the quality of the knowledge (Valentini, 2012) and it is important to control for this as important knowledge might be more diffused quicker.

Statistical analysis and findings

Since the dependent variable is dichotomous, we ran logistic regression analyses. The results of the analyses are presented in Table 3.   In Table 3, column 1 presents a model with just the control variables. In Table 3, column 2 presents the results for the regression at the dyadic level when the dependent variable is Decision to acquire alliance partner. The coefficient estimate for *Total Unrelated Knowledge* is positive and significant indicating overall support for our hypothesis 1 that alliance unrelated knowledge flows leads to a higher likelihood of partner acquisition. The coefficient estimate for *Total Related Knowledge* is negative but not significant therefore not providing support of our second hypothesis. One alternative explanation could be that higher related knowledge might sometimes lead to acquisition as this could be a signal of

synergies and good coordination between the firms and the opportunity for greater things if merged.

Conclusions and limitations

Both alliances and acquisition are mechanisms for acquiring knowledge. Acquiring knowledge in important for firms as it leads to increased ability of creating new products (Rosenkopf and Almeida, 2003). In this paper, similar to Oxley and Wada (2009) we decomposed knowledge transfers in alliances in knowledge flows that are within the scope of the alliance and knowledge flows that are outside the scope of the alliance. Further, we examined whether knowledge flows inside and outside the scope of an alliance have an impact on the decision to acquire the alliance partner. Prior research suggests that knowledge flows within the scope of the alliance are intentional while knowledge flows outside the scope of the alliance occur mainly due to leakage and appropriability hazards (Oxley and Wada 2009). We have argued that intentional knowledge flows deter the acquisition process while unintentional knowledge flows lead to the decision to acquire the alliance partner.

This study has limitations inherent in patent data. One of the limitations of the patent data is that the commercial importance of patents as also as the propensity to patent in each industry are different. We included industry controls in the regressions in an attempt to account for this limitation. Despite the existing limitations in patent data, patent citations continue to be an accepted measure of the knowledge flows between partners. We hope future studies explore primary sources of data collection for measuring knowledge flows. Our research pertains only to R&D strategic alliances, therefore it would be useful to reexamine our findings in alternative samples and settings.

TABLE 1

Illustration of Related and Unrelated Knowledge transfer measure

Classes	A	B	C
Number of patent citations from firm i to firm j before the alliance	1	1	0
Number of patent citations from firm i to firm j after the alliance	3	1	1
Number of patent citations from firm j to firm i before the alliance	2	0	1
Number of patent citations from firm j to firm i after the alliance	5	2	1

TABLE 2: Correlation Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1.Acquisition dummy	1									
2.Total Unrelated Knowledge Flows	0.2421	1								
3.Total Related Knowledge Flows	0.1946	0.7414	1							
4.Prealliance Related Knowledge	0.2275	0.5574	0.5944	1						
5.Prealliance UnRelated Knowledge	0.1902	0.5703	0.4234	0.724	1					
6.Total Number of Prealliance Patents in Related Areas	0.1563	0.2791	0.3315	0.472	0.3362	1				
7.Total Number of Prealliance Patents in UnRelated Areas	0.0628	0.2823	0.1249	0.1663	0.3577	0.3141	1			
8.Technological Overlap	0.1116	0.3991	0.3938	0.3632	0.2668	0.2015	0.041	1		
9.Firm Knowledge Diversity	0.0026	-0.1434	-0.0999	-0.2203	-0.2127	-0.2097	-0.2298	0.1297	1	
10.Alliance Experience	0.1673	0.3798	0.3891	0.4134	0.3453	0.6332	0.4527	0.2856	-0.1561	1
11.Total Partners' Knowledge Importance	0.1572	0.3744	0.3584	0.4551	0.4479	0.8389	0.654	0.2032	-0.2127	0.7776

TABLE 3

Regression results – Decision to acquire alliance partner

VARIABLES	(1) Acquisition dummy (1 yes; 0 no)	(2) Acquisition dummy (1 yes; 0 no)
Total Unrelated Knowledge Flows		0.027***
		(0.008)
Total Related Knowledege Flows		-0.001
		(0.000)
Prealliance Related Knowledge	0.007	0.007
	(0.005)	(0.005)
Prealliance UNRelated Knowledge	0.021	-0.000
	(0.028)	(0.026)
Total Number of Prealliance Patents in Related Areas	0.000	0.000
	(0.000)	(0.000)
Total Number of Prealliance Patents in UnRelated Areas	0.000	0.000
	(0.000)	(0.000)
Industry controls	Included*	Included**
Year controls	Included**	Included**
Technological Overlap	0.368	0.070
	(0.517)	(0.531)
Firm Knowledge Diversity	0.756*	0.868*
	(0.385)	(0.383)
Alliance Experience	0.005**	0.005*
	(0.002)	(0.002)
Total Partners' Knowledge Importance	-0.000	-0.000
	(0.000)	(0.000)
Constant	-4.483***	-4.732***
	(0.535)	(0.565)
Observations	629	629

Robust standard errors in parentheses

*** $p<0.001$, ** $p<0.01$, * $p<0.05$, + $p<0.1$

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Supply Chain Management and Logistics - Abstracts

An integrated model to design a multi-period and product closed loop supply chain

Supply Chain Management and Logistics

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This paper presents a model to design a closed loop supply chain network. In this model, we consider multiple time periods, multiple products, multiple objectives and uncertainty on the supply and demand. We use an integrated approach to solve our model. Making better decisions strategically, tactically and operationally are obtained from our model.

Blockchain Technology: A Two-sided Market Perspective

Supply Chain Management and Logistics

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Blockchain is a technological advancement that shows promise for easing some global supply chain issues, such as transparency, trust, and security. The present study investigates blockchain technology as a two-sided platform in which demand market and suppliers join and interact with each other. A two-sided market plays an intermediary role and focuses on externalities between the user groups. How the increased participation in one side of a blockchain platform, e.g. demand market, would encourage more users from the other side, e.g. suppliers, to join and use the platform is the focus of this study.

Comparison of Korean, Japanese and German Cases by Life Cycle Option Selection for Material-based CO2 Saving Rate and Cost

Supply Chain Management and Logistics

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Depletion of natural resources and global warming have become more serious issues beyond countries. Assembly products should be disassembled for recycling and reuse to deal with these issues. Reuse and recycling can contribute to reducing CO_2 emission since CO_2 emission for virgin material production can be saved by using reused parts and recycled materials. However, each part of selling revenue and CO_2 emissions depends on countries because of the different energy mixes. Collected parts in end-of-life (EOL) products need to be selected life cycle option. This study analyzes Korean, Japanese and German cases' life cycle option selection.

Design, Digitizing, and Executing Lean and Agile Smart Manufacturing Facilities for Global Supply Chain

Supply Chain Management and Logistics

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In today's global market, the bar has been set very high for the global manufacturing industry. The ability to produce and deliver quality products on time at a competitive price is an essential requirement. In this study we purpose guidelines for planning and executing lean and agile smart manufacturing facilities. Our approach is based on (1) the principle of linked cellular lean design where all steps including final delivery are uninterrupted; (2) smart or digital factory used in plant design and execution; and (3) direct access to sensors for productivity improvement. We will present actual examples of our approach.

Does Incentivizing Consumers to Collect Garments Achieve Sustainability and Increase Manufacturers' Performance?

Supply Chain Management and Logistics

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As more consumers become aware of the environmental impact of the fast fashion industry on sustainability, not only used garment collection efforts by the firms but also the consumer demand for garments with recycled/remanufactured content increases. Fast fashion companies design and produce new clothes more frequently, while also having to achieve sustainability. The purpose of this paper is to identify different strategies to motivate consumers to return old garments and explore how the collected garments are managed, whether/how they are recycled/reused in the upstream supply chain using the perspectives of Theories of Motivation and Resources-Based View of the Firm.

Fight Outsourcing and the Impact of Regional Carriers on Airfares

Supply Chain Management and Logistics

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To serve smaller cities and airports, major airlines often outsource flights to regional carriers. In this paper, we construct a quarterly panel data set over 20 years at both the route-level and the airport-level to examine the impact of such partnerships on airfares. Unlike recent research, our results show that increases in the growth of regional airline market shares increase fares. The results are robust to two-stage least squares approach which uses the initial airline-location shares to measure differential exposure to trends in regional airline growth. Data is provided from 1999 to 2018 by the U.S. Bureau of Transportation Statistics.

HUMANITARIAN LOGISTICS NETWORK DESIGN WITH INTEGRATED DATA ENVELOPMENT ANALYSIS METHOD

Supply Chain Management and Logistics

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This paper proposes an innovative procedure of integrating three data envelopment analysis (DEA) methods through the multiple- objective programming model to evaluate the efficiency of decision-making units (DMUs). The three DEA methods are (i) classical DEA, (ii) cross efficiency DEA and (iii) multiple criteria DEA. These DEA methods have intrinsic weaknesses in terms of discriminating power and ranking efficient DMUs. This paper combines these three methods to compensate for each other's weaknesses. A case study of designing the humanitarian logistics network (HTLN) system demonstrates that the integrated method performs well for designing the HTLN system effectively and efficiently.

IDENTIFYING TENSIONS IN THE U.S. THIRD PARTY LOGISTICS (3PL) INDUSTRY THROUGH PARADOXICAL LENS: GROUND MOVEMENT FOCUS

Supply Chain Management and Logistics

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1. *The University of Rhode Island*

This study extends paradox theory to 3PL domain by identifying paradoxes embedded in the 3PL firms, focusing on ground operations. Drawing upon Lewis's (2000) classes of paradoxes- learning, organizing, belonging and performance- a questionnaire is developed through a Delphi approach followed by a case study to identify the paradoxes within the 3PL firm's operations. We select UPS, DHL and FedEx as the sample companies. The developed questionnaire provides the guidelines to identify paradoxes within other sectors and the findings of this study can assist future researchers to determine the impact of the identified paradoxes within various settings in the firm.

Is Your Supply Chain Ready To Embrace Blockchain?

Supply Chain Management and Logistics

Dr . Naeem Bajwa [1]

1. *University of Arkansas at Little Rock*

This paper describes the evolution and current state of supply chain management and examines ways blockchain can improve current supply chain processes and activities. The paper examines the current use of blockchain technology in the agriculture, automotive, diamond mining, and transportation industries. Further, it discusses potential applications, risks, and challenges associated with the integration of blockchain technology and supply chain management.

Livestock Feedstock Sourcing and Transportation Planning

Supply Chain Management and Logistics

Dr . EunSu Lee [1]

1. *New Jersey City University*

The Korean hay market has been steadily growing in transactions due to increased beef consumption. Korean feedstock importer has been operating a local factory in the United States to improve the procurement process and acquire sustainable supply. This study utilizes the Geographic Information System (GIS) to predict production and to estimate effective intermodal freight transport routes. The study uses mixed integer programming to find the best transportation options and suppliers based on the existing feedstock factory. Preliminary results of the study show that the location of inter-modal terminals is one of the critical factors of production site.

Panel Proposal - Strengthening Undergraduate Research in the Interdisciplinary Logistics and International Trade Program

Supply Chain Management and Logistics

Dr . ANSHU ARORA [1], *Dr . Amit Arora* [1], *Dr . Mohamad Sepehri* [1], *Dr . Pradeep Behera* [1], *Dr . Malva Reid* [1], *Ms . Mayumi Fleming* [1], *Ms . Brea Ellis* [1], *Mr . kyle kelley* [1], *Ms . Rosslynne Terry* [1]

1. *University of the District of Columbia*

This panel focuses on the development of STEM-Business focused Logistics and International Trade (LIT) program by incorporating supply chain, logistics, and international trade analytics curricula; and fostering undergraduate student research in LIT areas across two schools: School of Business and Public Administration, and School of Engineering and Applied Sciences. The LIT program through LIT Analytics Center will augment existing engineering and business programs through multidisciplinary courses in global logistics, supply chains, transportation, international trade, business research and analytics, entrepreneurship, and international business. This panel focuses on how undergraduate research transforms students as leaders in 21st Century workforce (NSF Grant# 1912070).

PREDICTING REMANUFACTURED PRODUCT FRAUD USING NEURAL NETWORKS

Supply Chain Management and Logistics

Mr . Aditya Pandit [1], *Dr . Surendra Gupta* [1]

1. *Northeastern University*

Fraud in remanufacturing is a rarely touched upon topic of research primarily due to the lack of its observable volume in remanufacturing industry compared to conventional manufacturing. Previous research has targeted related topics that include warranty policy, maintenance and pricing strategies. Neural networks (NN) have been found to be effective in detecting & targeting credit card fraud, this paper attempts to adapt these NN models to tackle the issue of remanufacturing warranty fraud. Setting up such models would allow remanufacturers to not only preempt fraud but also to distinguish between fraudulent methods and the sources from where they originate.

Pricing Modeling for New and Remanufactured Products Across Generation in an Equilibrium Environment

Supply Chain Management and Logistics

**Ms . Liangchuan Zhou** [1], **_Dr . Surendra Gupta_** [1]

1. _Northeastern University_

The concept of environmentally conscious manufacturing and product recovery (ECMPRO) has been extended from remanufacturing to the view of marketing issues in a closed-loop supply chain. Pricing decision for new and re-manufactured products is critical to the survival of both items. Manufacturers and retailers, as the key members in supply chains, address pricing policies for different items to maximize their profits. This paper exhibits the price models for a manufacturer, a remanufacturer, and a retailer in the Nash equilibrium environment. The demand is based on customer's perceived value. The results show optimal wholesale prices and retail prices for each product.

Smart Compassion VR: Engaging donors with virtual reality to donating cash for disaster relief

Supply Chain Management and Logistics

Mr . Hee Yoon Kwon [1] **_, Dr . Koray Ozpolat_** [1] **_, Dr . Anis Triki_** [1]

1. _The University of Rhode Island_

We designed a virtual reality experience that is intended to promote cash donation to disaster relief. More cash donation will alleviate the problem of material conversion, aggravated by unsolicited material donations. We explore the effect of media immersiveness on change of behavioral intention, mediated by user engagement, sense of presence, and compassionate locus of control (C-LOC).

Supply Chain Integration through Supplier Satisfaction

Supply Chain Management and Logistics

Mr . James Gravier [1], *Dr . John Visich* [1], *Dr . Pedro Reyes* [2], *Dr . Michael Gravier* [1]

1. Bryant University , 2. Baylor University

In this research we investigate the performance requirements the customer should meet in order to satisfy the needs of the supplier. In this scenario we have supplier service (internal facing) and supplier satisfaction (external facing). Through supplier service activities the customer creates supplier satisfaction. Customer satisfaction and supplier satisfaction can strengthen the relationship between the supplier and the customer, thereby creating a higher opportunity for supply chain integration. We focus our research on the drivers of supplier satisfaction in the three categories of Communication, Financial and Process and make propositions on their contribution to supplier satisfaction and supply chain integration.

Supply Chain Performance Dynamics in the Presence of Product Deletion: A System Dynamics Approach

Supply Chain Management and Logistics

Dr . Seyedehfatemeh Golrizgashti [1] **_, Dr . Seyed Hossein Hosseini_** [2] **_, Dr . Qingyun Zhu_** [3] **_, Dr . Joseph Sarkis_** [4]

1. _Islamic Azad University_ , **2.** _CEO, Model-Based Management Systems Institute (SAMAM)_ , **3.** _The University of alabama in Huntsville_ , **4.** _Worcester Polytechnic Institute_

Diverse product portfolio breadth and depth increase sales and profit; but also increase resource consumption, operational complexity, and reduce supply chain efficiency and agility. Products may be deleted for many organizational reasons. Limited literature has exposed such decision to supply chain management domain. In this study, system dynamics methodology is deployed to exam and measure product deletion impact on the core supply chain inter-related systems. A conceptual framework is built upon causal loop diagrams and stock-flow diagrams. Simulation findings indicate the performance change amongst supply chain systems through product deletion processes. Research and managerial implications will be discussed.

Supply Chain Resilience: An Adaptive Cycle Approach

Supply Chain Management and Logistics

Dr . Henry Adobor [1]

1. QUI

This research uses the adaptive cycle heuristic to explore supply chain resilience. The key insight is that the adaptive cycle concept can broaden our understanding of supply chain resilience because it shares resilience and complex systems dynamics with supply chain networks. As a heuristic, the adaptive cycle can explain the mechanisms that support or prevent resilience in supply chains, including our understanding of cross-scale resilience. Adaptive cycles may also give us new insights into the sort of competences required to avoid stagnation and promote resilience over time. The research extends the literature on supply chain resilience.

The Effects of Blockchain Application in Port Competitiveness: Multi-Theoretical Approach

Supply Chain Management and Logistics

Mr . Leo Hong [1]*, Dr . Douglas Hales* [2]

1. *University of Rhode Island ,* **2.** *The University of Rhode Island*

Although a few studies focus on using blockchain technology in supply chain applications, there is no comprehensive on the blockchain applications in the maritime shipping supply chain. Consignors, forwarders and shipping companies can be exposed to high transaction costs under a high level of uncertainty. We argue that blockchain limits/reduce opportunistic behavior, the impact of environmental and behavioral uncertainty which would lower the total transaction costs of searching, negotiating, and monitoring, as it allows for transparent and valid transactions. We conduct a comprehensive blockchain application and empirically evaluate its effects on port competitiveness based on RBV, TCE, and balanced theory.

Supply Chain Management and Logistics - Papers

An integrated model to design a multi-period and product closed loop supply chain considering the service level

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This paper presents a model to design a closed loop supply chain network. In this model, we consider multiple time periods, multiple products, multiple objectives and uncertainty on the supply and demand. We use an integrated approach to solve our model. Making better decisions strategically, tactically and operationally are obtained from our model.

Keywords: Network Design, Uncertainties, Service level, Substitution.

In closed loop supply chain (CLSC), the process of raw materials procurement, manufacturing products and satisfying the market demand with finished products is called forward supply chain flow (Sadeghi Rad & Nahavandi, 2018). On the other hand, collecting the returned products, inspecting them and apply the recovery process to maximize the utilization of the product represents the reverse flow of the CLSC. Companies have implemented the concept of CLSC due to environmental and government forces, customer awareness and the rapid increase in market competition (Ilgin & Gupta, 2010a). Although of the above reasons, CLSC has shown its capability in improving the company profit and reducing potential risks on the environment (Pazhani, Ramkumar, Narendran, & Ganesh, 2013).

Planning for CLSC can be done by three types of decisions: strategic decisions, tactical decisions, and operational decisions. Strategic decisions, also known as design decisions, are long-term planning horizon where it is impossible to modify them after the decision is made. Choosing a location or number of facilities to open is an example of the design decisions. Tactical decisions find themselves between strategic decisions, long-term planning, and operational decisions, short-term planning. They are the mid-term planning horizon which is used for selecting which transportation mode to use, for example. The short-term planning horizon, operational decisions, can represent the determination of the number of products to manufacture or ship (Pochampally, Nukala, & Gupta, 2009). The network design of CLSC refers

to the strategic and tactical planning for the CLSC. Although there are a large number of researches in the area of design CLSC network, there is still a need to develop models that would capture all the decisions in one model.

The available literature review on design CLSC network considering multiple objectives indicates that the majority of researches considered only economical objective, maximize profit or minimize the total cost, and environmental objective, reduce the carbon emission (Amin & Zhang, 2013; Gupta & Ilgin, 2018; Ilgin & Gupta, 2010b; Ilgin, Gupta, & Battaïa, 2015; Mardan, Govindan, Mina, & Gholami-Zanjani, 2019; Paksoy, Pehlivan, & Özceylan, 2012; Papen & Amin, 2019; Pazhani & Ravi Ravindran, 2018; Sadeghi Rad & Nahavandi, 2018; Shi, Liu, Tang, & Xiong, 2016). However, only a few studies consider the objective of maximizing the service level of demand zone (Pazhani et al., 2013; Ramezani, Bashiri, & Tavakkoli-Moghaddam, 2013; Zarandi, Sisakht, & Davari, 2011).

This paper presents a model consists of three objectives. The first objective is to minimize the total cost of the CLSC network. This includes the cost of opening a facility, cost of processing products, cost of transportation product, cost, cost of purchasing raw material and cost of substituting products. The second objective is to minimize the carbon emission resulted from the production process, using a transportation mode to ship products and disposal of unuseful products. Maximizing the level of service of the demand zones. This model consists of multiple periods and multiple products, and it considers product demand and the number of returned product uncertainty. Due to the multiple objectives and the uncertainties considered, our model is an integrated model of goal programming and robust optimization approaches. Moreover, our model allows product substitution because the demand stream of the new and remanufactured product should be separated (Ahiska, Gocer, & King, 2017) and its positive impact on the service level (Lang, 2010). The results of our model assist the supply chain decision-maker to plan for the CLSC network by taking strategic decisions, the optimal number of facilities to operate, tactical decisions, transportation mode to select, and operational decisions, amount of raw material to purchase, amount of products to process and ship between facilities in the CLSC network in each time period.

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COMPARISON OF KOREAN, JAPANESE AND GERMAN CASES BY LIFE CYCLE OPTION SELECTION FOR MATERIAL-BASED CO_2 SAVING RATE AND COST

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ABSTRACT

These days, depletion of natural resources and global warming have become more serious issues beyond countries. In the industrial field, assembly products such as electronic products should be disassembled for recycling and reuse to deal with environmental issues. Reuse and recycling can contribute to reducing CO_2 emission as well as reduction of natural resources since CO_2 emission for virgin material production can be saved by using reused parts and recycled materials. However, each part of selling revenue and CO_2 emissions depends on countries because of the different energy mixes of electronic power. Each collected part embedded in end-of-life (EOL) products needs to be selected life cycle option based on its remaining life. Life cycle option selection is to decide reuse, recycling, and disposal for each part environmentally and economically. This study analyzes Korean, Japanese and German cases' life cycle option selection. The assembly products are produced in Japan used and collected in each country.

Keywords: Assembly products, Disassembly, Recycling and Reuse, CO_2 saving rate and cost

1. INTRODUCTION

These days, the world population is about 7 billion, and also the population is still increasing now. People use assembly products such as home appliances and automobiles made of a variety types of natural resources. On the other hand, global warming is also identified as one of the serious environmental issues. The depletion of natural resources and the global warming are to be more serious environmental issues in these days. In the industrial field, an assembly product is disposed of such as electronic products even though they still have some useful parts/materials inside for recovery by reuse and recycling [1]. Life cycle option selection is to make each part reused, recycled and disposed of by disassembly [2][3]. Reuse and recycle can reduce not only the cost but also the environment loads instead of the using virgin material and parts. In the previous study, CO_2 emission recovery and cost reduction were achieved through the disassembly process. However, conditions of products and the price of multiple countries were not considered [2]. This study analyzes Korean, Japanese and German cases which are used for getting an economical value in the same CO_2 saving rate with each part's life cycle option selection by comparing each data.

2. METHOD

In this section, procedures of this research, and system boundary for CO_2 emission and cost is described.

1) Estimation of material based CO_2 saving rate and cost of 4-usage computer parts

The CO_2 emission for each part of the computer is estimated based on the Life Cycle Inventory (LCI) database using the Bills of material (BOM) of the computer. Disposal cost, sales of material, landfill cost

and disassembly cost are calculated by the Recyclability Evaluation Method (REM) software by Hitachi Ltd [2].

2)   The formulation for selecting disassembly parts

Each part will be selected using 0-1 integer programming [4] and ε constraint method [5] to be reused, recycled and disposed of for achieving the target CO_2 saving rate in each country. Obsolescence and a disassembled precedence relationship in the disassembly process are also considered.

3)   Comparison of Korean example with Japanese and German cases

The life cycle option of each part will be different among the 3 countries since revenues of reused parts are different. That thing is compared and analyzed to find an optimal place for the environment and economy [2].

In this study, CO_2 emission of the computer is considered from raw material production level to the material production level regarding Life Cycle Assessment (LCA) [6][7].

3.   FOMULATION & ASSUMPTION OF THIS RESEARCH

In Hasegawa et al. (2019) [2], the parts disassembly is operated with two objectives for economy and environment. The economical objective is to minimize recovery costs in Eq. (1). It consists of reuse, recycling, disassembly, and treatment cost. In reuse cost of the Eq. (1), the obsolescence of the parts causes the reuse cost depreciation. The straight-line method is used as well as [2] for estimating cost on usage year and each country's used data about the cost depreciation.

On the other hand, the environmental objective in Eq. (2) is to maximize the total CO_2 saving rate when parts are reused or recycled. The CO_2 saving rate is defined as a ratio of saved CO_2 volumes by reuse and recycling against total CO_2 volumes for a virgin material production. Each notation is as follows :

i : index for the predecessors of part j with task j
j : Index of parts/tasks($j = 1,2, ...,N$)
N : Numbers of parts
u : Usage year
l_j: Life expectancy of part j
$Ctre_j$: Treatment and disposal cost of part j
Crs_j: Reuse cost of part j
$Cdis_j$: Disassembly cost of part j
e_j: CO_2 saving rate at part j

$$C = \sum_{j=1}^{N} Ctre_j x_j + \sum_{j=1}^{N} Crs_j \frac{l_j - u}{l_j} y_j + \sum_{j=1}^{N} Cdis_j (x_j + y_j) \rightarrow Min \tag{1}$$

$$E = \sum_{j=1}^{N} e_j (x_j + y_j) \rightarrow Max \tag{2}$$

$$E \geq \varepsilon_{CO2} \tag{3}$$

$$z_i \leq z_j \quad \forall i \in P_j, \quad \forall j \in J \tag{4}$$

$$x_j + y_j + z_j = 1, \quad \forall j \in J \tag{5}$$

$$uy_j < l_j, \forall j \in J \tag{6}$$

E : Total CO_2 saving rate of parts
C : Total recovery cost of parts`

ε_{CO2}: Constraint of total CO_2 saving rate of selected parts

P_j : Set of tasks that immediately precede task j at part j

x_j: Binary value: 1 if part j is recycled, otherwise 0

y_j: Binary value: 1 if part j is reused, otherwise 0

z_j: Binary value: 1 if part j is crushed and disposed of, otherwise 0

0-1integer programming and the ε constraint method are used for solving the life cycle option selection in this research. To achieve both goals in this study two objectives function as shown in Eq. (1) and (2) are used. The environmental objective function in Eq. (2) is transposed to the ε constraint as shown Eq. (3). By using the ε constraint method, two objectives can be attained simultaneously. Eq. (4) ensures a disassembly precedence relationship in each disassembly task on the assembly product. Eq. (5) shows that only one operation can be applied, and each part will be reused, recycled, or disposed of, in this situation. Eq. (6) is that a usage year cannot be exceeded each part's usage years which does not exceed its life expectancy.

In this research, numerical experiments were operated using the GLPK model [8] with 0-1 integers programming and ε constraints for finding solutions. Research assumption is as follows:

● Sales revenues for reused parts in Korean case are surveyed in Korea Auction (www.auction.co.kr) [9], and Joonggo-nara (https://cafe.naver.com/joonggonara) [10] which are the biggest internet market site in Korea. The other two cases for prices in [2] are also used for Japanese and German cases.

● Disassembly cost in each country (Korea and Germany) is calculated using each minimum wage rates based on Japanese data.

● Treatment and disposal costs are estimated based on Starbucks index (https://www.finder.com/starbucks-index) [11] rates based on the price of Japanese.

● For considering the life expectancy for each part, products onto this research assumed 4years usage computer in all countries.

● The original product was produced in Japan, used anywhere and then collected in Korea, Germany, or Japan.

● All currency in this research is the Japanese Yen [¥]. A negative value on cost means profit.

● The target total CO_2 saving rate changed from 0 to 100% to obtain solutions by selecting reused, recycled and disposed parts while minimizing total cost.

4. COMPARISON OF INPUT COST DATA AMONG 3 COUNTRIES

In Figure 1, each country`s data onto reused and the recycled cost are surveyed and compared. Regarding costs, under than 0 is a positive value which means profits. Average [K] which is shown as a horizontal line means the average recovery cost in Korea. Almost the costs of German parts are the highest. The German average cost -140.31[¥] is almost 4 times lower than the Japanese -35.48[¥], and 1.6 times lower than Korean -85.78[¥]. But, in the side of cost efficiency, German case for reusing, and recycling is the best solution example, #2 Cable, #9 Big fan cover, and #12 Speaker only German have a positive profit through reusing and recycling. However, this situation always does not happen in all parts. In the case of #10 Small fan, and #11 Inside switch, the German parts have the lowest cost among 3 countries, although
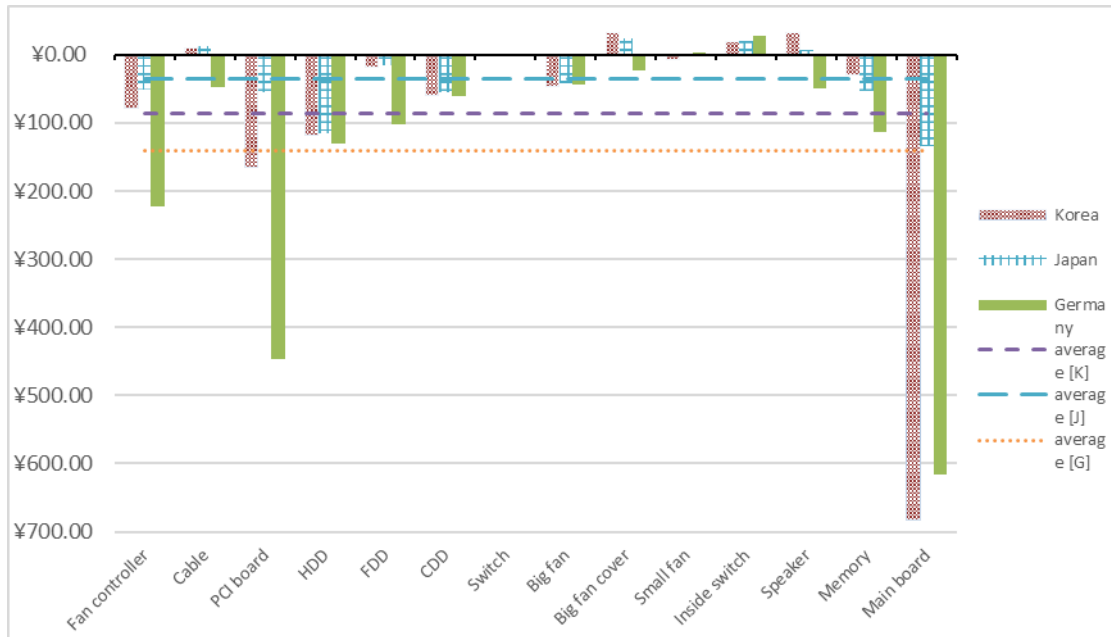
Fig.1 : Comparison of 3 countries about reuse and recycling cost of each part

the total cost is covered with other products. If this research considers the other costs when products are exported or collected such as transportation cost and CO_2 emission, also Japanese case can be a good option in some parts such as #4 HDD, #6 CDD, #8 Big fan, and #10 Small fan. These 4 parts are made of Al/Al alloy which takes a big weight portion of the whole product about over 50%. In case of #4HDD, the cost difference is only -16.35[¥], #6 CDD of the difference is -4.75[¥], #8 Big fan is -5.03[¥], and #10 Small fan is -4.23[¥]. However, these 4 parts in the Japanese case have small gaps among 3 countries' data by considering the weight of the part. Thus, can be enough to reuse or recycle parts in Japan.

In the case of #14 Mainboard which has the lowest cost in all parts of the product, and 10 years of life expectancy, it is only over 600[¥] in the computer parts in Korean case. The Korean cost of this part is 5 times higher than the Japanese one for -134.91[¥], and even 1.1 times higher than the German one for -615.24[¥]. Therefore, #14 Mainboard should be collected in Korea.
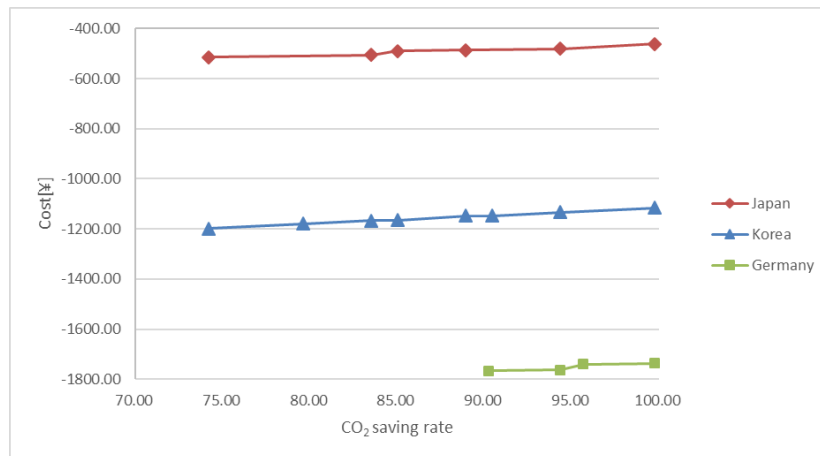
Fig.2 : Comparison of total reused and recycled cost among 3 countries

It is found that recycling and reusing, the German is definitely the best choice for recycling and reusing among 3 countries on the economical side. However, in this research, it should be considered not only economical but also environmental factors through the disassembly process. For example, #14 Mainboard

in the Korean case, and #4HDD, #6 CDD, #8 Big fan, and #10 Small fan in the Japanese case, each factor can make a different result with part's status. For example, if a decision maker considers a lot of situations such as tax, policy, and system in the country, product selection can be operated in different places. By considering many factors not the only side of cost, it is checked that each place has enough merit for the environmental and economic side through disassembly works.

Fig.2 shows the total cost of each target saving rate in each country. 3 lines almost had the same shape in this figure. When the higher CO_2 saving rate is, the more cost will be paid than the lower rate. It proved that these 3 countries can have the same behaviors when they want to reach CO_2 reduction through the disassembly process. In Fig.2, a trade-off relationship could occur in any countries which wants to use recycled and reused parts for the economical and environmental side. In this section, recycled cost and reused cost in each country are described in the same figure.

5. RESULTS OF LIFE CYCLE OPTION SELECTION

In these days, when a product is made, materials are from over the world. Because of this global supply chain, countries share responsibility on products and materials for saving natural resources and preventing CO_2 emission [12]. By collaborating with each country, it can enhance environmental and economic efficiency.

5.1 RESULTS OF KOREA LIFE CYCLE OPTION SELECTION

Table .1 Life cycle option selection of 4-usage-computer in Korean BOM

No.	Partname	Material type	Total Weight [g]	Cost [C] Reuse $Crs_j + Cdis_j$	Cost [C] Recycle $Ctre_j + Cdis_j$	CO_2 saving rate.	Life expectancy	Target CO_2 Saving rate(%) 0~75	75~80	80~84	84	85~89	89~91	91~95	95~
1	Fan controller	Circuit board	50	-77.92	0.00	0.24	10	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse
2	Cable	PVC	220	25.76	9.66	1.57	10	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle
3	PCI board	Fe	300	-165.76	0.00	32.50	10	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse
4	HDD	AL/AL alloy	1500	-43.04	-117.41	12.32	5	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle
5	FDD	AL/AL alloy	500	5.38	-18.83	4.11	5	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle
6	CDD	AL/AL alloy	1000	7.11	-59.63	8.22	5	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle
7	Switch	Circuit board	50	0.00	0.00	0.24	10	Dispose	Dispose	Dispose	Dispose	Dispose	Dispose	Dispose	Dispose
8	Big fan	AL/AL alloy	1000	25.05	-47.32	8.22	5	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle
9	Big fan cover	Fe	100	0.00	32.37	10.83	10	Dispose	Dispose	Dispose	Recycle	Dispose	Recycle	Recycle	Recycle
10	Small fan	AL/AL alloy	500	10.94	-6.52	4.11	5	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle
11	Inside switch	Fe	50	0.00	18.76	5.42	10	Dispose	Recycle	Dispose	Dispose	Recycle	Recycle	Dispose	Recycle
12	Speaker	SUS	300	31.58	31.83	9.35	10	Dispose	Dispose	Reuse	Dispose	Reuse	Dispose	Reuse	Reuse
13	Memory	Circuit board	100	-30.42	0.00	0.48	10	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse
14	Main board	Circuit board	500	-683.73	0.00	2.39	10	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse
	Total		6170.00	-541.99	-25.85	100.00	Total rate	74.16	79.58	83.51	84.99	88.93	90.41	94.34	99.76
	Average		440.71	-74.80	-1.85		Total cost	−1197.87	−1179.11	−1166.29	−1165.50	−1147.53	−1146.73	−1133.91	−1115.15

As to refer table 1 called as BOM, table 1 shows each part's CO_2 saving rate, cost for reuse and recycle, material type, name, weight and life expectancy for 4 usage-year the computer in Korea. Total cost means that how much cost is required through reuse and recycle. The sum of the CO_2 saving rate shows the CO_2 saving rate of disassembled parts. 8 solutions were found through numerical experiments. In the reuse parts, #1 Fan controller, #3 PCI board, #13 Memory, and #14 Mainboard were identified in all target CO_2 saving rates. This is because the reuse cost of these parts is lower than the recycle cost as shown in table 1. Additionally, the #3 PCI board has the highest CO_2 saving rate among the parts. In the recycled parts, #2 Cable, #4 HDD, #5 FDD, #6 CDD, #8 Big fan, and #10 Small fan were also recycled in all rates as well as reused parts. The part #2 Cable was only found with the recycled parts which have a high recycle cost. The other parts for #7 Switch, #9 Big fan cover, #11 Inside switch, and #12 Speaker could be disposed of by changing the target CO_2 saving rates.

In 0-75% on the target CO_2 saving rate, 4 parts for #7 Switch, #9 Big fan cover,   #11 Inside switch and #12 Speaker were disposed, even though they had longer remaining life expectancy. However, when the total CO_2 saving rate was becoming higher to 99.76%, #9 Big fan cover, #11 Inside switch, and #12 Speaker were switched to be reused or recycled for attaining higher CO_2 saving rate.

As the target CO_2 saving rate was becoming higher, some parts were reused or recycled. For example,

for the #11 Inside switch, it was recycled in 75-80% of target CO_2 saving rate. However, part #11 was turned to be disposed of in 80-84%. A similar situation also happened in other parts, either recycling or reusing process was operated such as #9 Big fan cover and #12 Speaker.

In disassembly, when some of the parts are disassembled, they have disassembly precedence relationships among disassemble tasks. According to the disassembly precedence relationship of computer in this research, #2 Cable has to be removed to disassemble the parts #4 HDD, #5 FDD, and #6 CDD. Thus, #2 Cable should be recycled, because recycling #4 HDD, #5 FDD, and #6 CDD can earn more profits by part's revenue and increasing CO_2 saving rate instead of disassembling other parts, even though #2 Cable has lower CO_2 saving rate (1.57%) to relative the cost 13.31[¥] compared with the other parts. Compared to those 6 recycled parts, only #2 Cable was recycled although it was difficult to earn profit by selling recycled materials.

In this section, the part was recycled, reused or disposed of depending on getting the CO_2 saving rate while attaining optimal cost reduction. Those situations also occur regardless of the country.

5.2 COMPARISON OF LIFE CYCLE OPTION SELECTION AMONG 3 COUNTRIES

Table .2 Comparison of Life cycle option selection of each part among 3 countries

No.	Partname	Material type	Total Weight [g]	Korean CO₂ Saving rate(%)								Japanese CO₂ Saving rate						German CO₂ Saving rate			
				0~75	75~80	80~84	84	85~89	89~91	91~95	95~	0~75	75~84	84	85~89	89~95	95~	0~91	91~94	95	96~
1	Fan controller	Circuit board	50	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse
2	Cable	PVC	220	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Reuse	Reuse	Reuse	Reuse
3	PCI board	Fe	300	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse
4	HDD	AL/AL alloy	1500	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle
5	FDD	AL/AL alloy	500	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle
6	CDD	AL/AL alloy	1000	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle
7	Switch	Circuit board	50	Dispose	Dispose	Dispose	Dispose	Dispose	Dispose	Dispose	Dispose	Dispose	Dispose	Dispose	Dispose	Dispose	Dispose	Dispose	Dispose	Dispose	Dispose
8	Big fan	AL/AL alloy	1000	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle
9	Big fan cover	Fe	100	Dispose	Dispose	Dispose	Recycle	Dispose	Recycle	Recycle	Recycle	Dispose	Dispose	Reuse	Dispose	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse
10	Small fan	AL/AL alloy	500	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Recycle	Dispose	Recycle	Dispose	Recycle
11	Inside switch	Fe	50	Dispose	Recycle	Dispose	Dispose	Recycle	Recycle	Dispose	Recycle	Dispose	Dispose	Dispose	Recycle	Dispose	Recycle	Dispose	Dispose	Recycle	Recycle
12	Speaker	SUS	300	Dispose	Dispose	Reuse	Dispose	Reuse	Dispose	Reuse	Reuse	Dispose	Reuse	Dispose	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse
13	Memory	Circuit board	100	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse
14	Mother board	Circuit board	500	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse	Reuse
	Total		6170.00	74.16	79.58	83.51	84.99	88.93	90.41	94.34	99.76	74.16	83.51	84.99	88.93	94.34	99.76	90.23	94.34	95.65	99.76
	Average		440.71	-1197.87	-1179.11	-1166.29	-1165.50	-1147.53	-1146.73	-1133.91	-1115.15	-514.19	-506.48	-489.68	-485.79	-481.97	-461.28	-1766.65	-1763.63	-1739.69	-1736.67

Table 2 shows each solution under the target CO_2 rate, total recovery cost, and total CO_2 saving rate. Compared to Korean CO_2 saving rate with Japanese case, total 6 solutions, have the same percentage as Koreans except 2 solutions. Due to in a different selection results between two countries, only one part #9 Big fan cover was treated as reusing in Korean case. Because of the treating method which is a good way to get a profit between reusing and recycling in each country. Comparing German case, #2 Cable, and #9 Big fan cover were handled by different ways of Korean and Japanese cases. Therefore, each reused market of country's prices contribute that which parts will be selected for reuse, recycling or disposal.

6. CONCLUSION AND FUTURE STUDY

In this research, the 3 countries have each solution for attaining a target CO_2 saving rate using life cycle option selection and BOM which contains CO_2 saving rate, recovery cost, the weight of each part, and material type about the 4-usage computer.

- CO_2 saving target rate was achieved in each country by considering two factors for environment and economic. This research applied 0-1 integer programming (Hiller and Lieberman, 2005) and the ε constraint method (Eskandarpour et al., 2015) to disassembly parts selection to achieve two objectives simultaneously.

- In the Korean case, the parts of the computer are recycled, reused, and disposed of as follows each type in table 1. In table2, each part had a method for reuse, recycle, and disposal in country. Because

they have a different format of market, reused cost and wage even though the same product is used. Thus, cost revenue can be different in collected and disassembled countries.

- The different values of each part in a different country, in comparison Korean, Japanese, and German cases, the Korean solutions were similar to the Japanese case excluding total cost. In contrast, only the German case had solutions starting at a higher total rate such as over 80% and lower cost by the reused highest cost of three countries. This is because that German cases had highest 6 revenues of reused selling parts Thus, only if the cost of efficiency is considered, most of the parts should be collected in German because high revenue can be gotten as attaining the same high CO_2 saving rate at the same time.

- In this research, two object functions were considered for economy and environments. The Japanese case was not a better choice than Korean and German cases for reuse and recycle in terms of cost aspects. However, if this research also considers the cost of the transportation fee, tax and weight of parts, results can be different.

FUTURE WORK

Further researches should apply other factors such as transportation and tax among 3 countries. The other reducing process like refurbishment can be accepted.

ACKNOWLEDGE

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HUMANITARIAN LOGISTICS NETWORK DESIGN WITH INTEGRATED DATA ENVELOPMENT ANALYSIS METHOD

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ABSTRACT

This paper proposes a new procedure of integrating three data envelopment analysis (DEA) methods through the multiple objective programming (MOP) model to evaluate the efficiency of decision-making units (DMUs). The three DEA methods are (i) conventional DEA, (ii) cross efficiency DEA (CEDEA), and (iii) multiple criteria DEA (MCDEA). The conventional DEA method has an intrinsic weakness in terms of discriminating power due to its nature of self-evaluation. The other two methods, CEDEA and MCDEA, are proposed to overcome a weak discriminating power of the conventional DEA method but turn out to show a few weaknesses too. This paper combines these three methods to compensate for each other's weaknesses. A case study of designing the humanitarian logistics network (HTLN) system for South Carolina demonstrates that the integrated approach performs well in terms of developing the HTLN system effectively and efficiently.

KEYWORDS

Data Envelopment Analysis, Multiple Objective Programming, Humanitarian logistics network,

INTRODUCTION

The conventional DEA produces a single, comprehensive measure of performance for each DMU. The best ratio among all the DMUs would identify the most efficient DMU, and every other DMU would be rated by comparing its ratio to the best one. However, a weakness of the DEA-based assessment is that a considerable number of DMUs out of the set of DMUs to be rated are classified as efficient so that it may suffer from a lack of discrimination particularly. DEA allows each DMU to be evaluated with its most favorable weights due to its nature of the self-evaluation. To remedy this critical deficiency, the cross-efficiency DEA (CEDEA) method is suggested by Sexton et al. (1986) as a DEA extension to rank DMUs with the main idea of

using DEA to do the peer evaluation, rather than the conventional DEA's pure self-evaluation. They (1986) construct a CE matrix that consists of two evaluation results, the self-evaluation and the peer-evaluation. It can usually provide a full ranking for the DMUs to be evaluated and eliminate unrealistic weight schemes without requiring the elicitation of weight restrictions from application area experts (see Anderson et al., 2002).

Li and Reeves (1999) propose a multiple criteria DEA (MCDEA) model under the framework of multiple objective linear programming (MOLP). The MCDEA model involves a broader definition of relative efficiency that the conventional DEA introduces. In other words, several different efficiency measures are defined under the same constraints. Each measure serves as a criterion to be optimized. However, they (1999) do not explain how to rank DMUs but merely show which DMUs are more efficient than other DMUs by solving the MCDEA sequentially with one objective out of three objective functions. A DMU, which is consistently efficient regardless of the objective function, is considered to be more efficient. Then, if several DMUs turn out to be consistently efficient after evaluated by MCDEA, the question of how to rank them in terms of efficiency remains.

This paper proposes an innovative procedure for integrating these DEA methods by utilizing each method's strengths. The new integrated process starts with applying the conventional DEA method, which can identify and select efficient DMUs. Then, applying the MCDEA by a multi-objective programming approach for those selected efficient DMUs. Finally, various CE evaluation DEA methods are applied to rank the efficient DMUs using the results generated by the MCDEA. The proposed procedure would complement each other. The applicability of the proposed procedure is demonstrated for a humanitarian supply chain network (HTLN) design problem in a pre-disaster scenario, which consists of finding the optimal emergency response facility (ERF) locations and allocation scheme of humanitarian supplies through ERFs, where all ERFs are under the risk of disruptions.

HUMANITARIAN LOGISTICS NETWORK

In 2019, the UN warns that climate crisis disasters are happening at the rate of one a week, and such emergency events causing death, displacement, and suffering are occurring much faster than predicted. Indeed, many practitioners have insisted that adapting to the climate crisis

should be considered as one that needed investment immediately. In 2017, the U.S. experienced a historic year of weather and climate disasters. In total, the U.S. was impacted by 16 separate billion-dollar disaster events, including three tropical cyclones, eight severe storms, two inland floods, a crop freeze, drought, and wildfire. During 2018, the U.S. experienced a very active year of weather and climate disasters. In total, the U.S. was impacted by 14 separate billion-dollar disaster events: two tropical cyclones, eight severe storms, two winter storms, drought, and wildfires. The past three years (2016-2018) have been historic, with the annual average number of billion-dollar disasters being more than double the long-term average. The number and cost of disasters are increasing over time due to a combination of increased exposure, vulnerability, and the fact that climate change is increasing the frequency of some types of extremes that lead to billion-dollar disasters.

In this respect, the basic task of humanitarian logistics network (HTLN) comprises acquiring and delivering or providing disaster relief items such as medicine, drinking water, temporary shelter, food, and daily commodities that are vital to alleviate the suffering of people. The HTLN design has become an important strategic decision due to the major damage inflicted by several natural disaster events. Indeed, after emergencies, it is critical through emergency response facilities (ERFs) to distribute humanitarian aid to the affected areas efficiently and effectively for saving human lives and alleviating suffering, and for a rapid recovery. Van Wassenhove (2006) emphasizes that since the disaster relief is 80% logistics, it would follow that the only way to achieve this is through slick, efficient, and effective logistics operations and, more precisely, supply chain management.

Hong and Jeong (2019) consider an HTLN design problem, where they study the ERFs location-allocation decision for the efficient distribution of emergency supplies from the ERFs to the affected areas. The ERFs considered in this paper are three distinctive ones, as shown in Habib et al. (2016). They are (i) Central Warehouses (CWHs) or Distribution Warehouses (DWHs), where emergency relief commodities are stored, (ii) intermediate response facilities termed Relief Distribution Center (RDC) or Commodity Distribution Point (CDP), where people can more effectively gain access to relief goods, and (iii) neighborhood sites (NBSs) in need of humanitarian items.

The primary objective of the strategic level is to strengthen emergency preparedness as well as to select the most cost/distance-effective location of CWHs and CDPs among a set of candidate locations, to establish the distribution of emergency supplies throughout the HTSC, and to assign NBSs to CDPs and CDPs to CWHs. Determining such locations/allocations is a critical area in the design of an effective HTSC. However, traditional cost-based facility location models implicitly assume that located facilities will always be in service or be available and do not consider an associated risk of disruption. All facilities are susceptible to disruptions due to natural disasters, accidents, breakdowns, weather, or strikes. The effects of disruptions could be aggravated as a result of a lack of flexibility and interdependency in the HTSC.

This paper follows Hong and Jeong (2019) who formulate a goal programming model for HTLN design problem. The four objectives are considered simultaneously to design the HTLN. The first objective is to minimize the total logistics cost (TLC) consisting of the ERF facility cost and operating costs. The second one is to minimize the maximum coverage distance (MCD) such that each NBS is covered by one of CDPs, and each CDP is covered by one of CWHs within the endogenously determined distance.   The third objective is to maximize the expected amount of satisfied demands (ESD) by the ERFs, where each ERF is subject to disruptions, assuming that if an ERF is damaged or disrupted, it can't cover any demand that it is supposed to cover. The fourth goal is to maximize the covered demands in case of emergency (CDE), assuming that each location should be within a certain distance, D_c, of the nearest DRCs to be served in case of emergency (Deckle et al., 2005). Considering TLC and MCD to be minimized as two inputs and ESD and CDE to be maximized as two outputs, they apply the GP model to generate the decision-making units (DMUs), which are the optimal solutions produced by solving the MOP models for a given set of weights.

CASE STUDY

A case study using major disaster declaration records in South Carolina (SC) is considered. Forty-six counties are clustered based on proximity and populations into twenty counties. Then, one city from each clustered county is chosen, based on a centroid approach and assume that all population within the clustered county exists in that city. The distance between these cities is considered to be the distance between counties. The database also provides a list of counties

where a major disaster was declared. They assumed that when a major disaster is declared, the emergency facility in that county is disrupted and shut down. Based on the historical record and the assumption, the risk probability for each neighborhood (a county or a clustered county) is calculated. The potential five locations for CWHs were selected based upon population, the proportion of area that each location would potentially cover, and the proximity to Interstate Highways in SC.

SUMMARY AND CONCLUSIONS

Several weaknesses have appeared as the conventional DEA has been applied to a wide variety of evaluation areas. The conventional DEA evaluates DMUs in terms of self-evaluation, so a lack of discrimination power has been the major weakness of it. To remedy this weakness and increase the discrimination power, the several cross-efficiency (CE) evaluation DEA methods and the multiple criteria DEA (MCDEA) model have emerged.

The contribution of this paper is to propose an innovative procedure of identifying efficient DMUs and ranking them, by integrating three DEA methods, conventional DEA, MCDEA, and CEDEA method. To demonstrate the proposed procedure, this study uses the HTLN design problem, whose goal is to relieve and minimize the effects of a disaster. To design more balanced HTLN schemes, a GP model is applied to generate various HTLN schemes. Then, the proposed procedure to evaluate many HTLN schemes is implemented. Through the case study, it is observed that the integrated DEA method enhances the discriminating power of the conventional DEA and ranks the efficient DMUs more consistently than CEDEA. This paper shows that the proposed approach would be used as an important tool for designing various supply chain network systems more efficiently and effectively.

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IDENTIFYING TENSIONS IN THE U.S. THIRD PARTY LOGISTICS (3PL) INDUSTRY THROUGH PARADOXICAL LENS: GROUND MOVEMENT FOCUS

Abstract

This study extends paradox theory to 3PL domain by identifying paradoxes embedded in the 3PL firms, focusing on ground operations. Drawing upon Lewis's (2000) classes of paradoxes-learning, organizing, belonging and performance- a questionnaire is developed through a Delphi approach followed by a case study to identify the paradoxes within the 3PL firm's operations. We select UPS, DHL and FedEx as the sample companies. The developed questionnaire provides the guidelines to identify paradoxes within other sectors and the findings of this study can assist future researchers to determine the impact of the identified paradoxes within various settings in the firm.

Keywords: Third-party logistics (3PL), Paradox Theory, Case Study

Introduction:

Logistics and Supply Chain Management (SCM) research is dominated by theories derived from other research fields (Stock, 1997; Defee et al., 2010; Halldorsson et al., 2015; Sandberg, 2017). One of the theories that have been brought into Supply Chain Management from organizational studies is the paradox theory (Sandberg, 2017). Lewis (2000) mentions that increasing technological changes, global competitions, and workforce diversity has revealed and intensified paradoxes, leading to conflicting demands, opposing perspectives, or seemingly contradictory findings. Choosing among competing tensions might give a temporary performance relief to the firm, but in order to achieve long term sustainable goals, a firm should accept the presence of paradoxical elements in the system and attend them simultaneously (Lewis, 2000). Organizational effectiveness is inherently paradoxical; to be effective, an organization must possess attributes that are simultaneously contradictory, even mutually exclusive (Cameron, 1986).

The logistics industry is growing worldwide as more and more companies are outsourcing transportation, warehousing, and other logistics-related activities (Mitra, 2008). The principal reasons why companies use third-party services are a need to focus on core activities, to cut costs, and at the same time provide their customers with better standards of service (Sink and

Langley, 1997). A third-party logistics (3PL) business fulfills the demand for advanced logistics services, in such fields as, transportation, warehousing, freight consolidation and distribution, product marking, labeling and packaging, inventory management, cross-docking, product returns, order management, and logistics information systems (Rabinovich, Windle, Dresner, & Corsi, 1999). As companies are going global, the customers are becoming more impatient (Bai et al., 2018), therefore, to maintain service levels the 3PL firms are integrating sophisticated technologies leading to complex supply chains (Tang, et al., 2016). The U.S. 3PL industry has kept its growth in line with the global developments in this field. In 2018, according to USPS facts, the total package volume delivered by United States Postal Service alone was up to 6.2 billion packages, 100 percent more than 2010[1]. This growth trend has led to technological advances within the 3PL industry (Evangelista and Sweeney,2006), and as Lewis (2000) stated, the technological changes lead to complexities which result in differing tensions within the supply chains of the logistics companies. With the introduction of paradox theory in the supply chain, the researchers are increasingly adopting a paradoxical lens to understand and explain such differing tensions. Zhang, Yalcin, and Hales (2019) showed the trend of the occurrence of paradox sets is increasing in supply chain literature due to increasingly established global and complex network structures, which have led to more paradoxical elements being surfaced. Tensions such as competing demands between inventory level and inventory cost (Kull et al., 2012), adding route to the road network resulting in decreased efficiency (Braess paradox) (Frank, 1981), and tensions between short-term flexible supply partnerships and long term supply partnerships (Cerruti et al., 2016) are increasingly being faced by researchers and managers. In addition, issues related to company performance and sustainable initiatives (Coscieme et al., 2019; Brix-Asala et al., 2018; Smith and Lewis, 2011) in supply chain management (SCM) have been growing recently as well. Lewis (2000) enclosed paradox in four general classes: (i) learning, (ii) belonging, (iii) organizing and (iv) performing. This paper serves the purpose of identifying the paradoxical tensions inherent in the supply chains of the U.S. 3PL companies, focusing on ground operations, categorized in these four classes. It is important to identify these tensions because in order to create an effective organization (or a

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[1] USPS Facts 2018 (https://facts.usps.com/)

supply chain), paradoxes must be managed both internally among functions and externally in the interface towards other supply chain members (Sanberg, 2017).

We identify these tensions using a Delphi approach, followed by a case study. The Delphi approach is often used as a qualitative forecasting technique to investigate and understand the factors that influence or may influence decision-making on a specific issue, topic, or problem area (MacCarthy and Atthirawong, 2003). Case research provides an excellent means of studying emerging practices (Finch 1999) and provides methods for the development of the theory (McCutcheon and Meredith, 1993). Three 3PL companies, i.e., United Parcel Service (UPS), Federal Express (FedEx) and Deutsche Post (DHL) are selected for the research due to their dominant market share (17,162 USD Millions in 2018)[2] in the 3PL industry in the U.S. The theoretical contribution of this paper is to extend the paradox theory in the 3PL domain by identifying the paradoxical elements in the 3PL industry in the U.S.

Research Question:

R.Q.: *What paradoxes can be identified in the U.S. third party logistics companies?*

Literature Review:

Over the past 25 years, management scholars have sought to sharpen and apply paradox lens (Schad et al. 2016). In organization studies, some researchers define paradox as contradictions embedded within a statement (e.g., Murnighan & Conlon, 1991), human emotions (e.g., Vince & Broussine, 1996) or organizational practices (e.g., Eisenhardt & Westcott, 1988). Paradox studies adopt an alternative approach to tensions, exploring how organizations can attend to competing demands simultaneously (Smith and Lewis, 2011). Although choosing among competing tensions might aid short-term performance, a paradox perspective argues that long-term sustainability requires continuous efforts to meet multiple, divergent demands (Cameron, 1986; Lewis, 2000).

The four categories of paradox represent core activities and elements of organizations: learning, belonging, organizing, and performing (Smith and Lewis, 2011; Lewis, 2000). Hofstadter (1979) explains the learning paradox as follows: perceptions and actions are self-referential, relying, and

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[2] Armstrong and Associates, Inc. (https://www.3plogistics.com/3pl-market-info-resources/3pl-market-information/aas-top-50-u-s-third-party-logistics-providers-3pls-list/)

building upon themselves as actors attempt to change. Paradoxical tensions may reveal the need for learning, yet actors often use their extant cognitive and behavioral frames to construct new frames, trapping them within a double-blind (Bateson, 1973).

Organizing paradoxes arise when structuring the organization, and include conflicts between attributes such as commitment, trust, and creativity on the one hand, and efficiency, discipline, and order on the other side (Lewis 2000). The organizing paradox is closely related to the degree of collaboration (Mena, Humphries, and Wilding 2009) and tensions between control and flexibility (Lewis. 2000). Murnighan and Conlon (1991) found that string quartets require an authoritarian leader (first violinist) and democratic participation to achieve high performance. Also, they noted that quartets sharing a true love for or even obsession with their music were more likely to embrace conflicting needs for authority and democracy and to thrive. Quinn (1988) discovered that highly effective leaders display intricate and paradoxical behaviors and are capable of fostering consistency, stability, and control, as well as passion, courage, and wonder.

Belonging paradoxes are related to the issue of identity in the organization, which typically "foster tensions between the individual and the collective and between competing values, roles, and memberships" (Smith and Lewis 2011). A complex, worldwide supply chain with multiple participants, diverse cultural backgrounds, and different supply chain strategies has been recognized as a challenging task to manage for most supply chain organizations (Ganesan et al. 2009). Naisbitt (1994) used paradox to examine the rise of "universalism" as multinationals connect distant locales through central goals and advanced telecommunications, and the rise of "tribalism" as local groups seek to retain their ethnic and linguistic distinctions.

Performing paradoxes stem from the plurality of stakeholders and result in competing strategies and goals (Smith and Lewis, 2011). Tensions surface between the differing, and often conflicting, demands of varied internal and external stakeholders (Donaldson & Preston, 1995). In line with paradox theory, performance indicators such as costs, service, and lead times have been compared against each other and presented as trade-offs, dilemmas, or similar (Christopher, Peck, and Towill 2006; Trent and Monczka 2003).

Tensions are in existence among different goals and strategies in the logistics industry. Scholars have acknowledged the notion of trade-offs for a long time within the industry. However, these

trade-offs are mainly limited to tensions regarding operational performance in the physical flow of goods, typically cost vs. lead time considerations (e.g., Christopher, Peck and Towill 2006; Lowson 2001). So far, logistics researchers have lacked a more formal theoretical framework for the further identification of classification of the paradoxical elements present in the industry (Sandberg 2017).

According to Lieb (1992, p. 29), 3PL involves ''the use of external companies to perform logistics functions that have traditionally been performed within an organization. The functions performed by the third party can encompass the entire logistics process or selected activities within that process''. In a similar vein, (Coyle et al., 2003) suggest that 3PL involves an external organization ''that performs all or part of a company's logistics functions''. When logistics service is outsourced, the 3PL provider becomes a significant player in the supply chain process that brings products and services to end customers (Ellram, 1990). 3PL is affected by changes in the structure, processes, and strategies of the supply chain in which it is embedded, as highlighted in the works by Bask (2001) and Delfmann et al. (2002). The growing e-commerce has led to complex supply chain networks. Logistics companies are confronted with changes in their respective market environments (Delfmann et al., 2002). This complexity has given rise to tensions in the 3PL supply chains, which are identified in this paper.

Method:

In order to explore paradoxes in the 3PL industry, relevant literature is reviewed on the paradoxes and the 3PL industry. We select UPS, FedEx, and DHL as our targeted case companies. These companies being the big players in the logistics industry (Singh et al. 2006), allow us to have generalized enough findings. A questionnaire is developed through a Delphi approach to elicit insights about the paradoxical tensions within the supply chain of 3PL companies.

The Delphi Approach

Delphi study allows aggregation of opinions and extracts underlying topics in a structured manner (Seuring and Miller, 2008). This approach is a systematic, iterative process to elicit a consensus view from a panel of experts (MacCarthy and Atthirawong, 2003). The Delphi

approach uses a group of experts relevant to the subject to produce a more precise and more educated response than is obtainable from one individual. The method avoids group interactions of individuals, which may result in induced responses; therefore, it is different than brainstorming or other similar exercises. The panel in the Delphi method is selected on their experience and/or knowledge of the subject under consideration. Tavana et al. (1996) note that the Delphi method comprises three particular features:

(1) anonymity among the panel of experts;
(2) obtaining a statistical group response from a well-designed questionnaire; and
(3) controlled feedback.

In our case, the purpose of the Delphi study itself is to develop a questionnaire that works as a guide for the 3PL industry. However, we develop a pre-questionnaire that acts as a directing instrument for the experts to give in their knowledgeable responses for the development of the framework. This pre-questionnaire is developed based on the literature review, which is pre-tested with colleagues to check for clarity and consistency. A pilot study to validate the pre-questionnaire is conducted with experts who have the knowledge of paradoxes and 3PL in order to provide comments and feedback. The questions are revised and finalized with input from the experts.

Once the pre-questionnaire is finalized, a panel of experts is designed to have representatives from academia, consultancies, and industry. The panelists are chosen based on their experience and knowledge regarding the topic being investigated. Pre-questionnaire is emailed/mailed to the panelists, followed by a reminder email within 20 days. The questions are open-ended and allow participants to provide and express their opinions or add information freely and independently. Delphi study being an iterative process, responses are summarized and redistributed for discussion for the next round. Through a process of convergence, this continues until a consensus is reached. Once the questionnaire is finalized, Lawshe's (1975) ratio is calculated for each question in the questionnaire to quantify the face validity. CVRi is computed as follows

$$CVRi = (n_e - \frac{N}{2})/(n_e/2)$$

Where n_e is the number of Subject Matter Experts (SMEs) indicating the measurement item i as essential and N is the total number of SMEs in the panel. Lawshe (1975) further established minimum CVRis for different panel sizes, shown in figure 1.

No. of Panellists	Minimum Value
5	.99
6	.99
7	.99
8	.75
9	.78
10	.62
11	.59
12	.56
13	.54
14	.51
15	.49
20	.42
25	.37
30	.33
35	.31
40	.29

Figure 1: Lawshe (1975) minimum value of CVR for different panel sizes.

The Case Study

Following the approval of content validity ratio, personal, in-depth, on-site interviews are conducted with each manager. Recent research has observed mid-management to play essential roles during overall organizational transformation (Huy, 2002), corporate restructuring (Balogun, 2003; Balogun and Johnson, 2004), strategy shifts (Rouleau, 2005), or structural role redefinitions (Currie and Procter, 2005). In our research, we interview Mid-Level managers of the mentioned companies, as their day to day behaviors and activities contribute to successful operations. Also, each case company comprises of different services such as air, ground, rail, and freight operations (Rajesh et al., 2010). Our focus is on ground operations. Therefore, the mid-level managers involved in the day to day supply chain operations are interviewed. The unit of analysis for this research is the company level.

A face-to-face interview allows the interviewer to solicit the information directly from the respondent (Forza, 2002). There is more flexibility in sequencing questions, and the respondent can get the details and explanation at the spot. This method is very effective in administering complex questions such as related to paradoxes. To ensure that all the responses are recorded comprehensively, interviews are conducted in pairs, which allows one researcher to conduct the interview and the other to take notes and record the interview using an audio recorder. The audio files are used to transcribe for coding purposes. The anonymity of responses is guaranteed.

We interview the participants until no further new information is obtained in the firm, i.e., theoretical saturation is achieved. According to Strauss and Corbin (1990), theoretical saturation, in effect, is the point at which no new insights are obtained, no new themes are identified, and no issues arise regarding a category of data. Therefore, we stop collecting the data when the results start to repeat or when the patterns start to appear within the firm. After the data collection, we ask two research assistants to individually code the quotations into four variables, i.e., belonging, performing, organizing, and learning paradox. Cohen's kappa (Cohens,1960), defined as K, is calculated based on the agreements of coding from the two individual coders. It measures the agreement between two coders who each classify N items into C mutually exclusive categories. If the coders are in complete agreement, then K=1. If there is no agreement among the coders, then k=0. The Cohen's kappa value greater than .7 indicates the high validity of the questions.

Anticipated Results:

We anticipate extending the paradox theory into the U.S. 3PL industry by identifying the paradoxes in the ground operations of 3PL firms. Paradox theory is still in its earlier stages of development, and the findings of this paper have implications for advancing this theory in SCM. The idea of paradox states that the optimal design is not the solution (Sandberg, 2017); rather the continuous balance of tensions inherent in the organization should be the focus of the firm.

Beyond its theoretical contributions, this study has practical implications for SCM in the 3PL industry. The questionnaire developed should work as a guideline for future research purposes involving 3PL and paradoxes. Managers in the 3PL industry would be able to utilize the paradoxical lens to identify the tensions within the supply chain operations. Recent trends have shown that the companies are increasingly outsourcing their logistics function to 3PL companies, which have led to the massive growth of these companies. As a result of this growth, 3PL companies face several challenges while serving customers across the U.S. Amongst these challenges are the embedded tensions within the firms that require a paradoxical lens to be identified, which is provided by our paper.

Future Research:

The findings of this paper would aid future researchers to determine the impact of these elements in different firm settings. Researchers are encouraged to utilize our findings within the

sustainability domain. As sustainability emerges as an increasingly important institutional logic in society, our findings can be used to uncover the meditating or a moderating impact of managing the paradoxes between stakeholder pressure and environmental performance.

Lastly, our research focuses on the ground operations of the 3PL only; the developed questionnaire can provide the basis to identify paradoxes within other logistics sectors as well, such as the air, rail, sea, and reverse logistics operations.

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PREDICTING REMANUFACTURED PRODUCT FRAUD USING NEURAL NETWORKS

Abstract

Fraud in remanufacturing is a rarely touched upon topic of research primarily due to the lack of its observable volume in remanufacturing industry compared to conventional manufacturing. However it is a problem that can be forecast due to the ever rising demand for remanufactured products. Previous research has targeted related topics that include warranty policy, maintenance and pricing strategies. Neural networks (NN) have been found to be effective in detecting & targeting credit card fraud, this paper attempts to adapt these NN models to tackle the issue of remanufacturing warranty fraud. Setting up such models would allow remanufacturers to not only preempt fraud but also to distinguish between fraudulent methods and the sources from where they originate.

Keywords: End-of-life; Reverse supply chain; Fraud; Remanufacturing; Warranty; Neural networks

1. Introduction

Advances in technology have fueled the rise in electronics and thus endowed the customers with access to inexpensive high quality consumer goods. The abundance of high quality and inexpensive products has also changed has also altered the consumers 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. Consequently since there is a shortened product life cycle this leads to a steady degradation of natural resources to compensate for the ever increasing demands of customers and introduces even more waste into the environment.

Environmental legislation has encouraged firms into moving away from disposal and more toward End of Life (EOL) strategies. Environmentally conscious manufacturing can be carried out at any stage of the products life, right from a products design phase to its EOL, which are all instrumental in getting a product to meet environmental standards. 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. Fraud can occur at any stage of the products life cycle such as during the manufacturing process (eg the use of substandard components in product assembly) and even after the products EOL (eg . Improper disposal). 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. Previous papers have concentrated on how fraud can be deterred by modeling the issue using tools such as discrete event simulation [5] and game theory [6]. This paper approaches the issue of fraud detection, and the contrast between a prevention approach versus a penalization approach to combating fraud.

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 [7]. Many case studies have examined RL problems involved in consumer product maintenance and product EOL. Du and Evans [8], Tan *et al*. [9], Piplani and Saraswat [10] 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*. [11] and Shih [12]. Reverse logistics encapsulates many different activities, which also include remanufacturing and refurbishing related processes. Remanufacturing is currently most applied to consumer electronics, which involve complex electro-mechanical and mechanical products, which have cores that, when recovered, will have value added to them that is high relative both to their market value and to their original cost [13]. While remanufactured products can boast many

benefits, environmental and otherwise, consumers are still hesitant to purchase remanufactured products. Because of misconceptions held by consumers, manufacturers often search for market mechanisms to encourage consumers into purchasing their products.

2.2. Warranty as a marketing strategy

The scale and features offered by a product warranty service have in the past been used as tool for competitive marketing. Such additional features may include bundling additional services, extending the warranty periods, offering favorable terms etc. The goal of experimenting with these additional services is to discover ways of making the product more appealing to the customer. Podolyakina [14] identified the relative level of cost incurred to the manufacturer in order to fully satisfy the consumers warranty expectation.

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 [15] 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 [16] planned out the optimum marketing strategy for maximizing profits that includes considerations such as pricing, warranty service and production. There exist other parties (such as the customers and maintenance service agents) that are also trying to maximize their own profits to the detriment of the warranty provider.

2.3. Warranty Fraud

Fraud can be seen as misrepresentation, storage or negligence of a truth for the purpose of manipulating the financial statement to harm the company or organization that also includes embezzlement, theft or any attempt to steal or unlawfully obtained, abuse or harm assets of an organization [17]. Automotive vehicles and other consumer products that have multiple components are more likely to suffer from warranty fraud than other products under warranty. In the past, statistical fraud detection methods have been useful in handling fraud. There have been attempts to integrate newer concepts such as Internet of things (IOT) to address fraud Tan *et al*. [18].Warranty fraud in the remanufacturing industry have been recently explored by Pandit and Gupta [19][20], which explored the issue of service agent warranty fraud by employing discrete event simulation.

2.4 Neural networks and fraud

Widely used statistical classification methods such as linear discriminant analysis and NN have been shown to be effective tools in such supervised situations [21-25]. Hawkins et al. [26] proposed a hybrid approach combining business rules, anomaly detection, advanced analytics and social network analysis into hybrid fraud algorithms to score each claim. There have been many NN models that have been developed to deal with fraud in the credit card sector and the literature review of these attempts helped provide a framework for how to deal with remanufactured product fraud.

3. Description of the system
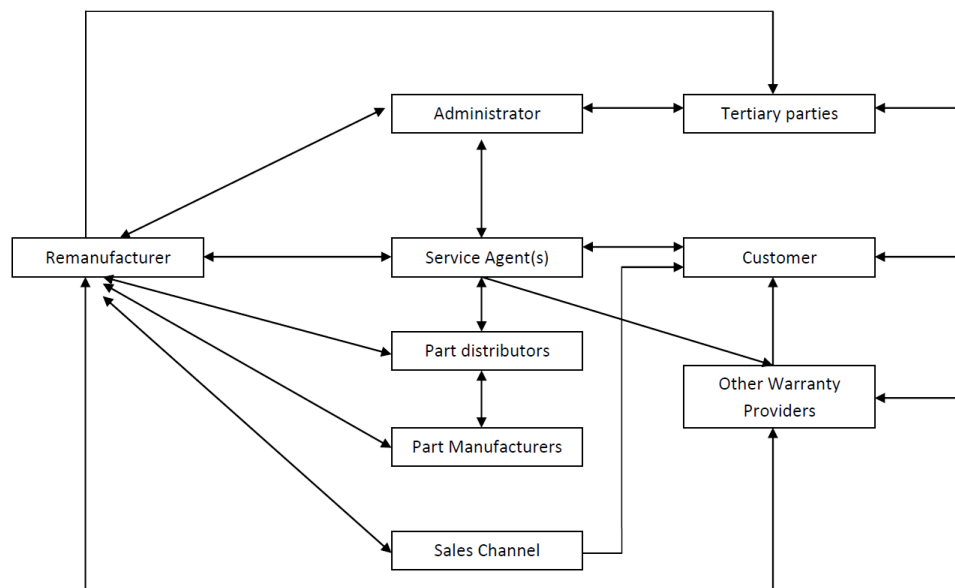
Figure 1. Key parties involved in a warranty servicing chain

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. Figure 1 describes the information flow between the key parties in a typical remanufactured product warranty service [27, 28]. 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 three categories (Table 1).

Table 1. Parties in a warranty servicing chain

Categories	Parties
Primary	Warranty provider, Service agent, Customers
Secondary	Parts manufacturer, sales channel , Warranty administrator
Tertiary	Leasers ,Inspectors, Logistics companies, Underwriters & Insurers, Government, Shareholders

4. Methodology

The methodology and medium used for committing credit card fraud greatly resembles the "overcharging fraud" scenario that occurs in product warranty service. This primarily occurs between the service agent and the warranty provider wherein the service agent creates fictional claims that result in the defrauding of the warranty provider. The primary parties involved are the service agent and the warranty provider. Another similar scenario is the extra charging fraud scenario, which takes place between the warranty administrator and the warranty provider (The NN model considered the former scenario).

Data set

The dataset that was used as the basis for the experimental model contains transactions made by credit cards in September 2013 by European cardholders. In this dataset we have 492 frauds out of 284,807 transactions. The dataset is highly unbalanced, the positive class (frauds) account for 0.172% of all transactions. This data set was then modified by using the fraud incidence rates established by Kurvinen, M., Töyrylä, I., & Murthy [28] for different manufacturing fraud scenarios. Data for both fraudulent and non fraudulent scenarios were thus generated for a remanufactured warranty fraud scenario.

Future work

In a real world scenario the existence of frauds in isolation are highly unlikely, additionally simply detecting the existence of fraud may not be enough sufficient, as tracking down the origin of the fraud in a vast supply chain network is both time consuming and expensive. Thus being

able to recognize patterns that are characteristic of specific types of fraud is essential in expediting this process. Therefore the future direction of this research will attempt to detect/distinguish between multiple types of frauds.

Conclusion

The topic of remanufacturing and its relation to sustainability was briefly discussed, in addition the issue of fraud and how it expresses itself in a products life cycle were briefly elucidated .Based on fraud detection methodologies that exist in other sectors , we attempt to setup a detection model for warranty fraud . The model could be further refined if we considered actual data from the industry as opposed to experimental data used in this paper. Finally, directions that the model can take in the future were discussed.

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PRICING MODELING FOR NEW AND REMANUFACTURED PRODUCTS ACROSS GENERATION IN AN EQUILIBRIUM ENVIORNMENT

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ABSTRACT

The concept of environmentally conscious manufacturing and product recovery (ECMPRO) has been extended from traditional material recycling and remanufacturing to the view of marketing issues in a closed-loop supply chain. Pricing decision for new and remanufactured products is critical to the survival of both items. Manufacturers and retailers, as the key members in supply chains, address pricing policies for different items to maximize their profits. This paper exhibits the price models for a manufacturer, a remanufacturer, and a retailer in the Nash equilibrium environment. The manufacturer sells new product belonging to the earlier generation, while remanufacturer sells remanufactured product belonging to the latest generation. The demand for new and remanufactured products depends on the prices and customer's perceived value in different segments. The results show optimal wholesale prices and retail prices for each product. The impact of the customer's ratio in each segment is discussed.

Key words: Pricing, Remanufacturing, Generation, Equilibrium

INTRODUCTION

Environmentally conscious manufacturing and product recovery (ECMPRO) is a comprehensive concept of manufacturers' responsibility regarding take-back legislation, customers' awareness of green products, and economics [1]. Based on the literature surveys in the year 1999 [2] and 2010 [3], many attentions were focused on the environmentally conscious design and production,

material recycling, and remanufacturing. Lately, topics are extended to reverse and closed-loop supply chains, including marketing-related issues to promote remanufactured products.

For high-tech products, manufacturers launch new generation models intensively to meet customers' requirement on fashion design and technology innovation. To keep the product's quality at a high level, manufacturers use a massive amount of new materials, breaking the government's principle of environmental regulation. Remanufacturing operations solve the dilemma, creating an opportunity to transfer the recycling burden to a profitable business. Except for recycling and remanufacturing process, market and excavate the value of the remanufactured products are another essential issue.

From the perspective of customers, heterogeneous customers have various perceived values on different types of products. Quality-conscious customers prefer the brand-new product, while technology-savvies focus on technology innovation. However, new product belonging to earlier generations has a discount on technology depreciation, remanufactured product belonging to the latest technology has an inferior on perceived quality. Customers in different segments have differentiated values on these types of products. Manufacturers need to identify the market position of different type of items, selling them with differentiation prices to different customer segments. At the same time, avoid cannibalization with new generation models.

In the view of a supply chain system, manufacturers, retailers, and even suppliers need to find an optimal way to allocate the supply chain capability and set up appropriate prices for different types of products to maximize the profit in a centralized or decentralized supply chain structure. A successful marketing strategy for new and remanufactured products can address customer's perceived value and purchase habit, at the same time, keep the equilibrium in profit from new and remanufactured products of different generations for all the supply chain members.

This paper will address wholesale price and retail price decisions for new and remanufactured products in different generations in an equilibrium environment. In the following sections, previous papers regarding pricing strategy for different supply chain members are discussed. Then the problem statement of this study will be initiated. Models, numerical example, and the conclusion of this specific problem will be provided.

LITERATURE REVIEW

Many researchers focused on pricing decisions for new and remanufactured products. In high technology industry, manufacturers release new generation models in regular cycles. Prices of commodities differ from various generations. Researchers search for the optimal price for high-technology or seasonal products in three ways. First, price can be decided by customer's reservation value in diverse segments for different types of products. Second, price can be impacted by customer's purchase preference in different sales channels and bargaining behavior. Third, price can be adjusted by vertical and horizontal competition and cooperation among different manufacturers and retailers.

Finding an optimal price helps balance the tradeoff between generating more revenue and losing business opportunities. In many cases, optimal price is based on customer's perception. Customer's acceptance of the products and willingness to pay (WTP) are critical to the pricing strategy. To understand people's purchase behavior, Kuo and Huang examined the dynamic retail price decisions for the products from two different generations with the consideration of inventory level and remaining selling periods [4]. They generalized Nash bargaining solution model in two scenarios, posted-pricing-first and Negotiation-first to find out the optimal posted price. Zhu and Yu also conducted a case study on new, remanufactured, and refurbished electronic products to analyze customer's buying behavior by building a dynamic game model, but they paid more attention on the service level [5]. Liu, Guo, Guo, and Lei examined the customers' WTP and acceptance level for the remanufactured products by deciding the independent price for the new product in the first cycle period and the joint pricing strategy for both new and remanufactured products in the second cycle [6]. They showed that all supply chain members receive benefit from selling remanufactured products. The opinion is supported by Gan Pujawan, Suparno, and Widodo (2017) [7]. They established a two-time period model to find optimal prices for new and remanufactured products in a separate sales-channel, where the remanufactured products are sold through a direct channel, while the new products are sold via the retailer.

Manufacturer and retailer are key members in a product supply chain. Both manufacturer and retailer have pricing strategies to optimize the profit. Karimabadi, Arshadi-khamseh, and Naderi examined the optimal pricing decisions by building game theory models in one manufacturer and one retailer environment with fuzzy variables [8]. Giri, Chakraborty, and Maiti considered a

system with one manufacturer, one retailer, and one third-party, where the manufacturer sells new products through retailer and e-retailer while the third-party and e-retailer are responsible for collecting used parts [9]. They decided optimal retail, wholesale, acquisition prices, and return product collection rate in five scenarios, including centralized, Nash game, manufacturer-led, retailer-led, and third party-led. Apart from the study on an environment of one manufacturer and one retailer, another volume of papers keeps eyes on the horizontal competition between two manufacturers or two retailers. Hsiao and Chen analyzed internet channels, the pricing strategies, and the channel structure using the market Nash Equilibrium method [10]. Gu and Gao conducted a study on the closed-loop supply chain in an environment with two manufacturers and one retailer [11]. They find optimal prices for all the three members, and believe it is the best choice if the retailer collects used cores. Zhao, Wei, and Li investigated the remanufacturing decision for two substitutable products, new products produced by raw materials and remanufactured products incorporated used parts [12]. They examined the research problem in Manufactuurer-Stackelberg and Retailer-Stackelberg models with several sub-conditions. Luo, Chen, Chen, and Wang conducted a related study but focused on the two differentiated brand products supplied by two manufacturers [13]. They built up seven game models with different power structures and found that the competition between the manufacturers benefits the retailer. They found that more profits are received by increased acceptance of the average brand for the whole supply chain. Aydin, Kwong, and Ji extend the research to the closed-loop supply chain in a multi-objective optimization problem [14]. They proposed a case study on tablet PCs in a system containing a manufacturer, a remanufacturer, and a chain retailer, aim to find pricing decisions, product return rate, and product line solutions by Stackelberg game theory and Genetic algorithm. Some researchers were focused on service's impact. Wang and Wang built Retailer-Stackelberg, Manufacturer-Stackelberg, and Nash Equilibrium models in monopoly market with one manufacturer, one remanufacturer, and one retailer, indicated that a growth in customer's acceptance level on remanufactured products leads to lower prices and higher service levels and reduce profit in general for the members with less power on price decision [15].

Most of the papers we reviewed are concentrating on the negotiation between the sellers and the buyers in the supply chain. They use game theories to discover the optimal prices or supply chain strategies with different bargain powers. However, very a few of them take notice of the product differences in technology development over generations and quality condition. In the previous

study, researchers built up a time-dependent model for high-technology products across generations [16]. Then they conducted an empirical study for selling iPhones through eBay, and compared the actual selling prices with the theoretical prices [17], [18]. They also considered how buyback prices and acquisition quantities influence the selling prices of different types of products [19]. In this paper, we will build up a Nash Equilibrium model to understand the insight of optimal price strategy for the manufacturer, the remanufacturer, and the retailer when the manufacturer and the remanufacturer sell new and remanufactured high-technology products to the retailer, and retailer sells different products to different customers in various segments.

PROBLEM STATEMENT

The paper studies pricing decision for two types of products in a supply chain with a manufacturer, a remanufacturer, and a retailer. Type 1 products are the new commodities belonging to the early generation. Type 2 products are the remanufactured items belonging to the latest generation. The market of the two products is separated from the premium market which sells new products belonging to the latest technology. Manufacturer sells Type 1 products to the retailer at a wholesale price w_1, while remanufacturer, sells Type 2 products to the same retailer at w_2. The retailer sells the product to customers at the different retail prices p_1 and p_2. The cost of manufacturing a new product is c_1, while the cost of a remanufactured product is c_2. Assume $c_1 > c_2$.

Customers are classified into two segments. The first segment is the quality-conscious that customers are concerned more on quality than technology. The second segment is the technology-savvy that customers in this category take more attention on technology development than the product condition. Compare to the new products belonging to the latest generation, Type 1 products are depreciated in technology, while Type 2 products are inferior in quality. α_1 and α_2 are the discount factors of generation obsolescence in quality for quality-conscious customers and technology-savvies respectively. β_1 and β_2 are the discount factors of remanufacturing inferiority for quality-conscious and technology-savvy customers. We assume that $\alpha_1 > \alpha_2$, and $\beta_1 < \beta_2$, $\alpha_1 > \beta_1$, and $\alpha_2 < \beta_2$. Supply constraint is not considered.

The wholesale prices for each type of product and the retail prices are decided by a Nash Equilibrium model. Two manufacturers and one retailer make price decisions simultaneously.

MODEL

As described in Paper [13], the authors consider one product is priced at p, the customer perceived value v is uniformly distributed over [0, 1]. Therefore, the demand of the product is $Q = \int_P^1 dv = 1 - p$, for $0 <= p <= 1$. We develop the model to two types of products with different generations and product condition. We assume that v is the perceived value for the new product belonging to the latest generation. The perceived value of Type 1 product is $\alpha_1 v$ and $\alpha_2 v$ for quality-conscious customers and technology-savvies respectively. While the perceived value of Type 2 products is $\beta_1 v$ and $\beta_2 v$ quality-conscious customers and technology-savvies. Quality-conscious customers will purchase Type 1 product when $\alpha_1 v - p_1 >= 0$ and $\alpha_1 v - p_1 >= \beta_1 v - p_2$, and purchase Type 2 product when $\beta_1 v - p_2 >= 0$ and $\alpha_1 v - p_1 < \beta_1 v - p_2$. Technology savvies will purchase Type 1 product when $\alpha_2 v - p_1 >= 0$ and $\alpha_2 v - p_1 > \beta_2 v - p_2$. They choose Type 2 product when $\beta_2 v - p_2 >= 0$ and $\alpha_2 v - p_1 <= \beta_2 v - p_2$. We also assume δ is the proportion of the customers in quality-conscious segment, the proportion of technology savvy is 1-δ. Therefore, the piecewise demand function can be derived.

Demand function

When $P_1 < P_2$, all the quality-conscious customers will buy Type 1 products; the technology-savvy customers will choose Type 1 items if $\beta_2 - \alpha_2 < p_2 - p_1$.

When $P_2 < P_1$, all the technology-savvy customers will by Type 2 products; quality-conscious customers will choose Type 2 items if $\alpha_1 - \beta_1 < p_1 - p_2$.

Therefore, the demand functions of Type 1 and Type 2 products are as follows in function (1) to (4).

Condition 1: $p_1 < p_2$

Region 1: When $0 < \frac{\beta_2}{\alpha_2} < \frac{p_2}{p_1} < 1$ and $P_1 < \alpha_1$, $P_1 < \alpha_2$, all customers will buy Type 1 products.

$$\left[\begin{array}{l} D_1\ (p_1, p_2) = \delta\ (\alpha_1 - p_1) + (1-\delta)\ (\alpha_2 - p_1) \\ \\ D_2\ (p_1, p_2) = 0 \end{array} \right. \qquad\qquad (1)$$

Region 2: When $\frac{\alpha_2}{\beta_2} < \frac{p_1}{p_2} < 1$ and $p_1 < \alpha_1$, $p_1 < \alpha_2$, $p_2 < \beta_2$, all Quality-conscious customers will buy Type 1 products, some technology savvies will purchase Type 1 products instead of Type 2 products.

$$
\left[
\begin{array}{l}
D_1\ (p_1,\ p_2) = \delta\ (\alpha_1\text{-}p_1) + (1\text{-}\delta)\ \left(\frac{p_2-p_1}{\beta_2-\alpha_2} - \frac{p_1}{\alpha_2}\right) \\[2em]
D_2\ (p_1,\ p_2) = 0 + (1\text{-}\delta)\ \left(\beta_2 - \frac{P_2-P_1}{\beta_2-\alpha_2}\right)
\end{array}
\right.
\tag{2}
$$

Condition 2: $p_1 > p_2$

Region 3: When $1 < \frac{\alpha_1}{\beta_1} \leq \frac{p_1}{p_2}$ and $p2 < \beta1$, $p2 < \beta2$, all customers will buy Type 2 products

$$
\left[
\begin{array}{l}
D_1\ (p_1,\ p_2) = 0 \\[1.5em]
D_2\ (p_1,\ p_2) = \delta\ (\beta_1\text{-}p_2) + (1\text{-}\delta)\ (\beta_2\text{-}p_2)
\end{array}
\right.
\tag{3}
$$

Region 4: When $1 < \frac{p_1}{p_2} < \frac{\alpha_1}{\beta_1}$, some quality conscious customers will purchase Type 2 product instead of Type 1 product.

$$
\left[
\begin{array}{l}
D_1\ (p_1,\ p_2) = \delta\ \left(\alpha_1 - \frac{p_1-p_2}{\alpha_1-\beta_1}\right) + 0 \\[2em]
D_2\ (p_1,\ p_2) = \delta\ \left(\frac{p_1-p_2}{\alpha_1-\beta_1} - \frac{p_2}{\beta_1}\right) + (1-\delta)(\beta_2 - p_2)
\end{array}
\right.
\tag{4}
$$

The profit models for manufacturer, remanufacturer, and retailer can be generated based on the demand functions. We denote marginal profits of the retailer from Type 1 and Type 2 products as $m_1 = p_1 - w_1$, and $m_2 = p_2 - w_2$ respectively.

Vertical Nash Model

<u>*Condition 1, region 1:*</u>

Retailer's profit model:

$$\Pi_r = (p_1\text{-}w_1) * [\delta\ (\alpha_1\text{-}p_1) + (1\text{-}\delta)\ (\alpha_2\text{-}p_1)] \tag{5}$$

Manufacturer's profit model:

$\Pi_{m1} = (w_1-c_1) * [\delta (\alpha_1-p_1) + (1-\delta) (\alpha_2-p_1)]$ (6)

Remanufacturer's profit model:

$\Pi_{m2} = (w_2-c_2) * 0 = 0$ (7)

Functions from 5 to 7 are approved to be concave. Therefore, the optimal wholesale price and selling price of Type1 product are obtained. The maximized profits of Manufacturer 1 and retailer can be found accordingly.

$$w_1* = \frac{\delta\alpha_1+(1-\delta)\alpha_2+2c_1}{3}$$

$$p_1* = \frac{2\delta\alpha_1+2(1-\delta)\alpha_2+c_1}{3}$$

By the same method, the following results in each region are show below.

Condition 1, Region 2

Retailer's profit model:

$\Pi_r = (p_1-w_1) * [\delta*(\alpha_1-p_1) + (1-\delta)*(\frac{p_2-p_1}{\beta_2-\alpha_2} - \frac{p_1}{\alpha_2})] + (p_2-w_2) * [(1-\delta)*(\beta_2 - \frac{p_2-p_1}{\beta_2-\alpha_2})]$ (8)

Manufacturer's profit model:

$\Pi_{m1}= (w_1-c_1) * [\delta * (\alpha_1-p_1) + (1-\delta) * (\frac{p_2-p_1}{\beta_2-\alpha_2} - \frac{p_1}{\alpha_2})]$ (9)

Remanufacturer's profit model:

$\Pi_{m2} = (w_2-c_2) * (1-\delta) * (\beta_2 - \frac{P_2-P_1}{\beta_2-\alpha_2})$ (10)

Functions from 8 to 10 are approved to be concave. The optimal selling and wholesale prices in this condition are shown below.

$$p*_1 = \frac{3\delta\alpha_1\alpha_2+\alpha_2(1-\delta)(\beta_2-\alpha_2)[c_1+2\beta_2(\beta_2-\alpha_2)}{3(\delta\alpha_2+1-\delta)}$$

$$p*_2 = \frac{3\delta\alpha_1\alpha_2+\alpha_2(1-\delta)(\beta_2-\alpha_2)[C_1+2\beta_2(\beta_2-\alpha_2)}{3(\delta\alpha_2+1-\delta)} + \frac{c_1+2\beta_2(\beta_2-\alpha_2)}{3}$$

$w*_1 = \dfrac{2c_1 - 2\beta_2(\beta_2 - \alpha_2)}{3}$

$w*_2 = \dfrac{2c_1 + \beta_2(\beta_2 - \alpha_2)}{3}$

Condition 2, region 3:

Retailer's profit model:

$\Pi_r = (p_2 - w_2) * [\delta * (\beta_1 - p_2) + (1 - \delta) * (\beta_2 - p_2)]$ (11)

Manufacturer's profit model:

$\Pi_{m1} = (w_1 - c_1) * 0 = 0$ (12)

Remanufacturer's profit model:

$\Pi_{m2} = (w_2 - c_2) * [\delta * (\beta_1 - p_2) + (1 - \delta) * (\beta_2 - p_2)]$ (13)

Functions from 11 to 13 are approved to be concave. We get the optimal w_2 and p_2.

$p*_2 = \dfrac{2\delta\beta_1 + 2(1-\delta)\beta_2 + c_2}{3}$

$w*_2 = \dfrac{\delta\beta_1 + (1-\delta)\beta_2 + 2c_2}{3}$

Condition 2, region 4:

$\Pi_r = (p_1 - w_1) * [\delta (\alpha_1 - \frac{p_1 - p_2}{\alpha_1 - \beta_1})] + (p_2 - w_2) * [\delta (\frac{p_1 - p_2}{\alpha_1 - \beta_1} - \frac{p_2}{\beta_1}) + (1 - \delta)(\beta_2 - p_2)]$ (14)

$\Pi_{m1} = (w_1 - c_1) * [\delta (\alpha_1 - \frac{p_1 - p_2}{\alpha_1 - \beta_1})]$ (15)

$\Pi_{m2} = (w_2 - c_2) * [\delta (\frac{p_1 - p_2}{\alpha_1 - \beta_1} - \frac{p_2}{\beta_1}) + (1 - \delta)(\beta_2 - p_2)]$ (16)

Functions from 14 to 16 are approved to be concave. We can get optimal solutions in this condition.

$p*_1 = \alpha_1(\alpha_1 - \beta_1) + \dfrac{\beta_1[(1-\delta)\beta_2 + \delta\alpha_1]}{(1-\delta)\beta_1 + \delta}$

$$p*_2 = \frac{\beta_1[(1-\delta)\beta_2 + \delta\alpha_1]}{(1-\delta)\beta_1 + \delta}$$

$$w*_1 = \alpha_1(\alpha_1 - \beta_1) + \frac{\beta_1[(1-\delta)\beta_2 + \delta\alpha_1]}{\delta + \beta_1 + \delta\beta_1}$$

$$w*_2 = \frac{\beta_1[(1-\delta)\beta_2 + \delta\alpha_1]}{\delta + \beta_1 + \delta\beta_1}$$

NUMERICAL EXAMPLE AND ANALYSIS

In this section, we will apply a numerical example to see how prices are varied by different customer ratios in two segments in the four regions.

We assume $c_1 = 0.6$, $c_2 = 0.3$. In region 1, assure $\alpha_1 = 0.9$, $\alpha_2 = 0.7$. Table 1 shows the wholesale price, retail price, and the profit. The profit of the retailer, the manufacturer, and the whole supply chain are increased when the ratio of quality-conscious customers is increased.

Table 1. Wholesale price, retail price, and the profit in Region 1

Region 1				profit		
Value	w1	p1	Retail	Manufacturer	remanufacturer	supply chain
$\delta=0.2$	0.65	0.69	0.002	0.0025	0	0.0045
$\delta=0.5$	0.67	0.73	0.0044	0.0055	0	0.0099
$\delta=0.8$	0.69	0.77	0.0068	0.0085	0	0.0153

In Region 3, we assume $\beta_1 = 0.7$, $\beta_2 = 0.9$. Table 2 shows the result. The profit of the retailer, remanufacturer, and the supply chain decreased when the ratio of quality-conscious customers is increased.

Table 2. Wholesale price, retail price, and the profit in Region 3

Region 3				profit		
Value	w2	p2	Retail	Manufacturer	remanufacturer	supply chain
δ=0.2	0.49	0.67	0.0342	0	0.0285	0.0627
δ=0.5	0.47	0.63	0.0234	0	0.0195	0.0429
δ=0.8	0.45	0.59	0.0126	0	0.0105	0.0231

CONCLUSION

This paper provided the demand and profit models for the new product belonging to the early generation and the remanufactured product belonging to the latest generation. Customer's perceived value influences the demand of each product. Customers are classified into two segments, quality-conscious and technology-savvies. They have differentiated value on the two products. The optimal wholesale price and retail price for each product are obtained in a vertical equilibrium environment. The manufacturer's wholesale price is decided by the retailer's margin.

The study catches up the research opportunity that few researchers studied on new and remanufactured products across generations and decided the prices in an equilibrium environment. In the future, we can extend the study by doing more numerical analysis about how customers' perceived value influences the profit in all the four regions. Also, we can explore the results in Retailer-Stackelberg and Manufacturer-Stackelberg environment.

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SUPPLY CHAIN RESILIENCE: AN ADAPTIVE CYLE APPROACH

Abstract

This research uses the adaptive cycle heuristic to explore supply chain resilience. Adaptive cycles explain the long-term dynamics of change in complex adaptive systems. Adaptive cycles assume that dynamic systems such as supply chain networks go through stages of growth, development, collapse, and reorientation. Adaptive cycles also suggest that the resilience of a complex adaptive system such as supply chains are not fixed but expand and contract over time. To demonstrate resilience requires such systems to navigate each of the cycles' four stages successfully. A key feature of the adaptive cycle is the existence of pathologies, and periods during which major changes occur. Periods of collapse following major disturbances may cause some attributes of the system to be lost. At the same time, the period of creative destruction that adaptive cycles go through creates opportunities for novelty and innovation. The key insight is that the adaptive cycle concept can broaden our understanding of supply chain resilience because it shares resilience and the complex systems dynamics with supply chain networks. As a heuristic, the adaptive cycle can explain the mechanisms that support or prevent resilience in supply chains, including our understanding of cross-scale resilience. Adaptive cycles may also give us new insights into the sort of competences required to avoid stagnation and promote resilience overtime. Knowing how to prepare for, and overcome key pathologies associated with each stage of the adaptive cycle can broaden our repertoire of strategies for managing supply chain resilience across time. We extend the literature on supply chain resilience and offer implications of the paper for research and practice.

Keywords

Supplier chain resilience, adaptive cycles, front loop, back loop, supply chain management

INTRODUCTION

Resilience has emerged as an important concept in the supply chain literature, and a growing body of research is emerging on the concept (Christopher & Peck, 2004; Pettit et al., 2010; Maruf, Chowdhury & Quaddus, 2016; Tukamuhabwa et al., 2015, Chowdhury, Quaddus & Agarwal, 2019). Largely described as a tool for managing supply chain risk and vulnerability, resilient supply chains are said to be capable of absorbing or avoiding disruptions (Pettit et al. 2010; Sheffi & Rice, 2005), or recovering much faster after a disruption (Zsidisin et al., 2010). Normatively, firms have been encouraged to build resilient supply chains (Wiel & & Marcus, 2013; Blackhurst et al., 2011).

Our understanding of supply chain management has improved substantially with the emerging research. However, some gaps remain in our understanding of both supply chain resilience (SCRES), and the extent to which it can explain supply chain dynamics. First, the emerging research has suggested that knowledge for managing such dynamic systems such as supply chains may just be beginning (Tukamuhabwa et al., 2015, Adobor & McMullen, 2018). For example, we know that resilient supply chains need to be ready, respond to disruptions, recover and grow (Hohenstein et al., 2015). Knowledge of the competencies required for managing each of these four phases may need additional research. The understanding of the cycles of change in dynamic systems such as supply chains are nascent, and a greater understanding of the key features of each stage of the evolutionary process, as well as capabilities required for navigating each phase, will be of theoretical and practical importance. Second, because resilience is a property of dynamic systems, it is important to focus on system attributes and the dynamic structure of supply chain networks. As Walker et al., (2004, p.1) note, "resilience of a system needs to be considered in terms of the attributes that govern the system's dynamics." Some researchers in the organizational

sciences have already adopted a complex adaptive systems framework, a perspective more in tune with the dynamic nature of supply chains, to understand supply chain management and supply chain resilience (Choi et al., 2002; Li et al., 2009; Hearnshaw & Wilson, 2013). Finally, there has been some suggestion that the existing research on supply chain management would benefit from more solid theoretical grounding (Tukamuhabwa et al., 2015) and the field, therefore, would benefit from the development of theoretical frameworks that extend our understanding of the nonlinear dynamics associated with supply chain networks.

To identify valuable insights on supply chain dynamics, we adopt the adaptive cycle framework from the natural sciences (Holling, 1986, Gunderson & Holling, 2002) to explore SCRES. Researchers in resilience theory and ecology have explored similar dynamics (Holling, 1986; Gunderson & Holling, 2002) and we borrow from that literature to explore supply chain dynamics in this paper. The focus of the paper is to explore how knowledge about adaptive cycles can inform our understanding of SCRES. We explore how supply chain networks as complex adaptive systems may maintain their structural and functional integrity when faced with disruptions. According to Gunderson and Holling (2002), adaptive cycles explain how systems recover and reorganize after transformations, their capacity to adapt to changes and generate novelty (Gunderson & Holling, 2002). Also, adaptive systems demonstrate how systems balance "persistence, adaptation and transformation" (Davoudi 2012, p. 304), features that resilience supply chains should have.

As complex adaptive systems, supply chains may mimic the evolutionary processes in adaptive cycles and help explain how complex adaptive systems such as supply chain networks can maintain their structural and functional integrity when confronted with unexpected or novel events such as disruptions (Allen et al., 2005, p. 959). Like socio-ecological and complex adaptive

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systems, supply chains must have the capacity for persistence, adaptation, and transformation in the face of disruptions (Hohenstein et al*.,* 2015). The value of adaptive cycles is that they can provide insights into the behavior of a system, including why a system changes and the properties supply chains should have at specific stages as well as how we can build cross-scale resilience. Organizational scientists have used the concept of adaptive cycles to understand such things as organizational change events (Linnenluecke & Griffiths, 2010), ecosystems dynamics, and organizational resilience (Williams, Whiteman & Kennedy, 2019). Although supply chains mirror dynamical systems, no studies to our knowledge has incorporated the concept of adaptive cycles to understand supply chain resilience. We bridge this gap by developing a conceptual framework incorporating adaptive cycles to understand SCRE dynamics. We organize the paper as follows to explore the issues. First, we discuss supply chains as complex adaptive systems to reflect their dynamic structure. Second, we introduce the concept of adaptive cycles and discuss the three key properties that shape the dynamics of the cycle. We then discuss the key pathologies associated with each phase of the cycle. Third, we discuss the implications of adaptive cycles for managing SCRES. Finally, we explore the implications of the study for research and practice, including the limitations of the framework.

Supply Chains as Complex Adaptive Systems

Christopher and Peck (2004, p.2) define SCRES as "the ability of a supply chain to return to its original state or move to a new, more desirable state after a disturbance." Eltantawy (2016) describes two forms of SCRES, engineering, and ecological resilience. Engineering resilience focuses on efficiency and control, and ecological resilience on the adaptive capacity of the system. The third form of SCRES, evolutionary resilience, has also been applied to SCRES (Adobor & McMullen, 2018; based on Davoudi, 2012; Simmie & Martin, 2010; Folke et al., 2010). In this

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research, we conceptualize supply chains as complex adaptive systems (CAS) following earlier research (e.g. Pathak et al., 2007, Wycisk et al., 2008, Choi et al., 2001).

Emerging research on supply chains suggests that the CAS perspective reflects the dynamic and nonlinear nature of supply chain networks (Pathak et al., 2007; Statsenko, Gorod, & Ireland, 2018). According to Stacey (1996, p.10), CAS consists of several active agents, who interact with each other according to sets of rules. Pathak et al., (2007) in relating this idea to supply chains liken agents to firms who interact by exchanging information, goods, and services to build collective advantage (Choi et al., 2001; Cumming et al., 2005). Wycisk, McKelvey & Hulsmann, 2008, p.113) suggest that CAS interact with their environment, such systems then adapt and co-evolve to create dynamic, and emergent realities (Kauffman, 1993). Agents in a CAS exhibit self-organization (Nicolis & Prigogine, 1989), a feature supply chains demonstrate too (Choi et al., 2001; Nilsson & Gammelgaard, 2012; Wycisk et al., 2008). Self-organization is a process in which "new structures, patterns, and properties emerge without being externally imposed on the system" (Choi et al, 2001, p. 354). Since CAS demonstrates nonlinear behavior, small changes can have dramatic effects on the system, which Lorenz (1986) describes as the "butterfly effect." Surana et al., (2006) equate the "bullwhip" effect in supply chains to the butterfly effect. Although it is almost impossible to predict the future in dynamic systems, such systems demonstrate stability by being drawn to stability regions Lorenz (1986) named "attractors." Byrne and Callaghan (2014, p. 26-27) define attractors as "something towards which a dynamical system evolves, a specific location in the state space." CAS can use learning as a strategy to attain fitness with its environment (Wycisk et al., 2008, Kauffman, 1993). Finally, CAS transforms system characteristics as goals, scale, through space and time (Walker et al., 2006; Wysick et al., 2008). The description of a

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supply chain as a complex adaptive system implies that SCRES is a dynamic, and nonlinear concept since resilience is a feature of such dynamic systems (Nilson & Gammelgaard, 2012).

Insert Figure 1 about here

CONCEPTUAL FOUNDATIONS: THE ADAPTIVE CYCLE FRAMEWORK

According to Gunderson and Hollings (2002), the adaptive cycle is a heuristic for portraying patterns of change and resilience in complex systems. Figure 1 presents a stylized representation of an adaptive cycle based on Gunderson and Hollings' (2002) seminal work. Originally derived from the comparative study of the dynamics of ecosystems, the adaptive cycle helps explain the mechanisms that support or prevent resilience in systems (Gunderson & Holling, 2002; Briggs et al., 2010). The heuristic may allow us to organize our ideas about resilience (Gunderson & Holling 2002). Although developed initially to understand change in ecological systems, the adaptive cycle heuristic has since been extended and applied to understand change and resilience in socio-ecological, economic, and social systems (see e.g. Abel, Cumming & Andries, 2006; Fath, Dean & Katzmar, 2015; Simmie & Martin, 2010). Some of these studies have sought to analyze the dynamics of one or more phases, instead of all the phases in the adaptive cycle (e.g. Abel et al., 2006) while a few studies applying the heuristic to social-ecological systems have applied it to all the four phases (Vang Rasmussen & Reenberg, 2012). Cumming & Collier (2005) note that there is some evidence that not all systems adhere to the adaptive cycle model completely. However, most of these studies have found that the adaptive cycle is an important heuristic for explaining changes in socio-ecological systems, especially those seeking to understand resilience and specific phases within the cycle.

According to the theory of adaptive cycles (Gunderson & Holling, 2002, Holling, 1986), dynamical systems such as ecosystems and socio-ecological systems do not tend toward some stable or equilibrium condition. Instead, as Gunderson and Holling (2002) note, such systems pass through the following four characteristic phases: rapid growth and exploitation (r), conservation (K), collapse or release "creative destruction", (α), and renewal or reorganization (Ω). The resilience of a system contracts as a system passes from growth to conservation because it becomes fragile. Holling (2002) notes that resilience increases as the system moves towards renewal or reorganization as the system allows for experimentation and novelty. Gunderson and Holling (2002) observed that adaptive cycles "alternate between periods when they accumulate resources (incorporation) periods when they transform the resources, and shorter periods that create opportunities for innovation and change." Davoudi (2012, p. 304) notes that adaptive cycles present "several paradoxes such as persistence versus change, flexibility versus efficiency, resiliency versus transformation, and connectedness versus adaptability." These states may be evident in supply chains. Gunderson and Holling (2002, p. 34-41) note that the phases in an adaptive cycle are not "necessarily sequential or fixed and systems function in multiple cycles as a series of nested adaptive cycles." This behavior has been termed "panarchy."

According to Hollings & Gunderson (2002), adaptive cycles exhibit two major phases or transitions. The first, often referred to as the *front loop* (forward cycle), from r to K, is a slow, incremental phase of growth and accumulation. The second, referred to as the *back loop* (backward cycle), from Ω to α, is a rapid phase of reorganization where renewal takes place and windows of opportunity for innovation are created. Wahl (2016) suggests that the opportunity for redesign, reorganization, and renewal is high during the back loop because rigid systems collapse at this point. When that happens, established patterns are destroyed and resources may be redistributed

throughout the system (Simmie and Martin, 2010). Davoudi (2015) notes that the capacity for adaptive cycles to demonstrate adaptation at different scales and during different periods "allows systems to be both efficient and innovative; they are highly connected yet also free to experiment because these properties manifest themselves at different times and scales" (p. 304).

According to Hollings (2001, p 394), three general properties shape the adaptive cycle and the future state of a system, regardless of its scale. These are the *potential* of a system. According to Fath et al., (2015), the potential of a system include the resources available to the system, e.g., economic and social capital. Holling (2002) notes that the potential of the system is a very important characteristic of an adaptive cycle because it determines the range of future options possible. Second, is *connectedness,* or the internal controllability of a system, that is, the degree of flexibility or rigidity of the system. Finally, is the *adaptive capacity* or resilience of the system, a measure of its ability to deal with vulnerability and shocks. Wycisk et al., (2008, p. 115) define adaptation as "the structural, physiological and/or behavioral processes of systemic change that increase the expected long-term success of a system."

Knowing the renewal properties of the adaptive cycle is important for two main reasons. First, as Holling and Gunderson (2002) note, since the level of potential and connectedness change during the four phases of the cycle, we can distinguish each phase of the adaptive cycle by determining the strength of these properties. In practical terms, what this means is that actors can determine which phase of the adaptive cycle they are in by carefully studying the level of potential and connectedness of the system. Second, because these properties are key to shaping the adaptive cycle and the future state of systems such as supply chains, knowing the level of these properties is important. Finally, adaptive cycles also demonstrate pathologies, known as "traps" (Gunderson and Holling, 2002). Our understanding of these properties may be important for understanding

supply chain resilience at focal and cross-scale as well as the dynamics of SCRES across temporal scales. Table 1 presents a summary of the adaptive cycle and its properties. It relates the level of resilience to cycle properties at each phase of the cycle. It also describes the key features of each stage.

<u>Insert Table 1 about here</u>

ADAPTIVE CYCLES: IMPLICATIONS FOR SUPPLY CHAIN RESILIENCE

Supply chains mimic adaptive cycles in several ways. First, both adaptive cycles and supply chains are focused on building system resilience. There seems to be a close complementarity between the four phases of SCRES and those of the adaptive cycle. Fath et al., (2015, p 2) define resilience as "the capacity of a complex adaptive system to navigate all stages of the complex adaptive cycle." As the authors observed, because a resilient system is one that can navigate all the stages of the adaptive cycle, it is helpful to explore the key features for success through each stage. This definition mirrors a popular definition of SCRES, that of Christopher and Peck (2004). Similarly, Hohenstein et al*.,* (2015) identify and define resilient supply chains as those that can manage the four distinct phases of supply chain readiness, response, recovery, and growth following a disruption. Davoudi et al., (2013) suggest that the adaptive cycle metaphor accounts for how systems respond to, adapt and recover after a disruptive event. Adaptive cycles inform us that both internal stress and external events can cause disruptions in complex systems. Sundstrom & Allen (2019) observe that adaptive cycles are about internally generated dynamics in complex adaptive systems. Adaptive cycles hold that change in complex systems can be sudden and unexpected, and we know that supply chain disruptions can be sudden and unpredictable (Christopher & Peck, 2004). For example, no one could have predicted the 2001 Tsunami and its destructive effects on

supply chains in Japan. As Weiberg (2012) notes, we can use adaptive cycles to visualize and contextualize how transformations happen continuously in systems.

Second, resilient supply chains need to maintain their integrity after disruption and as Allen et al., (2005, p.959) put it "adaptive cycles are about the commonality in the mechanisms by which ecosystems, societies, economies, and other complex adaptive systems maintain their structural and functional integrity when confronted by unexpected or novel events." Finally, the idea that most changes in system dynamics occur through catastrophic events, rather than gradual change, may be reflective of the "low probability, high impact" nature of supply chain disruptions (Christopher & Peck, 2004). Adaptive cycles are complex adaptive systems, and supply chains have been conceptualized as CAS (Wycisk et al., 2008). Adaptive cycles have several characteristics, which may offer guidelines for managing SCRES. These are the properties of the adaptive cycle, key pathologies associated with the cycle, and the stages of its evolution, notably the front and back loops. There are several implications for SCRES from adaptive cycles.

Properties of Adaptive Cycles: Implications for SCRES

The properties of adaptive cycles are very important since they shape the adaptive cycle and the future state of a system, regardless of its scale. Three of those properties are capital, potential, and resilience. Holling and Gunderson (2002) note that since the level of potential and connectedness change during the four phases of the cycle, we can distinguish each phase of the adaptive cycle based on their relative levels. First, potential is defined as the capacity of a system to change using accumulated resources. Nkhata et al., (2008) suggest that trust and commitment are two key attributes of potential. Resources may include social and economic capital. Bello and Bovell (2012, p. 86) define social capital as "the goodwill that is engendered by the fabric of social relations and that can be mobilized to facilitate action." The authors note that social capital can be deployed to

manage supply chain disruptions because social capital promotes supply chain stability (Uzzi, 1997). Social capital in supplier relations can be developed through building network ties, shared language, trust, norms of reciprocity and mutual obligations (Coleman, 1988; Nahapiet & Ghoshal's, 1998). Trust, "the willingness to be vulnerable to another party based on a belief in their competence and reliability" (Mishra, 1996, p. 265) makes it possible to predict behavior (Folke et al., 2005) and promotes supply chain performance (Ireland & Webb 2007). As Greening and Rutherford (2011) note, some amount of trust is helpful for building resilience, but too much trust can breed dependence and negatively affect resilience. Ruhl et al., (2005) note that social capital increases the flexibility of organizations to promote adaptive capacity and collaboration in the system. As Klerkx et al., (2010) note, individuals can play a role in building informal social networks that undergird social capital. Jüttner and Maklan (2011) proposed that social capital promotes collaboration, visibility, and flexibility, all of which in turn promote SCRES. Although the relationship between social capital and SCRES may be more complicated than is often discussed (Gölgeci & Kuivalainen, 2019), the preliminary research suggests that social capital is an important asset to have in supplier networks. Research has shown that collaboration is an important capability for building SCRES (Jüttner & Maklan, 2011; Pettit, Fiksel & Croxton 2010; Wieland & Wallenburg 2013). Importantly, Johnson, Elliot, and Drake, (2013) argued that firms can purposefully build their social capital. Accumulating the resource of social capital should enhance the *potential* dimension of an adaptive cycle. Economic capital is the second form of capital that may promote resilience. Pettit et al., (2010) suggest that financial capital in the form of capacity to withstand fluctuations in cash flow, as well as the firm's market position are important capabilities for building SCRES. Strong capital, both social and financial, should promote a high level of *potential*, while a weak capital base implies a low capacity for supply chain

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adaptation, transformation, and overall responsiveness to changes and therefore the system's overall resilience.

A second key property of adaptive cycles is *connectedness*. Holling and Gunderson (2002) define this as the degree to which actors in a system are linked together. Connectedness touches on the level of rigidity or elasticity of the system. Applying this definition to social systems, Nkhata et al. (2008, p.6) define connectedness as "the degree to which actors in social relationships are linked and the degree to which the strength of these links mediate change in social relationships". Related to supply chains, connectedness includes the number of firms in a supplier network, the number of ties they share, as well as the overall size of the network. Tightly connected networks would be rigid, while loosely coupled systems remain flexible. Research has shown that loosely coupled supply chains are preferable to tightly coupled ones. For example, Wagner, Mizgier, and Arnez (2012) argue that tightly coupled supplier networks expose members to greater risks and vulnerability. The reverse, loose coupling promotes flexibility, which enhances SCRES (Pettit et al., 2010, Tukamuhabwa et al., 2015).

Finally, is *resilience* defined as the capacity in the system for innovation and adaptation (Fath et al. 2015). Pettit et al., (2010) suggest that adaptability, including the capacity to modify operations in response to challenges, is an important capability for SCRES. Adaptive capabilities promote ecological resilience in supply chains (Eltantawy, 2016; Adobor & McMullen, 2018). Building system capacity can foster innovation and adaptation is supply chains. Sabahi & Parast (2019) show that innovation capabilities such as knowledge sharing and agility can promote SCRES.

<u>Insert Table 2 about here</u>

Front and back loop: Implications for SCRES

The concepts of front and back loops in adaptive cycles are important to our understanding of how resilience may contract and expand over time. Gunderson and Holling (2002) note that the period of the front loop is marked by system transition from the exploitation of resources to conservation. It is also a period of relative stability, as well as when a system grows until it reaches maturity (Davoudi et al. 2013). Connection and capital accumulation increases during this period (Holling, 2001). The front loop of the cycle describes how a complex system emerges and how the structure and functions of the system develop. As systems get old, they eventually become rigid and decline. At the same time, this period opens up "new and unpredictable possibilities" (Davoudi, 2012, p. 302). The back loop comprises periods of growth, followed by one of system collapse and reorganization. According to Gunderson and Holling (2002), this period is one of great uncertainty, high resilience, but an opportunity for novelty and transformation (Gunderson & Holling, 2002). The adaptive cycle holds that the resilience of a system reduces as it gets older (Holling, 1986) but a period of opportunity opens up after the system collapses (Gunderson and Holling, 2002, Olsson et al., 2006). Davoudi et al., (2013) note that the system may lose its capacity in the back loop because a disturbance or shock can push the system into a period of creative destruction before it reorganizes (Gunderson & Holling, 2002). Davoudi et al., (2013), note that the back loop is an opportunity to engage in system innovation and experimentation. This period can be the beginning of an opportunity for transformation and the building of new configurations or a new "front loop" (Gunderson & Holling 2002, Walker et al., 2004, Folke et al., 2010). Table 2 presents the key features of both the front and back loop, including what triggers movement to the next phase as well as conditions prolonging each phase. The capabilities needed to extend desirable phases may be particularly insightful for building SCRES. During the phase of the front loop, effective leadership, and new ideas would be particularly helpful. In the back loop, firms need to avoid

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incremental innovation, and rigidity, foster experimentation and the willingness to develop new mental models to push the system out of the back loop towards a new front loop. The lesson for supply chain managers here is to be ready to encourage actor agency and take advantage of resources to build innovation as the system reaches the back loop. Managers can use this knowledge to build SCRES.

Pathologies of Adaptive Cycles: SCRES Implications

The usefulness of the pathologies associated with the adaptive cycle is that they alert us not only to the potential dysfunctions to be prepared for as we build resilient supply chains, but also what to avoid. Table 1 (based on Fath et al., 2015) presents a summary of key pathologies and associated preparedness behaviors and capacities that actors must develop at each phase of the cycle. It is insightful to observe that avoiding each pathology requires that key competencies be developed ahead at each unrelated phase. As Cabell & Oelofse (2012, p. 3) note, several of the preparedness activities involve "behavior-based indicators of resilience which can act as a barometer of overall resilience; their presence suggests a resilient complex system whilst their absence or disappearance suggests a loss of resilience and greater vulnerability to disturbances."

First is the poverty trap. Carpenter and Brock (2008, p. 42) describe a system in the poverty trap in physiological terms as a person who is out of shape: "The muscles and skeletal system have a latent potential to develop strength for a wide range of activities, but this potential is untapped. A program of regular exercise could build strength." Resilience and connectedness are low in a poverty trap making the potential for change very difficult (Allison & Hobbs, 2004). As Holling et al., (2005) note actors may have many ideas at this stage but cannot focus on useful ideas to move the system out of this condition because the poverty trap diminishes sources of novelty. This as Carpenter and Bock (2008) note diminishes the systems "capacity to adapt." According to Fath

et al., (2015, p. 5- 6), we can push a system out of the poverty trap through three main paths. One can push a system out of the poverty trap by building the system's adaptive capacity based on learning and behavior change. However, a system lodged in the poverty trap is already degraded; building adaptive capacity may not be easy. Second, learning and behavior change can push a system out of a poverty trap. Firms must adopt what Argyris and Schön (1996) termed double and triple-loop learning. This as opposed to incremental, single-loop learning. Pahl-Wostl (2009, p. 359) suggest that while single-loop learning occurs within existing mental models, double-loop learning questions assumptions underlying a particular approach to a problem and triple loop learning challenges values, and norms underlying the assumptions. Such fundamental shifts in mental models are necessary to escape the rigidity trap because these forms of learning can lead to more meaningful adaptations. Learning must help actors modify their behavior. According to Fath et al., (2015) institutions can change both their short and long-term goals and strategies as part of their learning. Stern & Baird (2015) suggest that multi-loop learning promotes system resilience (Stern & Baird, 2015). Pettit et al., (2010) acknowledged that learning is an important capability for SCRES. Scholten, Scott, and Fynes (2019) suggest that developing learning routines are important for supply chain resilience. Finally, Fath et al., (2015) suggest that promoting what they call "emergent leadership" would be useful for escaping this trap. This form of leadership would involve key individuals, who assume agency and take up leadership roles to shake things up, so to say. Barlow (2012) notes that leadership is an important factor in improving supply chain resilience.

Second is the rigidity trap (Fath et al., 2015, p.3). The authors define this trap as a situation where a system becomes "so refined in its processes that there is little room for innovation." This is a period when the components of a system become tightly coupled, and rigid (Gunderson &

Holling, 2002). Butler and Goldstein (2010) suggest that systems stuck in a rigidity trap cannot learn, and if they do, they often end up using single-loop learning. Fath et al., (2015) suggest that maintaining diversity and redundancies can let systems escape the rigidity trap. Research on SCRES has shown that buffers in the form of reserve capacity (Pettit et al., 2010) and redundant capacities are important for building SCRES (Sheffi, 2007). The third trap is the vagabond trap. Fath et al., (2015) suggest that self-organization, access to stored capital, whether social or financial, as well as dependence on social memory, are important for escaping this trap. McIntosh (2000) defines social memory as the area in which captured knowledge about system change and adaptation is stored and later used to deal with change. Folke et al., (2005, p.453) note, "social memory is important for linking the past and the future." The authors note that an organizational culture that encourages openness and quick feedback would help the process of developing capabilities that help escape the vagabond trap. These same requirements apply to build SCRES. Building multiple layers of relationships between key boundary people in firms within the supply chain should help social memory. The final dysfunction associated with the adaptive cycle is the dissolution trap. The dissolution trap is a situation in which uncontained crises can destroy the system. Fath et al., (2015, p 4-5) note that the ability to identify and contain any deviations would help stop it from spreading throughout the system. This means that localizing crises is an important thing to do to avoid overall system collapse that results from the spread of crises. The authors also suggest that it is important to maintain the key functions of the system even under crises. To accomplish that, organizations can engage in improvisations all of which would be aided by leadership that demonstrates a real commitment to secure the system and avoid imminent collapse. The lessons here for SCRES are important. Supply chain networks face inevitable disruption and shock and the actors need to engage with similar behaviors to prevent the system from collapse.

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One key lesson is that maintaining existing contracts, supplies and deliveries even under a disruption is important. A crisis in the supply chain is a time for improvisation, leadership, and effort to contain the damage to local areas, and prevent it from cascading and spreading throughout the system. Supply chains that develop flexibility at both the organizational and system-level may be able to contain crises from spreading throughout the system. Garavelli (2003) defines flexibility as the ability of a system to respond rapidly to changes occurring inside and outside the system. Sheffi (2005) reports that firms such as Intel have been reported to build interchangeable processes and fabrications as a way of increasing flexibility. Other researchers have shown that building both firm, and system-wide or supplier network flexibility is important (e.g. Juttner & Maklan, 2011). Table 3 presents a summary of key pathologies, the competencies, behaviors, and culture that can enable supply chain actors to escape each of the pathologies associated with the adaptive cycle.

Insert Table 3 about here

Self-Organization: SCRES Implications

According to Fath et al., (2015), building a system's capacity for self-organization is an important part of building resilience across adaptive cycles. Abel et al., (2006) observed that the capacity for self-organization is the foundation for resilience. Kauffman (1993) describes self-organization as the capacity for dynamic systems whose evolution on the surface appear unpredictable and chaotic, to somehow manage to build order, become robust and resilient. Popularized by Nicolis and Prigogine's (1977) work on "dissipative structures" and the emergence of spontaneous order, self-organization refers to how stable patterns emerge in dynamical systems through individual behavior that becomes self-reinforcing (Kauffman, 1993; Anzola et al., 2017). Yates (1983, p.1) defines self-organization as "a process in which pattern at the global level of a system emerges

from numerous interactions among the lower-level components of the system. The rules specifying interactions among the system's components are executed using only local information, without reference to the global pattern." Although order is ubiquitous with self-organization, Prigogine & Stengers (1984) have shown that possibilities exist for such systems to evolve spontaneously towards disorder or "far from equilibrium." This happens when the system either breaks down or develops new properties. Gerrits (2010) argues that self-organization can be stimulated in social systems through individual agency and an understanding of the properties of the network would be helpful (Gerrits, 2010; Anzola et al., 2017). Although mainly associated with biological systems, self-organization has been used to explain group dynamism in organizations (Thompson, 1967) and cooperation in social systems (Helbing, Yu, & Rauhut, 2011). A critical concept in self-organization is "self-organized criticality" (SOC) (Bak, 1996). SOC demonstrates that systems can evolve through self-organization towards the "edge of chaos" (Kauffman, 1993). Bak (1996) suggests that small local disturbance of a system in a critical state may be amplified, generating a cascading effect throughout the system and pushing it towards catastrophe (Bak, 1996). In some sense, SOC promotes the idea of a critical threshold condition that if crossed, may lead to system collapse. Geng, Xiao, and Xu (2014) found that SCRES exhibit SOC characteristics.

A key condition for self-organization is the capacity of the system to import energy from the environment. As Prigogine and Stengers (1984) observed, unless an open system can import energy from outside, there can be no self-organization. Geng, Xiao, and Xu (2014) note that the ability of supply chains to get inputs in the form of materials and information from the open environment helps to reduce the entropy in a supply chain network. Levin (2005) notes that the ability to import energy helps system adaptation. The author defines adaptation as "the capacity of

a system to self-organize and reconfigure its structure and behavior to satisfy novel conditions" Hearnshaw & Wilson, (2013) describe one example of adaptability and self-organization at a firm-level in the cellular phone supply chain system. The authors describe the case of Nokia and Ericsson. Both firms shared Philips, as their sole supplier for parts. After a disastrous fire at the Phillips plant, Nokia engaged with Philips to reconfigure the design of their cellular telephones to allow them to use different chips by forming new connections with alternative suppliers and consequently did not suffer the same financial losses. Ericsson, on the other hand, did not adapt to change and suffered about a $2.3 billion loss in potential earnings (Sheffi & Rice, 2005).

Second, the actors in a complex system need to be connected for self-organization to emerge. According to Anderson (1999, p. 220), agents in a complex system are connected through feedback loops, with each agent acting on the local information it receives from the agent it is connected to. The interaction among these independent agents is governed by rules, which they apply repeatedly to create stable structures (Drazin & Sandelands, 1992). Importantly, Anderson (1999, p. 222) suggests that we can identify and isolate change in complex systems because most systems get their inputs from a few of the system's components. Further, Anderson, (1999) observed that although there have to be enough connections and interactions for the order to emerge, too tight coupling can have negative consequences including system decay. This may be so because as Simon (1996) notes, tightly coupled systems tend to have too many feedback loops, which make for instability. Being able to contain a change to local areas helps prevent the overall system collapse, and promote stability in self-organizing systems. Anderson (1999) notes that it is important that members in a social system contribute to that system for it to self-organize. In their study of the South Australian mining industry, Statsenko et al., (2018) found that connectedness among the firms contributed to resilience and adaptation. Nair et al., (2016) describe innovation in

supplier networks as an emergent phenomenon. Both adaptation and connectedness should positively influence SCRES through self-organization.

Third, feedback among the elements is necessary for self-organization. Stacey (1992) notes that positive feedback amplifies small changes, and can positively affect system growth. On the contrary, negative feedback helps regulate the system. Fourth, the elements in a complex system must have a capacity for encapsulation for self-organization to occur. Green, Sandenin & Leishman (2008) define encapsulation as a process through which different elements in a system combine to form a whole. The authors illustrate this concept with an example of how individual fish form a school by aligning their movements with their neighbors. The authors note that the concept is related to emergence, another condition necessary for self-organization. Holland (1995) notes that emergence arises when new complex patterns of behavior emerge as agents interact following simple rules, much like the school of fish. Arshinov and Fuchs, (2003) note that emergence also requires that the system import energy from outside. Knowledge about the conditions for self-organization has several implications for SCRES. For example, Geng, Xiao & Xie (2013) identified self-organization as the most important key to resilience and recovery in supply chains. Self-organization, including adaptation, has been discussed in SCRES. Self-organization in supply chains measures the ability of the supply chain to transform itself by incorporating information from the environment and adapting its behavior accordingly (e.g. Wycisk et al., 2008; Tukamuhabwa et al., 2015, Adobor & McMullen, 2018). Like any complex system, the agents or firms in a supply network build SCRES by interacting with each other, sharing information, getting feedback and adapting their behavior. Pettit et al., (2010) argue that joint learning helps emergent behavior in supply chain networks. There are some key implications of the concept of self-organization for SCRES.

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First, as "dissipative structures" (Prigogine & Stengers, 1984), supply chains can only be resilient if their members are committed to working together (*encapsulating*) and the importance of collaboration for SCRES is well noted (Takumuhabwa, et al., 2015; Scholten & Schilder, 2015; Christopher & Peck, 2004). Second, while connectedness is necessary for self-organization, tight coupling in a supply chain may prove harmful as it can lead to rigidity and system decay and collapse. As Anderson (1999, p. 222) notes, order emerges in self-organizing systems when the elements are "partially, not fully connected." The importance of both negative and positive feedback for learning, growth and behavior change for building SCRES cannot be overemphasized. More importantly, knowing that self-organization does not preclude human agency in complex social systems such as supply chains (Wycisk et al., 2008) emphasizes the role of human agency in building change to keep the system within a resilient landscape (Kauffman, 1993). Finally, one goal is to prevent SCRE from crossing a threshold of collapse, its SOC. Geng, Xiao, Xu (2014) concluded from their study of supply chain resilience of an automobile supply chain in China that SOC exists within SCRES, and that a supply chain that slips into self-criticality is in danger of collapse. More importantly, their findings show that it is possible for managers using purposeful action to prevent supply chains from slipping into SOC and losing resilience. The authors note that agency on the part of managers can be deployed to keep supply chains from crossing a point of SOC. This, they argue should be feasible because movement towards self-organized criticality is mainly controlled by internal, rather than external events.

CONCLUSIONS

Sundstrom & Allen (2019) note that the concept of adaptive cycles have remained mainly a conceptual and qualitative heuristic. However, the evidence shows that adaptive cycles are a

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pervasive feature of complex adaptive systems with some empirical validation (Gunderson & Holling, 2002; Fath et al., 2015; Sundstrom & Allen, 2019). Although the empirical application of adaptive cycles have been far and in between, this has not prevented the concept from being applied widely in dynamical systems theories (Kauffman, 1993; Fath et al., 2015, Davoudi et al., 2013). First proposed by Gunderson and Holling (2002), the adaptive cycle highlights the mechanisms that support or prevent resilience in complex adaptive systems (Biggs et al., 2010). Supply chains and adaptive cycles share characteristics of complex adaptive systems and resilience, and the metaphor of adaptive cycles has the potential to enhance our understanding of SCRES, and broaden the available collection of strategies for managing supply chains resilience at the firm, system and cross-system levels. Walker at al., (2002, p. 7) sum up the two goals of resilience management as: "preventing the system from moving to undesired system configurations in the face of external stresses and disturbance" and "nurturing and preserving the elements that enable the system to renew and reorganize itself following change." According to the authors, fostering renewal and reorganization relies on the adaptive capacity of the system, which resides in "aspects of memory, creativity, innovation, flexibility, and diversity of ecological components and human capabilities." The adaptive cycle model identifies all these capabilities for adaptation (Fath et al., 2015; Gunderson and Holling, 2002).

This paper contributes to the literature on SCRES in several ways. First, adaptive cycles may expand our understanding of SCRES in new and important ways. Specifically, the heuristics can help us build a better understanding of evolutionary or cross-scale resilience (Davoudi et al., 2013; Williams et al. 2019). Existing concepts of supply chain resilience have largely focused on engineering, and to some extent, ecological resilience (Eltantawy, 2016). While helpful, both resilience types would benefit from a greater study of evolutionary resilience, a form of resilience

that is more consistent with the non-equilibrium, dynamical view of supply chains as complex adaptive systems (Adobor & McMullen, 2018; Davoudi et al., 2013). The fact, as Homstrom and Hameri (1999) note is that supply chain research seemed to have moved away from "linear optimization" towards a dynamical perspective (see e.g. Pathak et al., 2007, Wycisk et al., 2008). Yet the evolution of research seemed focused mainly at a focal scale without consistent effort to study cross-scale resilience, despite the implicit recognition of cross-scale resilience. As Bristow and Healey (2014, p.95) observed, "resilience is about systems changing as circumstances change, adaptation when necessary, and transformation rather than continuing to do the same thing better" (based on Goldstein et al., 2013). Indeed, As Davoudi et al., (2013, p. 311) observed, resilience building involves persistence (being robust), preparedness (learning capacity), adaptability (being flexible) and transformability (being innovative). These behaviors suggest cross-scale resilience capabilities across different time scales.

Second, the emerging research in adaptive theory demonstrates that adaptive cycles focus on a dynamic system's capacity to resist collapse and maintain vital functions, to adapt to changing conditions (learn and self-organize) and system capacity to apply knowledge to manage the system (Gunderson & Holling, 2002; Fath et al., 2015; Davoudi et al., 2013). The adaptive cycle heuristic allows us to see resilience, not as a fixed asset, but something evolutionary because it incorporates the "dynamic interplay of persistence, adaptability and transformation across timeframes" (Davoudi et al., 2012, p. 304). Such an understanding of SCRES has important implications for what firms need to do as resilience expands and contracts through time. More importantly, this characteristic informs us that supply chains may demonstrate different degrees of resilience over time.

Third, the adaptive cycle may allow us to generate hypotheses about SCRES dynamics. Holling and Gunderson (2002) stress that the adaptive cycle is a metaphor that can be used to

generate specific hypotheses about phenomena. The exact interpretations of resilience, potential, and connectedness, all key elements of adaptive cycles are system dependent, meaning that we can identify corresponding elements in any system under study, including supply chain networks. Third, adaptive cycles help explain how complex adaptive systems maintain their structural and functional integrity when confronted with unexpected or novel events, and that knowledge may prove useful to our understanding of SCRES. Fourth, adaptive cycles show that systems may benefit from disruptions and the idea that disruptions may be necessary to increase system vigor and diversity over the long term (Walker et al., 2006), can allow us to develop more rigorous explanations and management of the long-term resilience of supply chain networks. As Gunderson and Holling (2002) note, actors can see disruptions as periods of "creative destruction" that may be necessary for continuous development and resilience in the long term.

Finally, the adaptive cycle heuristic presents an opportunity to study cross-scale resilience. Although important, cross-scale SCRES has not been rigorously explored (see Williams et al., 2019 for a notable exception), issues of cross-scale change and disruption are becoming important for supply chains. For example, climate change may affect the whole system of primary agricultural commodity production, say cocoa and palm oil and irrevocably alter the resilience of producers, thereby affecting supply chains associated with these commodities. Williams et al., (2019) describe one such case: the cross-scale resilience of the palm oil supply chain in Borneo. Besides climate change, the rise of supranational and governmental intervention around primary commodities can challenge cross-scale resiliency. For example, the governments of Ghana and Ivory Coast, two neighbors and leading producers of cocoa have teamed up to both deal with issues of climate change and changing production patterns and influence global prices (Reuters, 2019). How we deal with resilience may be influenced by our knowledge of focal and cross-scale

resilience. How companies manage cross-scale resilience is an important area for research and adaptive cycles and the concept of panarchy may offer important guidelines on this issue. According to Holling (2001), panarchy is a nested set of adaptive cycles operating at distinct scales. Higher-level systems are larger, change slowly, while lower-level systems are smaller and change quickly. Changes at one level can cascade across the whole system (Gunderson & Holling, 2002). Allen et al., (2014) note that although the number of levels in a panarchy varies, they correspond to dominant scales present in the system. According to Allen et al., (2014, p. 580), "a key component of this model is that cross-scale linkages are related to within-scale system position within the adaptive cycle." According to the authors, panarchy is an example of successive adaptive cycles building on each other. The smaller adaptive cycles can exert an upward influence on the larger system while the larger system at the top exercises a downward influence on the smaller system below. Panarchies are different from regular hierarchies in which control is top-down only. System resilience requires that all the smaller adaptive cycles be resilient. Therefore, panarchy emphasizes cross-scale linkages in which processes at one scale can affect those at other scales to influence the dynamics of the whole system (Allen et al., 2014).

Implications for Research

The adaptive cycle may move our discussion of resilience beyond engineering and ecological resilience to include evolutionary resilience (Davoudi et al., 2013). While the first two presently dominates our theorizing on SCRES, evolutionary resilience may be more insightful than both may. Resilience implies change, adaptation, and transformation in response to stress (Carpenter et al., 2005), rather than a return to some normality. Adaptive cycles capture the idea of change, adaptation, and transformation. However, it appears that most of our current ideas about supply chain resilience are consistent with engineering resilience. For example, a focus on robustness and

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agility of supplier networks may be more consistent with engineering resilience (Tang, 2006). Few

studies have applied the extension to ecological resilience and fewer yet to evolutionary resilience.

However, the non-equilibrium view of resilience has much to offer our understanding of supply

chain dynamics. According to Alderson and Doyle (2010, p.), resilient systems exhibit five key

features: reliability (robustness to component failures) efficiency (robustness to resource scarcity)

scalability (robustness to changes to the size and complexity of the system), and evolvability

(robustness of changes on long time scales). The authors note that scalability allows a system to

shift relevant temporal and spatial scales to adjust to changed conditions. Evolvability implies the

capacity to keep doing both over long periods. The adaptive cycle heuristic may allow us to build

a greater understanding of the evolvability and scalability of SCRES, the two temporal and spatial

scale dimensions of resilience (Davoudi et al., 2013).

Designing research that relates supply chains to adaptive cycles may pose some challenges.

However, existing research on socio-ecological systems applying the heuristic may give us some

initial pointers (e.g. Fath et al., 2015). First, qualitative studies may be used to study this

phenomenon in supply chains. For example, Abel et al., (2006) used a case study to test the

explanatory usefulness and policy relevance of the adaptive cycle to study processes of collapse

and recovery in regional social-ecological systems in Zimbabwe and Australia. Gotts (2007) notes

that the adaptive cycle is useful for recognizing changes in system behavior during the various

phases of its evolution. Second, it is possible to use quantitative modeling to relate adaptive cycles

to SCRES. Research progress may be made by studying just one or two of the cycles at a time to

get familiar with the nuances of doing this sort of research. The hierarchical nature of adaptive

cycles and the concept of panarchy makes it imperative to explore multi-level approaches to the

study of SCRES. Indeed, panarchy explains dynamics within systems and therefore the concept

provides guidance to how we can measure dynamics within larger systems (Sundstrom & Allen, 2019). This can be done both at focal and cross-scale levels.

Implications for Practice

The adaptive cycle heuristic can guide managers in managing supply chain networks for resilience. First, the knowledge that supply chain networks may go through cycles in which resilience expands and contracts is important. The front loop of the adaptive cycle, defined by movement from exploitation to conservation, is a period of stability in the system. Although resilience increases during this period, actors need to remember that there are possibilities of pathologies developing. Namely, rigidity, and incremental innovation both of which make the system more vulnerable in the long term (Fath et al., 2015). Strong resilience at this time may be deceptive because it can prolong this front loop. This is the time for creative leadership in the system to enhance the possibilities of long-term system resilience. This may also the best period for experimentation. Managers should understand that high resilience promotes tight coupling among the actors and firms, making the system more vulnerable when a disruption occurs from some external or internal shock.

The back loop, a period shorter than the front loop also has implications for managers. Although this period is marked by turbulent change, it is an opportunity for innovation and creativity. Wahl (2016) suggests that the opportunity for "redesign, reorganization, and renewal is high during the back loop, due to the release of rigid structures, established patterns and the redistribution of resources throughout the system." This is the best period for reorganization and redesigning the supply chain network if the actors determine that the status quo will not work any longer. This is because it is a time for rigid structures to breakdown. The research suggests that managers can do two things at this time: if the desire is to recover from the turbulence without

changing the existing regime, managers need to invest in resources that allow them to preserve the existing system. However, if the desire is to transform and change existing regimes, then there is the need to invest in those things that promote transformation (Walker et al., 2004, Folke et al., 2010). The lesson is that disruptions may present opportunities for doing new things. How some Japanese firms reacted after the 2011 Tsunami offers some lessons for how destruction creates opportunities for innovation. It demonstrates how rigidity gave way to innovation. Fisher (2011) reports that some Japanese supply networks had a hard time recovering after the 2011 Tsunami disaster because they had "put all their eggs in one basket." Fisher's (2011) report suggests that several Japanese companies learned the lessons of focusing on too much efficiency (engineering resilience) and have already started investing in redundancy. According to Fisher, Canon may be one example of a firm demonstrating adaptation by moving to diversify its production base by expanding its Hita factory in Kyushu in southern Japan, as well as increasing production lines at its two factories in China.

Second, an important lesson for supply chain actors is the need for them to be interested in resilience across focal points and scales. The concept of panarchy emphasizes scale resilience. Building resilience cross-scale resilience may be an important capability for supply chain networks. Knowing how lower-order systems affect higher-order systems and vice versa may be important for building SCRES across scales and time. For example, resilience at the firm level may affect system-level resilience. At the same time, changes at higher levels may affect the whole supply chain network and its resilience. Williams et al., (2019) have shown how changes in climatic conditions in Borneo has affected the palm oil industry, an example of how changes at the socio-ecological level can affect supply chain resilience.

Third, the characteristics of the phases in an adaptive cycle and the nature of resilience associated with each phase may prove valuable for understanding how to leverage resources or when and where to intervene to build SCRES. Importantly, an understanding of the key determinants of resilience in adaptive cycles may help managers build SCRES. The potential of the system sensitizes managers on what sort of managerial, firm and system resources, skills and capabilities to build for SCRES. The capacity to adapt and innovate is another important determinant of system resilience in adaptive cycles. Managers need to focus on building the adaptive capacity of their supply chains and be willing to innovate to ensure system resilience. Finally, connectedness clarifies competences supply chain actors need to manage systems to increase resilience. These include trust, collaboration and other relational assets that have been noted in existing research (Fath et al., 2015). The idea that resilience expands and contracts with time is important. This idea should sensitize managers to the fact that temporary dips in resilience may be normal, and firms should expect such behavior in the supply chain. The key is to try to keep the system mainly within a phase where resilience can be extended.

Fourth, the adaptive cycle informs managers that disruptions may be an opportunity for change and creativity. Both researchers and practitioners have traditionally viewed supply chain disruptions as destructive. Indeed, the present thrust of SCRES research is to sensitize firms to prepare for or avoid disruptions altogether. While useful, that thrust fails to inform managers on what to do when disruptions inevitably occur. Adaptive cycles demonstrate that disruptions may be equated to periods of "creative destruction", an opportunity for renewal, novelty and system change (Holling, 2001). Incidentally, it seems that transformation after a disruption is one of the least understood periods of supply chain resilience. The goal of managers is to avoid dysfunctions by sticking to old arrangements when a period opens up for renewal. Davoudi (2012, p. 303) notes

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that turning crises into opportunities are not easy and require preparedness and the capacity for imagining alternative futures.

Finally, insights from adaptive cycles may help broaden our repertoire of management capabilities for SCRES. In addition to knowledge on skills required to manage phases of the adaptive cycle to promote SCRES, knowing how to avoid or manage the pathologies associated with the adaptive cycle will increase our knowledge of levers to use to either keep the system in a desirable cycle for a long time or what to avoid catastrophe. Avoiding the rigidity trap requires that firms maintain diversity, build social capital and redundancies in the system (Fath et al., 2015). Both system redundancy and diversity of function promotes SCRES (Adobor & McMullen, 2018; Tukamuhabwa et al., 2015). The vagabond trap can be avoided by promoting self-organization. Also, both social capital in the form of trust and other relational assets will help avoid this trap. The modularity of systems, in the form of diversifying sources of supply may help avoid this trap while improvisation, creativity, and leadership (Fath et al., 2015) can avoid the dissolution trap. Collectively, these skills expand the repertoire available for managers to build SCRES. Davoudi et al., (2012, p. 311) summarizes a four-dimensional framework for building system resilience: adaptability (being flexible) transformability (being innovative) persistence (being robust) and developing a learning capacity. These skills should prove useful to supply chain managers.

Limitations and future research

The frontiers of research in any field can be extended by borrowing concepts from other disciples as this current paper has done. Resilience is certainly one of those concepts that made its way into supply chain research from engineering and ecology. Resilience may have proven so useful to the point that like the mythological Icarus, its popularity may become its very undoing. As Rose (2007, p.384) notes, a lack of precise definitions of resilience has rendered the concept to be 'in danger

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of becoming a vacuous buzzword because of its overuse and ambiguity.' One way to avoid this is for researchers to define concepts like resilience and adaptive cycle clearly. In addition, it would be helpful to state what one is borrowing from other disciplines and note the limits of their applicability. Sartori (1984) cautions that while we can make concepts "travel" by applying them to new cases, "stretching" concepts too much would make them lose their usefulness. To the extent that supply chains are complex adaptive systems and resilient supply chains are capable of maintaining their structural integrity in the face of disruptions, the use of resilience and more specifically adaptive cycles can be useful in supply chain research. The adaptive cycle was derived from the study of ecosystems, and social systems such as supply chains are unlikely to operate exactly in the same ways as ecosystems. Indeed, as Cumming and Collier (2005) noted, not all social systems fit the adaptive cycle. However, because supply chains and all complex adaptive systems respond the same way to change events, are adaptive, and share resilience (Allen et al. 2005: 959), we can assume that supply chains mimic adaptive cycles. Knowing the limits of the applicability of concepts is important. For example, although the adaptive cycle predicts that systems go through cycles, the cycle itself is not predictive, nor does it "offer a framework for measuring resilience, instead, it emphasizes resilience as something that evolves and changes continually as systems adapt and change" (Davoudi et al., 2012, p. 310).

Importantly as Walker et al., (2006) observe, the phases of the adaptive cycle may not always follow the projected sequence. As Brunk (2002) suggests, the non-sequential nature of the phases of the adaptive cycle is explained by the fact that it is possible to extend a particular phase of the cycle through actor intervention. For example, actors can keep a system in a period of regeneration longer by developing the requisite capabilities for innovation. Brunk (2002) suggest that the disruptions in a system occur randomly and are not limited to specific and particular events.

Of course, any external disruption that is large enough can trigger a cascade (Abel et al., 2006). Importantly, however, actors can develop the resources to dampen such cyclicities and extending the periods of stability (Brunk 2002). Despite its limitations, the adaptive cycle may expand our understanding of supply chain resilience. As Carpenter et al., (2001) note, adaptive cycles can be useful metaphors, even if they are not a testable hypothesis. As the authors put it, "theory itself is rarely tested directly; indeed, it may not be testable in any definitive way. Instead, its success is measured by the utility of the concepts in terms of their ability to influence the research topics chosen by scientists and stimulate productive hypotheses" (p. 767).

Further application of the adaptive cycle heuristics would benefit from empirical studies using the framework to study a supply chain network and SCRES. Researchers have the option of studying some or all the phases of the cycle. A greater understanding of the properties of the adaptive cycle, and how these affect SCRES would also be useful. Paying attention to the determinants of resilience in the adaptive cycle, potential, connectedness, and resilience would be an important area for research. As both CAS and adaptive cycles demonstrate multilevel features (Wycisk et al., 2008; Davoudi et al., 2013; Williams et al., 2019), research that applies multilevel thinking to the study of these dynamic systems would make important contributions to the understanding of SCRES. This research identified some key system properties at each phase, the pathologies associated with each phase and the core capabilities and competencies needed to navigate each phase of the cycle to increase system, and related them to supply chain resilience.

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Table 1: The Adaptive Cycle and its Properties

Stage of Adaptive Cycle	Description	Properties of the Adaptive Cycle		
		Resilience	Potential	Connectedness
Growth	Resources are available and those actors that can act fast can take advantage and dominate the system.	Low	High	Low
Conservation	Accumulation of capital Lock in of several system actors. Reduced available resources Rigid and set system	High	Low	Increasing
Release	System and its functioning collapse Capital and connections bound up in a system are made available	Low	High	High

Reorganization	Available capital (human, social, cultural, environmental, financial, etc.) Connections exposed to new innovations Opportunity to build a new system configuration	High	Low	Decreasing

Based on Gunderson and Holling (2002).

Table 2: Adaptive Cycle: Front and Back Loop

Phase of the Adaptive Cycle	Description	Triggers of the next phase	Conditions prolonging the phase
Front loop: From Exploitation to conservation	A longer period of growth	Socio-ecological triggers:	Socio-ecological conditions:
	Defined by the accumulation of resources	Crises such as natural disasters	Institutionalization High resilience leading to lock-in of existing structures
	Stability	Shocks and disturbances	Lack of novelty
	Increased resilience Connectivity	Individual triggers: Internal crisis	Individual barriers: Lack of effective leadership
	Rigidity and vulnerability		

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Incremental innovation

Back loop: From release to reorganization	Shorter period of rapid change and innovation defined by the following:	Socio-ecological triggers	Socio-ecological conditions:
	Turbulence	Diffusion	Lack of resources
	Novelty change	Engaging stakeholders	Lack of novelty
	Low connectedness	Individual triggers:	Individual conditions:
	Variety	Visionary leadership	Inaction
	High unpredictability	Emergent leadership	
	Radical innovation.	Reframing	
		Experimentation	

(Adapted from Williams, Whiteman and Kennedy, 2019)

Table 3: Pathologies, resources, and culture for escaping traps

Stage	Competence	Resources	Culture
Escaping the vagabond trap α-stage			
	Cooperation with supply chain members	Supply chain culture that supports experimentation	Culture that takes the long term perspective about the supply chain benefits and avoids short term focus
	Work with customers		
	Share ideas with others		
	Create conditions for self-organization in the supplier network		
	Use stored social and financial capital		
	Social memory is important here		
	Foster loose coupling		

Escaping the poverty trap: r-stage

Build diversity into the supply chain Build redundancy into the supply chain Use negative feedback for corrective behavior	Chose supply chain partners carefully	Culture that promotes collective thinking. Supply chain members must perceive that there is value in the relationship

Escaping the rigidity trap: K-stage

Use negative feedback Maintain diversity Used stored capacity Try to contain the disturbance	Building buffers to cushion supply chain very important	Keep organization agile and welcome change

Escaping the dissolution trap: Ω-stage

Supply chain network leadership is key Ensure that vital functions are maintained even under disruption Improvise if you can Contain crisis to local areas	Ability to focus on core business	See opportunity in change. Recognizes that disruptions are an opportunity for renewal

(Adapted from Fath et al., 2015)

Figure 1: Adaptive Cycle
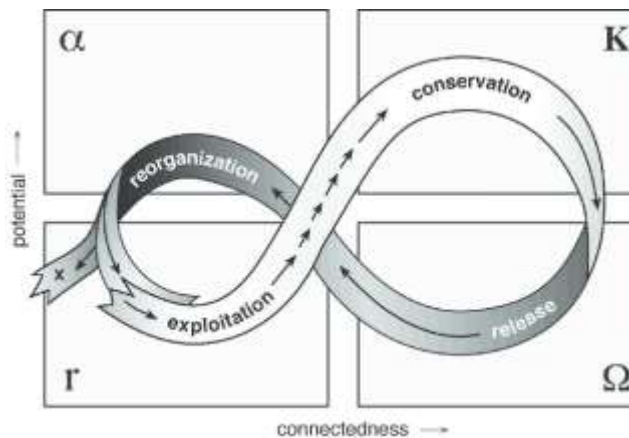
Source: *Panarchy* edited by Lance H. Gunderson and C.S. Holling, Chapter 1. Figure 1.
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Sustainability - Abstracts

Blueprint for Global Sustainability: Impact of Technology, Healthcare and Education

Sustainability

Dr . Viju Raghupathi [1]

1. *Brooklyn College of the City University of New York*

Sustainability ensures meeting the needs of the current generation without compromising that of future generations. There is a universal debate on the effects of emerging technology, healthcare and education for sustainable development. This research explores if these three sectors contribute effectively to a country's sustainable development. Using empirical data from World Bank for the years 2004-2018 for 34 countries, findings highlight how national efforts at ending poverty should be undertaken in parallel with improving education and enhancing economic growth, all while tackling climate change. This offers an excellent blueprint for global sustainability for now and the future.

Coastal City Climate Change Planning: A Network Optimization Cost-Benefit Approach for Coastal Cities Facing Flooding from Climate-Change-Induced Sea Level Rise

Sustainability

Mr . Donald Jenkins [1], *Dr . Foad Mahdavi Pajouh* [1], *Dr . Paul Kirshen* [1]

1. *University of Massachusetts Boston*

Current climate change scenarios estimate significant flooding risk to coastal cities. A city with a rich maritime history, Boston must also plan to mitigate potential flooding in the face of deeply uncertain estimates. This research extends existing flood cost-benefit research by using an at-risk network to model a coastal region lacking existing flood mitigation infrastructure to evaluate optimal cost-benefit strategies. Expected flood costs are included using a loss function sampling a range of scenarios, while investment costs are captured for overall infrastructure development. The problem is modeled as a large-scale mathematical program that optimizes for the minimal overall expected costs.

Heterogeneity in Corporate Green Supply Chain Practices Adoption

Sustainability

Ms . Yuan Chen [1] *, Dr . Joseph Sarkis* [2] *, Prof . Qinghua Zhu* [1]

1. *Shanghai Jiao Tong University ,* **2.** *Worcester Polytechnic Institute*

While studies have investigated the characterization of firms in environmental practices adoption terms, few studies focus exclusively on the implementation of green supply chain practices. Most of the findings are obtained from self-reported survey-based data. Using multi-year secondary China-based data based on professional auditing, this study evaluates organizational efforts for adopting supply chain environmental practices. A firm characteristic-based cluster analytic evaluation provides insights on how firm size, industry, and national brand play a role in green supply chain practice adoption. Strategic and operational exploratory implications are resultant.

IMPLEMENTATION OF PREDICTION MODEL FOR EQUIPMENT REPLACEMENT TIME BASED ON AVAILABLE INFORMATION

Sustainability

Mr . Yuta Inoue [1], *Mr . Tomoki Oshima* [1], *Prof . Aya Ishigaki* [1]

1. *Tokyo University of Science*

This study deals with the inventory management problems of the pump used for material transfer in the biomass plant. The spare parts are very expensive and precise, so the plant tries to manage the spare parts with a "Just-in-Time inventory" strategy.

In addition, the facility manager dynamically predicts the situation inside the pump while monitoring changes in indirect observation data based on experience.

This study proposes a method of inferencing the failure probability of the pump from the operation data of the past equipment and the blending ratio of the raw materials, and managing the inventory of the pump.

The Business Case For Corporate Social Responsibility

Sustainability

Prof . Shaike Marom [1], *Prof . Robert Lussier* [2]

1. *Kinneret College ,* **2.** *Springfield College*

To date, the 'business case' for pursuing corporate social responsibility (CSR) and integrating it within firms' strategy, is drawing on evidence about a positive impact that CSR has on corporate financial performance (CFP). However, the study of the correlation between corporate social performance (CSP) and corporate financial performance (CFP) has yielded various and contradictory results. This research sought to extend the validity of the said business case, by investigating the CSR-CFP relationship in Israel. The research concluded that the business case for advancing CSR as part of business strategy can be extended beyond the leading western economies.

Was Boeing's board complicit in the 737 MAX disasters?

Sustainability

Dr . Dov Fischer [1] *, Dr . Darline Augustine* [1] *, Dr . Ngoc Cindy Pham* [1]

1. *Brooklyn College*

This analysis is based mostly on public disclosures from the Boeing Company's Annual Reports (2007-2014) and Proxy Statements (2008-2015). In 2011, Boeing decided to modify the existing 737 airframes by adding new engines to the resulting 737 MAX. This decision to retrofit the existing airframe rather than launch a new airplane turned out to be a terrible business decision. The CEO convinced his compensation committee to factor "risk reduction" into its measure of economic profit and company performance score.

Sustainability - Papers

EXTENDING THE BUSINESS CASE FOR CORPORATE SOCIAL RESPONSIBILITY

Shaike Marom, Kinneret College, Israel

Robert N. Lussier, Springfield College, USA

ABSTRACT

To date, the 'business case' for pursuing corporate social responsibility (CSR) and integrating it within firms' strategy, is drawing on evidence about a positive impact that CSR has on corporate financial performance (CFP). However, the study of the correlation between corporate social performance (CSP) and corporate financial performance (CFP) has yielded various and contradictory results. This research sought to extend the validity of the said business case, by investigating the CSR-CFP relationship in Israel. The research concluded that the business case for advancing CSR as part of business strategy can be extended beyond the leading western economies.

Keywords: Corporate Social Responsibility, Financial Performance, Business Strategy, Business Case

INTRODUCTION

In recent years, the pursuance of corporate social responsibility (CSR) has gained wide recognition as a good practice that can lead to improved financial performance (Carroll & Shabana, 2010). Considerable research has been published on the relationship between CSR and financial performance, with meta-analysis studies of extant research revealing that the majority of results indicate a positive relationship between CSR and firm financial performance (Griffin & Mahon, 1997; Orlitzky, Marom, 2006). Accordingly, it has been concluded that "CSR and financial performance are generally positively related across a wide variety of industry and study contexts" (Orlitzky et al., 2003, p. 406). The positive impact that CSR can have on financial performance, referred to as the business case for CSR (Carroll & Shabana, 2010), has led many to recognize the potential value of integrating CSR into firms' strategy (Galbreath, 2009; Porter & Kramer, 2006). Aiming to extend the validity of the business case to incorporating CSR into strategy, this research investigated the CSR-to- CFP relationship within the business environment in Israel.

LITERATURE REVIEW

Corporate social responsibility

The premise of CSR is that corporations have moral responsibilities that go beyond simply making profit for their owners and shareholders (Berman *et al.*, 1999). Thus, various definitions state that CSR is "the continuing commitment by business to behave ethically and contribute to economic development while improving the quality of life of the workforce and their families as well as of the local community and society at large" (www.wbcsd.com, 2000); and "the voluntary actions that business can take, over and above compliance with minimum legal requirements, to address both its own competitive interests and the interests of wider society" (Timperley, 2008).

Since the mid-twentieth century, the definition of CSR has evolved from normative and ethics-oriented arguments to instrumental and performance-oriented focus (Carroll, 1999; Lee, 2008). During this time, CSR progressed from a low-relevance idea to a widely accepted concept in business, being promoted by various constituents, including governments, non-governmental organizations and individual consumers (Lee, 2008).

Several theories promoted CSR, each emphasizing on different aspects and meaning, including *descriptive*, *normative*, *instrumental* and *integrative* (Garriga and Melé, 2004). The normative view is based on a perspective claiming that corporations, above any other consideration, ought to undertake social responsibilities as an ethical obligation to the society by large. The integrative approach argues that businesses depend on society, including the resources from and consumed by society, for their existence and growth (Garriga and Melé, 2004). Manifesting this view, Eells and Walton (1974, p. 247) asserted that:

> "Insofar as the business system as it exists today can only survive in an effectively functioning free society, the CSR movement represents a broad concern with business's role in supporting and improving that social order."

By the instrumental perspective, CSR means that corporations are expected to achieve profits and financial stability, a concept rooted in the assumption that the role of corporation is wealth creation for the benefit of society at large (Donaldson and Preston, 1995; Garriga and Melé, 2004). Although the normative theory is fundamental, the instrumental aspect has developed as the most

powerful and important for corporations and stakeholders (Donaldson and Preston, 1995; Lee, 2008).

Theoretical concepts on the CSP–CFP link

Over the years, and in reaction to the disparate findings, several theoretical models have been proposed to explain the observed relationships between CSP and CFP. The most widely accepted theories were summarized in Preston and O'Bannon's (1997) six-cell-typology. When looking at the impact of CSP on CFP, the two influential (and contradictory) hypotheses are as follows:

The social impact hypothesis (Preston and O'Bannon, 1997) assumes that meeting the needs and expectations of various stakeholders increases financial performance (i.e., CSR positively influences CFP). Several mechanisms that mediate the relationship have been suggested; these include improving corporate reputation, decreasing business risk, gaining higher support from regulatory agencies, attracting more investment from financial markets, and others.

The trade-off hypothesis (Preston and O'Bannon, 1997) assumes that by increasing their social performance, firms incur unnecessary costs and consequently reduce their profitability, thus putting them at a disadvantage when compared to firms that are less socially active (i.e., CSR negatively influences CFP).

Past findings on the CSP–CFP link

The link between CSP and CFP has been widely studied during the last three decades. However, the results of these studies were not conclusive and in some cases contradictory (Griffin and Mahon, 1997; McWilliams and Siegel, 2001; Roman et al., 1999; Rowley and Berman, 2000). The correlation between CSP and CFP was found to be positive, negative, or non-significant, and with different causal directions. Most studies found a positive relationship between CSP and CFP (or stakeholder management and FP). Such positive relationship has also been supported by a meta-analysis by Orlitzky et al. (2003), which reviewed 52 previous studies, as well as a study by Griffin and Mahon (1997), which reviewed 51 previous articles on the subject. This led to wide acceptance of the notion that being socially responsible, and responding to stakeholders' needs and expectations, would result in competitive advantage, improved financial performance, and a higher value of the firm's objective function. Despite mostly positive findings, ambiguity still remains

about the factors that affect the direction of the relationship, and determine whether it will be positive, negative, or non-existent.

CSR as part of Firms' Strategy

With the potential to contribute to the bottom-line of the business, it has been suggested that CSR should be integrated into the strategy of the firm (Galbreath, 2009; Porter & Kramer, 2006). Several approaches have been suggested as to how CSR should be considered and integrated into a firm's strategy. According to Zadek (2000), the integration of specific CSR components, as part of the business strategy, should be based on whether they contribute to 1) building good reputation, 2) achieving cost benefits, 3) matching overall strategy, and 4) serving to reduce risks and promote innovation. A similar viewpoint has been suggested by Kurucz, Colbert, and Wheeler (2008). Accordingly, engagement in CSR components should be considered as part of business strategy, if they may contribute in one of the following aspects: 1) reduce cost of operations as well as risks associated, 2) achieve competitive advantage in their respective business environment, 3) build reputation; and 4) create additional value for multiple stakeholders simultaneously.

The integration of CSR into the strategy of the firm, as discussed above, is aimed to support achieving the mission and goals of the firm, as is the role of strategy itself (Galbreath, 2009). Thus, the business case for CSR refers to the justification that engagement in CSR will be rewarded with better financial performance (Carroll & Shabana, 2010). Such evidence, about a positive link between CSR and financial performance, will support the rational for firms' engagement in CSR and its integration into firm strategy.

Hypothesis

Drawing on prior impact theories and results from extant research, it is hypothesized that the CSR-CFP relationship will be positive, i.e. a positive impact of CSR on financial performance. Thus, the research hypothesis is formulated as:

Hypothesis: *When comparing two groups of companies, one with high CSR and the other with low CSR; the financial performance of the high-CSR group will be superior to that of the low-CSR group.*

METHOD

This study employed a cross-sectional research design, consisting of comparing CFP data of companies with differing levels of CSR. The details of the method including selection of sample, the operationalization of CSR and CFP, and data analysis, are explained below.

Sample: The sample of the study consists of the 100 leading companies in Israel which form the TA-100 index, of the Tel-Aviv Stock Exchange (TASE). This represents a similar approach to using the S&P 500 in the United States or FTSE 100 in the United Kingdom. Selection of the companies that make up the TA-100 index assures a high level of publicly reliable data, as companies traded on the stock exchange are required to make their audited yearly financial statement available to the public, adhering to fair-trading regulations.

Operationalization of Variables and Data: This research used an External Evaluation-Based scoring and ranking data, published by the social ranking organization in Israel – 'Maala' (www.maala.org.il). Maala - 'Business for Social Responsibility in Israel', is a non-profit organization, which promotes the concepts of corporate citizenship and social responsibility in Israel's business arena. The CSP data was scored in four main dimensions, with a scoring system of 100 points; with each dimension gauged by several indicators, as follows: *Business Ethics* (25 points), *Workplace and Human Rights* (25 points), *Community Investment* (25 points), *Environment* (25 points). CFP data was based on two indicators: Return-on-Equity (ROE) and Return-on-Assets (ROA); both are accounting-based measures of financial performance.

Data Analysis: Confirmatory data analysis was used to test the two hypotheses by comparing the two, or three, groups of companies, respectfully. The test applied a method of average ranking differentiation between the groups of companies. This test design follows a similar methodology applied by Verschoor and Murphy (2002) and Webley and More (2003). The average ranking differentiation method was selected because the two groups of companies were not matched in number of companies in each group, as well as due to their variety in terms of industry sector.

RESULTS

The research hypothesis was that when comparing two groups of companies, one with high CSR and the other with low CSR; the financial performance of the high-CSR group will be superior to

that of the low-CSR group. The test was based on the comparison between two groups of companies - those with high CSR and low CSR, and was conducted according to the method described above, with the following steps: First, the two-year measures of financial performance were calculated for each company. Next, the 84 companies of the sample were assigned a rank number, according to their calculated financial performance, which included a two-year average of ROE and ROA. Following, average rank was calculated for the companies in each group (low and high CSR). Finally, the difference between the average rankings of the two groups was calculated. The results are shown in Table 1.

	Based on Return-on-Assets (ROA)	Based on Return-on-Equity (ROE)
Average rank of financial performance for companies with high CSR	38.2	32.9
Average rank of financial performance for companies with low CSR	42.5	45.7
Percentile of better average ranking of financial performance of high CSR group relative to low CSR group	6.8%	15.3%

Table 1: Test Results

The comparison between the two groups of companies - low and high CSR, shows that companies with high CSR had better financial performance than those with low CSR. Thus, those findings support the hypothesis that a group of companies of high social responsibility have better financial performance than a group of companies having low social responsibility.

DISCUSSION AND CONCLUSION

Based on data from leading companies in Israel, the findings of this research provide evidence that practicing CSR by firms can positively impact financial performance of the business. This finding supports the research hypothesis that being a socially responsible company can lead to improved financial performance, and correspond with findings of previous research (Griffin & Mahon, 1997; Orlitzky et al., 2003). The research findings shows that CSR practices and impacts are holding true

for companies in Israel. This provides executives in Israel the sought after, local-based evidence that social responsibility does lead to improved financial performance in their country. These findings provide grounds, to include social responsibility as an important part in strategic management.

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Was Boeing's board sufficiently independent in its risk assessment of the 737 MAX?

Abstract

Incentive pay alignment is one of the key pillars of corporate governance. While the goal of incentive pay is to mitigate the principal-agent or agency problem in governance structures, incentive pay contracts can result in conflicts of interest that manifest in disastrous decisions. We present the case of the Boeing Company's 737 MAX jetliner to demonstrate how incentive pay structures and poor governance practices (such as insufficient independence of Board and Compensation Committee) led to incalculable risks for Boeing and the loss of hundreds of lives. This analysis is based mostly, on public disclosures from the Boeing Company's Annual Reports (2007-2014) and Proxy Statements (2008-2015). In 2011, Boeing decided to modify the existing 737 airframes by adding new engines to the resulting 737 MAX. This decision to retrofit the existing airframe rather than launch a new airplane turned out to be a terrible business decision, not to mention the cost in human lives. However, in his 2011 letter to shareholders, Boeing CEO Jim McNerney hailed that the decision would "reduce our business risk substantially for the next decade." The CEO also convinced his compensation committee to factor "risk reduction" into its measure of economic profit and company performance score. Consequently, CEO pay rose from less than $20 million in the two years preceding 2011, to over $26 million in the three years after 2011. Coincidentally, the CEO was a long-term veteran of General Electric, as were two of the four members of the compensation committee. Our analysis of the Boeing 737 MAX Jetliner case study reveals that self-serving managers can influence the compensation committee and put into place compensation incentives that can harm the company in the long-run.

Keywords
Boeing 737 MAX, incentive pay, compensation committee, non-GAAP performance measures, MCAS

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Introduction

In April 2019, after two brand-new Boeing 737 MAX jetliners crashed in the previous six months, Boeing CEO Dennis Muilenburg stated:

> "We at Boeing are sorry for the lives lost in the recent 737 MAX accidents. These tragedies continue to weigh heavily on our hearts and minds, and we extend our sympathies to the loved ones of the passengers and crew on board Lion Air Flight 610 and Ethiopian Airlines Flight 302… it's apparent that in both flights the Maneuvering Characteristics Augmentation System, known as MCAS, activated in response to erroneous angle of attack information… It's our responsibility to eliminate this risk. We own it and we know how to do it."

The ensuing investigations placed blame on a unique feature of the 737 MAX (Schaper, 2019). The plane came equipped with a Maneuvering Characteristics Augmentation System (MCAS), an autopilot feature that activates only when the plane is in the manual flight mode. During a congressional hearing regarding Boeing's 737 MAX airplane crashes on October 30, 2019, Muilenburg admitted that Boeing made mistakes in the design and development of the flight control system of the 737 MAX (Schaper, 2019).

Muilenburg took home more than $23 million in salary (including stocks and bonuses) in 2018 (after the first plane crash); in other words, just before the second deadly crash of its best-selling 737 MAX jetliner plunged the company into crisis (Isidore, 2019). This is a raise of 27 percent from 2017 (Clough & Melin, 2019). According to Cosgrove (2019), Muilenburg's cut in salary occurred as a result of public pressure and interrogation from congress with regard to the two deadly crashes, and the plunge of Boeing's revenues. Muilenburg opted for the cut in pay, instead of stepping down from the CEO position. Muilenburg acknowledged that Boeing made mistakes in the design and development of the flight control system on the 737 MAX and that these mistakes contributed to the crashes.

Our study does not focus on Muilenburg, but on the previous CEO, James McNerney, and the compensation committee that set his pay in 2011. That was the year the 737 MAX was launched. Ironically, one of the board members who enabled the under-funded launch of the 737 MAX was promoted to non-executive chairman in the shake-up after the 737 MAX crisis, when the title of chairman was taken away from Muilenburg and handed to lead director David Calhoun.[1] The focus of this study is not on Muilenburg. In fact, we show that he shares less responsibility than his board of directors, which were present in their role when the 737 MAX was launched in 2011.

The 737 MAX was developed on a shoe-string budget of $2.5 billion, less than a quarter of the cost of an all-new airplane (Flight Global, 2012). Boeing took short cuts which involved placing oversized engines on a 50-year old airframe. In the words of Boeing then CEO (James McNerney) in the 2011 annual report:

> "With development costs and risks far below an all-new airplane, the 737 MAX will provide customers the capabilities they want, at a price they are willing to pay, on a shorter, more certain timeline. This approach is an all-around winner for Boeing, too. We maintain our qualitative advantage over competitors in the segment, we free up resources to invest in other growth projects, ***and we reduce our business risk substantially for the next decade.***
> -- Boeing CEO James McNerney, *2011 annual report*

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[1] The incident of benefiting from one's own transgression bring to mind the Biblical reproach to King Ahab after he murdered Naboth and took possession of his property: "Have you murdered and inherited, too?" (1 King 21:19). In fact, a basic principle of justice is that a perpetrator, whether intentional or not, should not benefit from one's own transgression. The Latin legal maxim: Ex Injuria Sua Nemo Habere Debet (a wrongdoer should not be enabled by law to take any advantage from his actions; Duhaime's Law Dictionary, http://www.duhaime.org/LegalDictionary/C/CommodumExInjuriaSuaNemoHabereDebet.aspx)

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This "reduction in risk" was not merely a PR brag in the annual report. It directly tied in to the compensation policy as outlined in that year's proxy statement:

> "This above target performance resulted in a Company performance score of 1.6 … The above-target performance scores were primarily due to strong integrated performance across the Company, including ***better than-expected mitigation of risks.***"
> -- 2011 Annual Incentive Assessment, *2012 Proxy Statement*

Link between compensation incentives and MCAS

What Boeing envisioned in 2011 as an all-around winner with low business risks ended up a disastrous loser with incalculable business risks. After the first 737 MAX crash, but before the second crash, the FAA had assessed that the crash rate of the Boeing 737 MAX as substantially higher than previous Boeing models (Pasztor and Tangel, 2019). In fact, the FAA's internal risk assessment indicated that the 737 MAX design would result in one fatal crash every two or three years! Even before the first crash, internal Boeing engineers raised alr We will show how Boeing's claimed "reduction in risk" boosted the CEO pay in 2011. More than anyone else, it was the compensation committee of the board of directors that created the perverse incentives to launch the 737 MAX on a shoe-strip budget that results in the MCAS debacle.

The MCAS is basically a self-corrective feature. Because of a basic design flaw, the MAX has a tendency to pitch up, which would cause the plane to stall. The MCAS uses the rudder in the back of the airplane to artificially pitch the airplane down when sensors indicate that the airplane is pitching up (Gates and Baker, 2019). Once the MCAS is activated, it becomes a physical and mental struggle for pilots to overcome and deactivate it. In the case of the two crashes, the MCAS activated as a result of faulty signals from sensors indicating that the airplane was pitching up when it was in fact level. MCAS caused the airplane to pitch down and crash to the ground.

How did executive compensation policies contribute to the MCAS design flaw? The answer lies in four inter-related facts. First, MCAS was implemented to cover up a more basic physical design flaw in the airplane. The 737 airframe is fundamentally unsuitable for powerful twenty-first century jet engines, mainly because of the airframes low ground clearance (Vartabedian, 2019). The 737 dates to the post World War 2 era, when passengers boarded airplanes by climbing up a movable staircase. Back then, it was advantageous to keep a low ground clearance, but in today's age of jet bridges in every terminal, the low ground clearance is a liability. MCAS artificially compensated for the instability induced by heavy, powerful engines that sat two low, forward, and inward on the wings.

Second, the awkward design was as result of a desire of top management to save billions of dollars on airplane development costs. Rather that develop an all-new airplane similar in profile to the Airbus A320 family, or even Boeing's discontinued 757, Boeing chose to modify the existing 737.

Third, the MCAS features was hidden from pilots and even to some extent from the FAA. One of the selling points of the MAX was that pilots trained on flying older versions of the 737 did not need additional training. This feature was especially attractive to Southwest Airlines, which has a fleet consisting primarily of 737s (Gates, 2019). If pilots and the FAA knew of the full extent of the MCAS's ability to take control of the airplane, they would have demanded additional pilot training.

Fourth, Boeing's executive compensation policies incentivized (2) and (3) above. This is evidenced by the quoted passages above from Boeing's CEO letter to shareholders and the 2011 annual incentive assessment in the 2012 proxy statement (see the two quotes in the previous section).

Corporate Governance Literature Review

Effective corporate governance of industrial firms is important for the delivery of valued goods and services that support organizational goals (profit) and deliver societal benefits (Goergen & Tonks, 2019). In this section, we identify literature that provide theoretical support for our illustration of how insufficient independence of the Board of Directors and Compensation Committee at Boeing created unacceptable risks for the company. The central tension in the corporate governance literature is the conflict of interest between firms' downer-investors and the managers hired to determine firms' investment projects and payout decisions (Bergstresser & Philippon, 2006).

Board Independence

Boards of Directors are a governance instrument; and one of their key roles is to hire, incentivize, and monitor upper management (Main & Johnston, 1993). Board independence is often associated with improved decisions with regard to CEO turnover and executive compensation (Bebchuk & Weisbach, 2010).

At the time of the launch of the 737 MAX in 2011, Boeing CEO Jim McNerney also held the title of chairman. By combining the two roles, it laid the seeds of damaging board independence by offering the CEO an opportunity to pursue personal interests in populating the board with nominally independent directors (Miller & Xu, 2019). This potentially comprises the ideal alignment of personal managerial motives, corporate organizational goals and societal benefits. Self-serving executives can use short-term tactics, such as earnings management, which temporarily increase income earnings and consequently private benefits that may take the form

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of position retention and/or compensation gains (Miller & Xu, 2019). While our study does not focus on earnings management per se, the board and its compensation committee used subjective measures of risk to inflate the adjusted, non-generally accepted accounting principles (non-GAAP) measure of earnings used for compensation purposes. Guest et al (2018) find that the use of non-GAAP measures of earnings is associated with excessive compensation.

Compensation Committee Independence

Compensation Committee Independence or Compensation Committee Quality have profound implications for managerial remuneration. In the absence of an independent compensation committee, managers essentially write their own contracts with one hand, and sign them with the other (Main & Johnston, 2003).

Bebchuk & Weisbach (2010) explain that "the optimal contracting view", which sees executive (CEO) pay arrangements as the product of arm's length contracting between the compensation committee of boards and executives, leads to contracts that provide efficient incentives for reducing agency problems. Yet, there are concerns with regard to the apparent conflict of interests faced by Directors in deciding both their own pay and that of the CEO (Ntim et al, 2019).

On the other hand, "the managerial power view" questions whether pay arrangements are indeed the product of arm's length contracting and sees such pay arrangements as part of the agency problem (Bebchuk et al, 2002; Bebchuk & Weisbach, 2010). The power that CEOs have in setting their own pay, and rigging the Director selection process so that the independence of the Board is compromised (Ntim et al., 2019). Still, "the managerial power view" allows for the

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possibility that pay arrangements are sub-optimally structured in ways that lead to perverse incentives (Bebchuk & Weisbach, 2010).

One of the key mechanisms used by Boeing to set CEO pay is a risk-adjusted measure of GAAP earnings. Ironically, Boeing adjusted GAAP earnings higher for compensation purposes due to the perceived risk reduction attributable to the 737 MAX. As mentioned, Guest et al (2019) find that high non-GAAP earnings contribute to excessive CEO pay.

Governance Of 737 MAX Launch

Boeing's Announcement of the 737 MAX In 2011

In 2011, Boeing took the fateful decision to redesign the 737-airplane model and renamed it to the 737 MAX, instead of launching an all-new product to replace the 50-year old airframe. Subsequent events revealed that this fateful decision immensely raised Boeing's business and reputational risk, but management indicated that it would "reduce our business risk substantially for the next decade." Management then used the purported reduction in business risk to convince Boeing's compensation committee to upwardly adjust the measure of economic profit used for the compensation performance score. In 2013, Boeing finalized engineering of the 737 MAX ahead of schedule, for which the compensation committee used "product development" as a reason to again upwardly adjust the measure of economic profit and performance score. Boeing CEO James McNerney pay jumped from an average of $19.6 million in the two years before launch the 737 MAX in 2011, to an average of $26.5 million in the three years following the launch. McNerney retired as CEO in 2016 and was succeeded by Dennis Muilenburg, who was left to deal with two deadly 737 MAX crashes in 2018 and 2019. Our findings indicate that incentive compensation at industrial companies can have adverse long-term effects.

Boeing's Executive Compensation Policies

An examination of executive compensation policies at Boeing reveals strategic behavior indicative of self-serving motives that improve the CEO's private benefits; consequently, leading to negative firm risks and the cost of human lives.

When the 737 MAX was launched in 2011, James McNerney had been the company's CEO since 2005. Before coming to Boeing, McNerney served as a top lieutenant for Jack Welch at GE, followed by a stint at the head of 3M. We begin our analysis two years before the launch year of the 737 MAX and end it three years after the launch, when McNerney retired from both the company and its board of directors. Figure 1 illustrates that in the four years before the 737 MAX was launched in 2011, the CEO received average pay of $19.3 million. This jumped to $23 million in the year of launch. Then for the following three years, his pay averaged $26.6 million.

FIGURE 1
Boeing CEO James McNerney Total Pay in millions in years (2007-2014) before and after 737 MAX launch
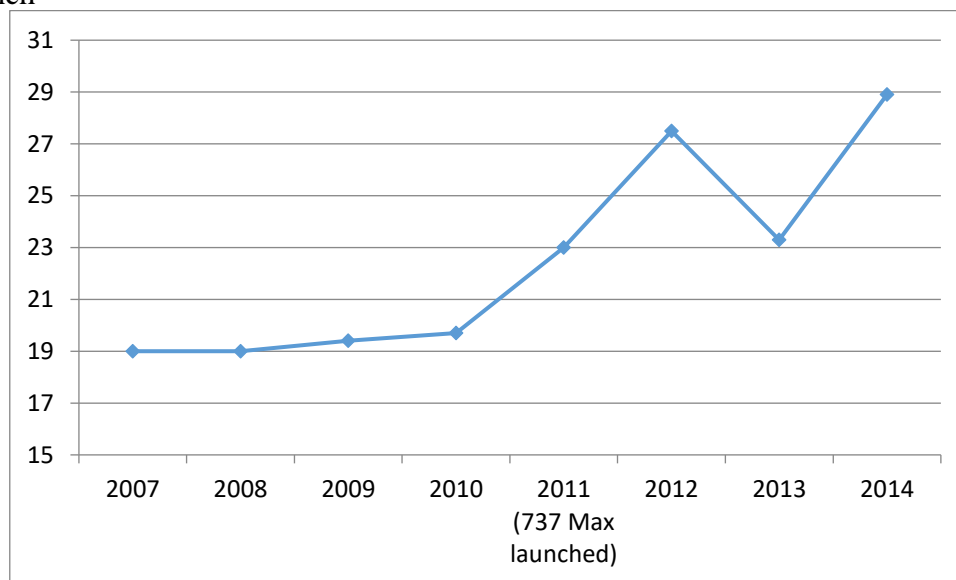
In its proxy reports, Boeing describes its compensation policies in a section called "Executive Compensation – Compensation Discussion and Analysis". The section includes "Performance

Highlights" to justify the compensation paid. These performance highlights include standard

financial accounting metrics such as revenues, operating cash flows, order backlog, and earnings

per share. However, the ultimate determinant of CEO pay is a "company performance score"

which is calculated based on "economic" profit. A company performance score (CPS) above 1.0

indicates that Boeing exceeded its economic profit goals for the year. Boeing defines economic

profit as "after-tax profit net of a capital charge". As we will see, the economic profit measure

motivated management to under-invest in 737 MAX products. Table 1 lists information from

proxy statements 2008-2015. Proxy statement 2008 was the first year that included detailed

company performance highlights. It is implied that these highlights are included in the

calculation of company performance score. In 2009, two years before the launch of the 737

MAX program the company performance score of 0.7 or 30% below the benchmark. However,

in all subsequent years CPS was above the benchmark peaking at 1.6 to 1.7 during the years

2011-2013. The company performance score is based on an internal Boeing measure of

economic profit, adjusted for benchmarks.

TABLE 1
 CEO Compensation, Objective Financial Performance, and Compensation Committee
Performance Score, 2007-2014, from Proxy Statements. Highlighted year 2011 is when Boeing
announced the 737 MAX.

Calendar Year	2007	2008	2009	2010	**2011**	2012	2013	2014
CEO pay, millions	19.0	19.0	19.4	19.7	**23.0**	27.5	23.3	28.9
Objective Financial Performance Measures								
Revenues, billion	66	61	68	64	**69**	82	87	91
Backlog, billions	327	352	316	321	**356**	390	441	502
Earnings per share	5.28	3.67	1.84	4.46	**5.34**	5.11	5.96	7.38
Compensation Committee Performance Score								
Percent of target met	150	60	70	140	**160**	160	170	130

The company performance reveals a large jump in revenues following 2011, from $69

billion to $91 billion in 2014. The results were driven by the all-new Boeing 787, whose

deliveries jumped from three in 2011 to 46 in 2012 (2012 annual report, p.26). As table 2 shows

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the entire increase in the order backlog was driven by 737 MAX orders, which were the only commercial airplane to grow its backlog. The backlog grew nearly doubled to 4,300 units in three years, more than offsetting declines across the other commercial airplane programs.

TABLE 2
Change in Backlog, 2011-2014. *Source: 2011 and 2014 annual reports.*

| | In units, by model | | | | | | In billions $ | |
	737 (includes MAX)	747	767	777	777X	787	Commercial Airplane	Total (includes Space and Defense)
2014	**4,299**	36	47	278	286	843	440	502
2013	**3,680**	55	49	314	66	916	373	441
2012	**3,074**	67	68	365	-	799	317	390
2011	**2,365**	97	72	380	-	857	293	356
Change 2011-2014	**82%**	-63%	-35%	-27%	NA	-2%	50%	41%

In 2011, Boeing's CEO, James McNerney, revealed on a conference call that the cost savings of modifying the 737 versus launching a new airplane were considerable. Just the research and development (R&D) cost savings associated with the engines were 85 to 90 percent as compared with a new airplane, which was estimated to cost $11 billion. According to this analysis, Boeing saved nearly $10 billion by avoiding a new design. (Flight Global, 2012). Minimizing R&D expenditures is a form of form of earnings management because restricting R&D expenditures can augment current earnings (Miller & Xu, 2019).

Boeing's internal analysis purported that the shoestring budget represented a reduction in business risk. Accordingly, even before earning a penny or making a single sale of a 737 MAX, the company allegedly reduced its risk profile. This had the effect of increasing actual economic performance relative to its goal and the effect of dramatically increasing the company's performance score for the year.

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FIGURE 2

2012 Proxy Statement on Key Drivers of 2011 Company Performance Score

Compensation Element	Goal	Actual Performance ($)	Actual Performance %	Key Drivers of Actual Performance
2011 Annual Incentive Plan	$1.252B	$1.932B	160%	Above-target performance due to strong, integrated performance across the Company and better-than-expected mitigation of risks
2009-2011 Performance Awards	$9.099B	$8.119B	68%	Below-target performance primarily due to delays and performance issues on development programs, the unexpected worldwide economic downturn beginning in late 2008, and continued challenges with the current U.S. defense budget and contracting environment

Boeing spells out the key drivers of actual performance. The company's revenues, operating cash flows were roughly the same as the previous two-year average. However, Boeing believed that the company had better-than-expected mitigation of risks.

The correlations coefficients between CEO pay, company performance score, economic profit, revenues, operating cash flows, backlog and EPS are presented in table 3. Our interest is on what drives CEO pay, the performance score, and economic profit. Surprisingly, economic profit is not positively correlated with the CPS, even though its sole purpose is to calculate the CPS. The explanation lies in the fact that CPS measures economic profit relative to target.

TABLE 3

Correlation matrix: Company Performance and CEO Pay, 2007-2014

	CPS	EP	EP-Target	Rev.	Cash Flow	Back-Log	EPS	CEO Pay
Company Performance Score	1.00							
Economic Profit	(0.22)	1.00						
EP minus target	0.94	0.06	1.00					
Revenues	0.48	0.10	0.42	1.00				
Operating cash flow	0.58	0.28	0.72	0.69	1.00			
Backlog	0.32	0.31	0.29	0.91	0.47	1.00		
Earnings per share	0.69	0.29	0.72	0.69	0.53	0.79	1.00	
CEO pay	0.46	(0.11)	0.36	0.87	0.49	0.83	0.70	1.00

Lack of Compensation Committee Independence

Chairman and CEO, James McNerney

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To appreciate the closeness between McNerney and the compensation committee, it is instructive to review his biography as described in Boeing's 2012 proxy statement: "Beginning in 1982, he served in management positions at General Electric Company, his most recent being President and Chief Executive Officer of GE Aircraft Engines from 1997 to 2000."

After leaving GE, McNerney served as CEO of Minneapolis-based 3M from 2001 to 2005. Concurrently, he also joined Boeing's board in 2001. In a somewhat unusual move, McNerney became the CEO of the company on which he served as an outside director, at which time he left 3M in July 2005. Boeing's proxy statement discloses that McNerney served on the boards of IBM and P&G. It does not disclose that he also serves on those boards' compensation committees (in the case of P&G as chair of committee). This experience on compensation committees will have helped McNerney in influencing the Boeing compensation committee.

FIGURE 3
Boeing CEO and the 2011 Compensation Committee: General Electric and McDonnell Douglas alumni

CEO James McNerney
    General Electric executive 1982-2000
    Boeing board member since 2000-2016
    Boeing CEO from 2005-2016

2011 Compensation Committee
  John McDonnell and Kenneth Duberstein - McDonnell Douglas alumni
    McDonnell Douglas board members until 1997
    Boeing board members since 1997
    Boeing compensation committee members since 1999
  Mike Zafirovsky and David Calhoun (lead director as of 2019) - General Electric alumni
    General Electric executives – Zafirovsky 1978-2000; Calhoun 1981-2006
    Boeing board members - Zafirovsky since 2004; Calhoun since 2009
    Boeing compensation committee– Zafirovsky since 2009; Calhoun since 2011

The Compensation Committee

Boeing's compensation committee in 2011 can be described as a "good old boy" network. Actually, the 4-member committee consisted of two networks: two long-term members

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which were holdovers from Boeing's acquisition of McDonnell Douglas in 1997 and two new members who were McNerney's close associates from General Electric.

Three Boeing directors sit on the board of Caterpillar: Boeing's lead director, David Calhoun, who is also the lead director of Caterpillar, Boeing's CEO and Chairman Dennis Muilenburg, and Susan Schwab, a professor at the University of Maryland School of Public Policy and former U.S. Trade Representative in the second Bush Administration. Two of Boeing's directors sit on the board of Marriott International: Lawrence Kellner, former CEO and Chairman of Continental Airlines and Susan Schwab (who also serves on the FedEx board).

GE alumnus Mike Zafirovsky

McNerney may have been the first GE alumnus on Boeing's board, but he was not the last. In 2004, he was joined by Mike S. Zafirovsky, a former lieutenant at GE. Having a close ally on the board could have helped McNerney get appointed as CEO in 2005. According to Boeing 2012 proxy statement: "Mr. Zafirovsky spent nearly 25 years with General Electric Company, where he served in management positions, including 13 years as President and Chief Executive Officer of five businesses in the consumer, industrial and financial services arenas, his most recent being President and Chief Executive Officer of GE Lighting from July 1999 to May 2000."

GE alumnus David Calhoun

In 2009, after McNerney has been serving as a board member for nine years and as CEO for four years, he was joined by yet another former colleague from GE. According to Boeing's 2012 proxy "Mr. Calhoun served as Vice Chairman of General Electric Company and President and Chief Executive Officer of GE Infrastructure. Before that, Mr. Calhoun served as President and Chief Executive Officer of GE Transportation; President and Chief Executive Officer of GE

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Aircraft Engines; President and Chief Executive Officer of Employers Reinsurance Corporation; President and Chief Executive Officer of GE Lighting; and President and Chief Executive Officer of GE Transportation Systems.

It may be bad enough for a CEO to recruit two former colleagues as "independent" board members. It is especially shocking that by 2011, the year of the 737 MAX launch, both Zafirovsky and Calhoun were serving on the *four-member* compensation committee, whose main charge was to determine what to pay McNerney.

McDonnell Douglas alumni John McDonnell and Kenneth Duberstein

In 1997, when Boeing bought McDonnell Douglas, several of the latter's board members joined Boeing's board. Two of these veterans, John F. McDonnell and Kenneth M. Duberstein became long-serving members of Boeing compensation committee. Both Duberstein and McDonnell had served as chair of the committee, with McDonnell serving as the chair until his retirement in 2011.

A key take-away is that two out of the four members of the committee were close professional colleagues of McNerney going back several decades and well before they went to work for Boeing or its board. Until 2011, the non-GE alumni were colleagues whose relationships went back decades. While they had no special relationship to McNerney, their close connection to each other raises questions on how willing they would be to question each other's professional judgement.

A 2018 news account of Calhoun being honored at his alma mater notes the close relationship between McNerney and Calhoun: "James McNerney, a former Chairman and CEO of Boeing who first met and worked closely with Calhoun at GE, has seen how much Calhoun values different perspectives. 'He's a very inclusive leader,' McNerney said. 'He's a guy who

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involves everyone. *He appreciates others' perspectives more than his own in many cases* and does a good job of synthesizing things.' (Lovegrove, 2018)."

It is questionable whether these characteristics describe an ideal member of a compensation committee supervising a CEO that one has had a close working relationship with, at a previous employer. From McNerney's perspective, it may have been especially expedient to have a member of the compensation committee who "appreciates others' perspectives more than his own." The same lack of independence applies to Zafirovsky, who also had a close relationship with McNerney, and in fact reported to the latter when they worked at GE (Lublin, 2007). Ironically, Boeing appointed Calhoun as its non-executive chairman in

Ironically, in October 2019 Boeing appointed Calhoun as its non-executive chairman, after stripping the title from its CEO (Tangel et al, 2019). The irony is that while CEO Muilenburg played no part in the inception of the 737 MAX in 2011, Calhoun played a pivotal role in enabling the bad decision to launch the 737 MAX in an underfunded manner.

Conclusions and Discussion

Our analysis of the 737 MAX Jetliner case study has revealed that the compensation committee at Boeing is an important facet for effective corporate governance at Boeing; and how the committee can effectively work is critical for the prudent management of the company to deliver safe products that will ensure the preservation of sustainable and consistent earnings.

From the analysis above, we find that the compensation committee at Boeing assumes a major role in crafting executive pay; accordingly, we suggest that the selection and composition of the compensation committees is of significant importance for effective governance at Boeing. This leads to the question of who serves on Boeing's compensation committee, as well as how long they serve and how they come to serve. Also, it seems worthwhile to establish processes

and policies that insulate the members of the compensation committee from organizational political play that can undermine the performance of the compensation committee.

One can only wonder if a more diverse compensation committee, both in terms of personal relationships and backgrounds, would have been more aggressive in pushing back on the risk assumptions presented by the CEO. Ironically, Boeing's compensation committee did have a lone woman member, but she lasted for just one year in 2010, after which she served on other committees. The similar professional background and the prior relations of the members of the compensation committee raise questions on the transparent and integrity of the selection process. The tight-knit, homogeneous committee in 2011 was not ideally constituted to challenge the CEO's claims about the reduced risk of the 737 MAX. In 2018, McNerney even praised committee member Calhoun "He appreciates others' perspectives more than his own in many cases and does a good job of synthesizing things." Such qualities may be admirable in friends and peers, but they do not describe independent oversight. However, it seems Boeing still has not learned a lesson to improve the diversity of the compensation committee, both in terms of personal relationships and backgrounds.

This case study also holds implication for scholarship of business ethics. Fang and Slavin (2018) advocate "Golden Rule" ethics advocated by Confucius and the monotheistic faiths, rather than "ethical egoism" based on self-interest. This case raises some interesting challenges to "Golden Rule" ethics. The mistakes that management and the board made would not have been easily remedied by a Golden Rule mindset. Rather, it would have taken an internal culture of "adversarial collaboration", as described by Kahneman and Klein (2009) and Tetlock and Mitchell (2009), for the board and its committees to question management's assertion about risk and potential reward.

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Teaching and Innovative Education - Abstracts

A PRELIMINARY STUDY OF AGE AND GENDER AND THEIR INFLUENCE ON STUDENT PERSPECTIVES OF ONLINE VERSUS FACE-TO-FACE EDUCATION AT A JESUIT INSTITUTION

Teaching and Innovative Education

Dr . Lynn Fish [1] *, Dr . Coral Snodgrass* [1]

1. *Canisius College*

As technology continues to evolve, insight into student perspectives of online versus face-to-face education is important to improving student understanding and motivation. Over time peoples' perspectives change. The purpose of this phase is to study how age and gender affect business student perceptions at a Jesuit, Catholic private University in the northeast.

AN OUTCOMES ASSESSMENT OF AN INNOVATIVE INFORMATION TECHNOLOGY EDUCATIONAL FRAMEWORK

Teaching and Innovative Education

Dr . Stephen Richter [1], *Mr . Jack Rappaport* [2], *Dr . Dennis Kennedy* [3], *Dr . Thomas Blum* [3]

1. *WEST CHESTER UNIVERSITY* , **2.** *Brilliance Consulting* , **3.** *La Salle University*

This paper extends the work of Richter et al. (2019) which proposes an innovative information technology framework that creates metaphors for various IT topics using popular music videos. In the present paper we present the results of the implementation and testing phases of the model, which was not part of the original paper. Both an informal assessment of the model as well as an experimental design with statistical results will be presented as part of the research. The proposed model extends the conceptual framework originally proposed by Rappaport et al. (2016, 2018) by considering a component of situated learning.

Blockchain in the Curriculum

Teaching and Innovative Education

Dr . William Wagner [1]

1. *Villanova University*

In recent years, the topic of Blockchain has attracted attention from areas as diverse as supply chain management to fintech. Some schools have aggressively tried to integrate it into the curriculum while others are taking a wait and see approach. Though it is most famous as the technology behind cryptocurrencies such as Bitcoin, it has the potential to have a major impact across the organization. This workshop will introduce participants to the core concepts behind blockchain and examine different strategies for integrating it into the curriculum to help increase students overall blockchain literacy.

Collaborative Undergraduate Business Experiences (CUBEs)

Teaching and Innovative Education

**Dr . Kathleen Ferris-Costa** [1] , _**Dr . Xiangrong Liu**_ [1]

**1.** Bridgewater State University

The focus of our initiative is to bring together a team of business faculty members to explore ways to reinforce career readiness through **C**ollaborative **U**ndergraduate **B**usiness **E**xperiences (CUBES). Funded by the BSU Innovation Grant, the project team will stimulate the college-wide dialogue about how to collaborate with external businesses and organizations to conduct semester-long CUBEs to help students better prepare for their future careers. Over a six-month period we will conduct various focus groups, reform several courses to include CUBEs in their curriculum and organize a networking event for faculty and representatives from local businesses interested in collaborating with students.

Curricular Considerations for Developing Project Management Skills (Even in Non-PM Courses)

Teaching and Innovative Education

Dr . Donna McCloskey [1]

1. *Widener University*

Project Management skills are consistently identified as being in demand for business and technology positions, yet it is not always identifiable in the curriculum. This session will present ways in which project management skills can be developed and deployed in non-project management courses as well as more holistically in the business curriculum. Topics will include more effective and realistic scheduling, documenting and utilizing lessons learned and providing constructive and effective feedback.

Developing a Distinctive Consulting Capstone Course in a Supply Chain Curriculum

Dr . Christopher Roethlein [1], Dr . Teresa McCarthy Byrne [1], Dr . John Visich [1], Dr . Michael Gravier [1], Dr . Suhong Li [1]

1. Bryant University

This article describes a required capstone course for students in a Global Supply Chain Management Program, where student teams work on rigorous, semester-long projects for primarily local and regional companies. This article discusses an extensive number of projects (83 projects for 42 companies) over an extended period of time (10 years), and our insights should be of interest to supply chain faculty who currently have, or plan to include, empirical projects as a key component of their course or supply chain program.

ENHANCING ACADEMIC SUCCESS: SCENARIO-BASED-LEARNING in ANALYTICAL BUSINESS COURSES

Teaching and Innovative Education

Prof. Xingxing Zu [1], *Prof. Ziping Wang* [1]

1. *Morgan State University*

To succeed in their education and future career, it is important for students of business majors to master necessary analytical skills, which are typically taught in decision sciences-related courses. It has been observed that due to lack of proper understanding of logic behind analytical techniques, students experience low performance in those courses and lag behind in completing their degrees. This study experimented using scenario-based learning to assist teaching analytical techniques in classes. Multiple cases were designed to provide simple yet relatable scenarios for students to better understand analytical problem-solving procedures and improvements were found in assessment outcomes.

EXPLORING THE RELATIONSHIP BETWEEN STUDENT ENGAGEMENT AND PERFORMANCE

Teaching and Innovative Education

Dr . John Weber [1] *, Dr . Bhupinder Sran* [1]

1. *DeVry University*

It is believed that student engagement and performance are related. The more a student is engaged in a course the more likely he is to do well. Courses taught using online platforms, gather large quantities of data about a student's activity. It is possible to identify how much time the student spent on each part of the course. including discussions and other online activities.

This presentation will explore which engagement behaviors are most closely related to performance. The study will use data from online and hybrid courses taught at a university with multiple locations.

Global Foresight: An Examination of Small Colleges Looking to Evolve

Teaching and Innovative Education

Dr . Rebekah Hanousek-Monge [1]

1. Molloy College

Global foresight is of optimum importance yet many small colleges and universities in the United States have been slow to evolve. Education should be transformative and inclusive of a diversity of thought within a global framework while also being respected and valued. This paper will examine the urgency for small colleges to adopt a global mindset therefore allowing global foresight to ensue. A closer examination of what it means to be a school which incorporates, develops and embraces a global mindset will also be discussed while recommendations for future activities to establish global foresight will be reviewed.

INCORPORATING CLOUD COMPUTING INTO COURSE INNOVATIONS

Teaching and Innovative Education

Dr . Zhengzhong Shi [1]

1. *University of Massachusetts Dartmouth*

As cloud computing service providers dramatically improve the capacity and variety of their cloud services at the global scale, more and more companies are planning to migrate or are in the process of migrating their information system (IS) infrastructures to the cloud. The uptrend dynamics in cloud computing supply and demand makes it imperative for business schools to incorporate the cloud innovation into their curricula. In this paper, I describe the efforts made and initial experiences with incorporating cloud computing into both the Master of Technology Management (MSTM) Program and the undergraduate MIS program in a business school.

Model For Teaching and Assessing Undergraduate Business Analytic Courses

Teaching and Innovative Education

Dr . Regina Halpin [1], *Dr . Kelly Rainer* [1]

1. *Auburn University*

The business workforce has brought to the attention of higher education institutions the expectations for business graduates to develop stronger analytical skills. The two reformed undergraduate courses presented are required by all business majors at Auburn University. The content is designed to de-emphasize the computational skills for statistical procedures while accenting the identification of business problems. Students learn to apply descriptive statistics as well as the appropriate predictive model to address the problem. They become familiar with prescriptive analysis, assess the outcome and, finally, ask the next question. The results after the initial implementation of the courses are discussed.

Newsvendor Game: A Behavioral Exercise in Decision Making under Risk

Teaching and Innovative Education

Dr . Chirag Surti [1], *Dr . Anthony Celani* [2]

1. Rider University , 2. Sheridan College

We cover two aspects of teaching single-period inventory-problem 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.

Publish Don't Perish: Methods that Improve Your Ability to get Published

Teaching and Innovative Education

Prof . Robert Lussier [1]

1. *Springfield College*

Learn methods that will increase the quantity and quality of your publications including: Selecting Topics and Journals, Time Management, Multiplying Publications, Answering the So What Question. It's a presentation, Q&A, sharing workshop. Lussier has 444+ publications (*FBR, ET&P, JSBM),* 6,700+ Citations, 1+ million textbooks sold. 413-364-9735 rlussier@springfield.edu

REINFORCING SPREADSHEET SKILLS THROUGH AN ONLINE INSTRUCTIONAL PLATFORM WHEN TEACHING A FACE-TO-FACE MIS COURSE

Teaching and Innovative Education

Dr . Esmail Mohebbi [1]

1. *University of West Florida*

The purpose of this paper is to share our experience with utilizing a customizable online instructional platform to help students refresh and reinforce their spreadsheet skills while taking an introductory course in Management Information Systems. In particular, the paper focusses on discussing the effectiveness of embedding an online self-paced Microsoft Excel training module in a face-to-face course in comparison to utilizing a traditional computer lab. We outline some of the challenges and benefits of utilizing this module and share a few insights based on our experience.

Revisiting: Visual Business Intelligence Course

Teaching and Innovative Education

Dr . Anil Aggarwal [1]

1. *University of Baltimore*

As social network diffuses so does the data generated through them. Data is generated at the speed of light and organizations must take advantage of it. Organizations are demanding graduates who can understand, manage and make sense of such data. Universities are obligated to provide these skills to their graduates. A new course which combines visualization and intelligence was developed. Developing a new course always creates challenges and opportunities. We discuss challenges that were encountered and how we resolved them. Institutions planning to develop such a course can learn from our experiences and modify it based on their needs.

Teaching Undergraduate Business Analytics Using Publicly Available, Free, Real World Data: Professors' Perspective

Teaching and Innovative Education

Prof. Allison Miller [1], *Prof. Christopher Lowery* [1], *Ms. Sarah Owen* [1]

1. *Georgia College*

Traditionally professors teaching business analytics and business statistics courses use databases which are familiar to them. On the other hand, in today's "Big Data" business world, students may benefit from having course projects that require them to "hunt and kill" their own databases and perform analyses using business analytics tools. A survey was conducted with 19 professors who teach Business Analytics or Business Statistics assessing their ideas, concerns, and experiences with taking such an approach in their courses. This study presents survey results and discusses the implications of such an approach from the standpoint of the professor teaching the class.

The Challenges in Teaching a Database Management Course for Business Analytics: Finding and Blending the Right Tools for Business Students

Teaching and Innovative Education

Dr . Ahmet Ozkul [1]

1. *University of New Haven*

In responding the demands of analytics positions in the companies, some traditional courses need to be updated in terms of content and tools. Database management fundamentals have been traditionally taught as part of management information systems. A typical database course would show relational database design fundamentals, Entity-Relationship diagrams, normalization, SQL, and data warehouses. However, business analytics curriculum usually includes a broad spectrum of methods and tools to use databases in older and newer ways. In this study, we present new challenges of designing and teaching a database course in the context of business analytics and solution alternatives to these challenges.

The relationship between the use of social media and the well-being of college students

Teaching and Innovative Education

Dr . Youqin Pan [1], *Prof . Leping Liu* [2]

1. *Salem State University ,* **2.** *THE UNIVERSITY OF NEVADA, RENO*

Social media is important tool for college students to maintain and develop social capital. Yet, few studies on the social implications of using social media have focused on students 's well-beings from the perspective of the social capital. The findings show that communicative use, academic collaboration, and self-disclosure on social media significantly predict bridging capital, but they are not positively related to bonding capital. Both bridging and bonding social capital are significant predictors of social well-being of college students. This study provides insights about how to use social media to promote social well-being of college students

Using Social Media in the Classroom

Teaching and Innovative Education

Dr . Kathleen Ferris-Costa [1] , *Dr . Krista Hill-Cummings* [2] , *Dr . Adriana Boveda* [1]

1. *Bridgewater State University ,* **2.** *Babson College*

This panel discussion will focus on the use of social media in the classroom, including Facebook, Twitter, Pinterest, Snapchat and Instagram. The interaction functionality of these platforms provides faculty and students with a venue to share ideas, converse about course topics and allows students to dialogue with one another by posting, sharing and collaborating. Rather than being passive receivers of transmitted knowledge, students can be active participants in the learning process.

Panelists will share their experiences with using social media in the classroom and provide suggestions on how participants might choose to use social media in their own courses.

USING SPREADSHEETING TO TEACH THE COMPONENTS OF THE BASIC TAX FORMULA AND THE EFFECTS OF THE TAX CUTS AND JOBS ACT

Teaching and Innovative Education

Dr . Deb Sledgianowski [1], *Dr . Steven Petra* [1], *Dr . Alexander Pelaez* [1]

1. *HOFSTRA UNIVERSITY*

This proposal outlines a teaching assignment for students in the individual taxation course. The assignment has students use spreadsheet software to create formulas calculating the components of the basic tax formula for individuals and create visualizations displaying the effects of tax policy. A motivation behind our development of this assignment is to provide new teaching resources to demonstrate the recent sweeping revisions to the Tax Cuts and Jobs Act of 2017 and to support the AACSB standards for accounting accreditation calling for learning experiences that develop skills and knowledge related to the integration of information technology in accounting and business.

Utilizing Open Educational Resources to Facilitate Student Engagement in Online Courses

Teaching and Innovative Education

Dr . Colleen Carraher Wolverton [1]

1. *University of Louisiana at Lafayette*

As university budgets have been slashed by $9 billion (Mitchell et al 2017) and instructors search for methods to decrease the cost of educational resources, open educational resources (OER) have increased in popularity (Delgado et al 2019; Ganapathi 2018; Navarrete et al 2016; Clements et al 2015). While studies indicate some potential issues with OERs (Lin and Wang 2018) including the quality of OERs (Camilleri et al 2014) and decreased student learning (Kersey 2019), we seek to present an OER option that provides opportunities for increased student engagement and higher level learning according to Bloom's taxonomy (Forehand 2010).

Teaching and Innovative Education - Papers

A PRELIMINARY STUDY OF AGE AND GENDER AND THEIR INFLUENCE ON STUDENT PERSPECTIVES OF ONLINE VERSUS FACE-TO-FACE EDUCATION AT A JESUIT INSTITUTION

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ABSTRACT

As technology continues to evolve, insight into student perspectives of online versus face-to-face education is important to improving student understanding and motivation. Over time peoples' perspectives change. The purpose of this phase is to study how age and gender affect business student perceptions at a Jesuit, Catholic private University in the northeast.

KEYWORDS: student perspectives, online education, face-to-face, age, gender

INTRODUCTION

Over the past seven years, we conducted two surveys of the business school population to uncover student perspectives on online (OL) and face-to-face (FTF) education. Our University is a mid-sized, Jesuit, Catholic, private school with a focus on teaching traditional arts and sciences, education and business. FTF class sizes average 17 students. Our survey includes two streams of research: questions on individual student factors (motivation, discipline, self-directed, independence, schedule flexibility, time and cost investment, happiness, and appropriateness of OL), and questions that address program factors (difficulty, preference, cheating, interaction between students, and interaction between the instructor and student). The initial survey revealed that students who had experienced and those who had never experience an OL class both overwhelmingly perceived FTF classes more positively than OL classes for all individual and program factors (Fish & Snodgrass, 2014). Since that time, the number of OL courses offered at the University has increased; however, not all students have taken an OL course.

Recently, we re-surveyed the business students and found that some perspectives had significantly changed (Fish & Snodgrass, 2019a, 2019b). With respect to individual factors, significant changes in student perspectives for students who had experienced OL education occurred for self-directed, time investment and appropriateness of education. By our recent survey, OL students felt that OL education was acceptable – a change from the original posture OL students took. With respect to students who never took an online class (the FTF group), few significant differences over the time period occurred as only the self-directed factor significantly differed between the two survey time periods (Fish & Snodgrass, 2019a). With respect to program factors, students who experienced OL courses did not change their perspectives on program factors over the time period. However, recent FTF students were more indifferent to the teaching environment than FTF students of the past and recent FTF students were not as positive about the interaction with the instructor (Fish & Snodgrass, 2019b). The question before us is: *Are student perspectives of online versus face-to-face education affected by age or gender?*

LITERATURE REVIEW

As the number of online courses and programs in the higher education system (Allen & Seamen, 2013) increases, there is a need to continue to assess both the student's and instructor's perspectives on OL education (Shieh, Gummer & Niess, 2008). Student perspectives are an important part of the educational experience. As technology and instructional delivery methods evolve, OL education – and students' perspectives - will change as well. Researchers have explored student perceptual differences between OL and FTF education by demographic factors – and the results often differ (Billings, Skiba & Connors, 2005; Dobbs, Waid, & del Carmen. 2009; Tanner, Noser, Fuselier, & Totaro., 2004a; Tanner, Noser, Fuselier, & Totaro 2004b; Fish & Snodgrass, 2014; Fish & Snodgrass, 2015; Fish & Snodgrass, 2016a; Fish & Snodgrass, 2016b). Results may also change over time. In a recent study, student perspectives changed on some – but not all factors (Fish & Snodgrass, 2019a; Fish & Snodgrass, 2019b). This paper seeks to present student perspectives based upon age and gender.

With respect to age, results vary. One research stream demonstrates that age does not impact upon student perspectives (Tanner, Noser & Langford, 2003), while another research stream indicates that age has a positive impact upon students' perspectives of OL learning (Tanner et al.,

2004-1; 2004-2). While one study found that adult students (21 and older) perceived OL education more favorably than younger students (Tanner et al., 2003), another study found that younger students (regardless of their culture) appeared to be more technologically savvy (Lee, Becker & Nobre., 2012). Many of the studies on student perspectives are over a decade old, when technological capabilities of delivering educational materials online was very different. *How do today's students feel about OL education? Are younger – or older – students more favorable to OL education?*

Gender issues may affect OL learning. Group composition, the degree of participation and elaboration may differ by gender (Prinsen et al., 2007). (Men may use fewer words, less elaboration, explain more and express disagreement more than women, and women are more likely to initiate conversation with questions and requests for information.) With respect to differences in perspectives by gender, research results also differ. Some studies indicate that gender does not play a factor in student perceptions for undergraduate students (Tanner et al., 2003; Chawla & Joshi, 2012; Fish & Snodgrass, 2015), while others indicate a difference (Tanner et al., 2004-1; 2004-2; Chaturvedi, & Dhar; 2009). In one study, women displayed a more positive attitude than men towards web-based learning (Chen & Tsai, 2007). However, another study suggests that males are significantly more comfortable with computers (Kay, 2009) and internet competencies are higher for males than females (Tekinarslan, 2011). Yet another study found that women experience a richer, more valuable presence in OL learning and are more satisfied than males (Ashong & Commander, 2012; Johnson, 2011). Another researcher reported no gender differences in computer self-efficacy (Tekinarslan, 2011). Other researchers found that women perceived OL course effectiveness higher than males particularly on program factors (Seok et al., 2010; Chang et al., 2014).

Cultural differences between men and women with respect to education exist. For example, comparing African-American perceptions to other American perceptions, men's perspectives are significantly different than women's as men view instructor assistance, friendliness, trust and interest in students, student interaction, and collaboration more negatively than their female counterparts (Ashong & Commander, 2012). Gender issues are still extremely relevant in societies that continue to separate men and women in the FTF - and OL - classrooms, such as in

Saudi Arabia (Hamdan, 2014). In general, regardless of culture, men tend to be more individualistic, while women tend to be collectivistic (Tsaw et al., 2011). (Individualistic people focus on their own personal goals and tend to be raised in Western cultures, while collectivistic people tend to focus on the group goals and be raised in Eastern cultures.)

With respect to our previous research, men and women did not differ significantly in their perspectives (Fish & Snodgrass, 2015). Since many of the studies cited here are over a decade old, and since similar research on student perceptions noted changes in student perceptions over time (Fish & Snodgrass, 2016a, 2016 b, 2019a, 2019b), perhaps men and women's perspectives on OL and FTF education have changed over time. *Do today's men and women students differ in their perspectives of OL and FTF education?*

Statement of the Problem. While OL education is a growing educational method (Allen & Seaman, 2013), not all students at the University have taken an OL course. Based upon the literature, the question before us is: *How do students – those that have taken and those that have not taken an OL course - perceive OL education compared to face-to-face (FTF) education today compared to over 5 years ago?* Our research within this paper aims to provide insight into this question specifically analyzing demographic factors of age and gender. In other words, *Are there differences between 'older' and 'younger' students? Are there differences between men and women's perspectives?* Theoretically, students should perceive the environments equally and not favor either traditional FTF or OL education. which leads to the following hypotheses:

Age:
Ho1: *Older and younger students who have taken an OL course do not differ in their perspectives of OL education.*
H11: *Older and younger students who have taken an OL course differ in their perspectives of OL education.*

Ho2: *Older and younger students who have never taken an OL course do not differ in their perspectives of OL education.*
H12: *Older and younger students who have never taken an OL course differ in their perspectives of OL education.*

Gender:
Ho3: *Men and women students who have taken an OL course do not differ in their perspectives of OL education.*

H13: Men and women students who have taken an OL course differ in their perspectives of OL education.

Ho4: Men and women students who have never taken an OL course do not differ in their perspectives of OL education.

H14: Men and women students who have never taken an OL course differ in their perspectives of OL education.

METHOD

At an AACSB accredited, Jesuit, Catholic University in the northeast, undergraduate and graduate business students completed an online Qualtrics-administered survey in 2012 and 2018. University Internal Review Board and Academic Vice President approval for distribution was granted for both surveys. Student participation was completed voluntary. Twice over the month of November, students received the survey link via a list serve.

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 OL or FTF environments, happiness with OL or FTF education, and appropriateness of OL at the University (See Appendix A). Students were also questioned as to which activities decreased or increased 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 (undergraduate or graduate), gender and online experience. Important to this study was the fact that in the 2012 survey a question as to participant age was not asked. 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.

Section A of the survey ("OL") was completed by students who experienced at least 1 online course, while Section B of the survey ("Traditional FTF") was completed by students who never

took an online course. While sections A and B had corresponding questions, Section A statements were specific to "I found" versus Section B statements were "I perceive". The last three questions in each section asked students 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

Given the survey setup, responses positively viewed the environment that a student was part of. For example, if an OL student felt that OL was more difficult than FTF, he or she would indicate a significant 'positive' for the OL environment. The scale for the FTF students was similar for their environment. Therefore, if the two groups perceive their own environment as different from the other teaching environment, a significant difference between the two groups would be detected. Since prior analysis demonstrated that the two groups – OL and FTF-- perceived a number of factors differently, the two groups were analyzed separately to denote any significant differences within the group. Chi-Square analysis using the contingency coefficient as the nominal value was performed using SPSS.

Age. Since the original 2012 survey did not ask participants for their age, our analysis is based upon the 2018 survey only. Since students were not required to answer every question, 77 students answered the 'age' demographic question and completed the OL perspectives section. With respect to the FTF group, 52 students answered the 'age' demographic question and the questions on their perspectives. Table 1 reveals the distribution of ages for the participants.

As shown in Table 2, for OL students, self-directed (p=.013), independence (p=.000), schedule flexibility (p=.001), happiness (p=.000) and appropriateness of online education (p=.001) significantly differed between the different age groups. For these factors, the alternative

hypothesis, H11 is supported. As shown in Appendix B, the distributions for each of these factors over age appear to demonstrate that *younger students are more positive to each of these factors than older student.*

As shown in Table 3, for FTF students, instructor interaction (p=.024) and happiness (p=.009) were significantly different over age, and independence was slightly significant (p=.055). For instructor interaction and happiness, the alternative hypotheses, H12 is supported. As shown in the distributions for these factors (see Appendix C), while younger students are 'split' over which environment that they favor for instructor interaction, older students show a slight preference to FTF over OL. With respect to happiness, younger FTF students significantly favor the FTF environment, while older FTF students are 'favorable' to the FTF environment. With respect to independence, younger students are 'split' between the two environments, while older students tend to prefer the FTF environment.

Table 1. Distribution by Age for Survey Participants

Age	OL Students	FTF Students
17		1
18		4
19	2	11
20	13	11
21	20	7
22	18	5
23	4	3
24	1	1
25	1	3
26	1	
27		
28	2	2
29	3	
30	1	
31	2	
32	1	
33		1
34	2	1
35	2	1
36		
37	2	
38		1
60	2	
Total	77	52

Table 2. Chi-Square Analysis OL 2018 by Age

Metric	Pearson Chi-Square Value	Df	Asymptotic Significance (2-sided)	Pearson's R	Spearman Correlation
Difficulty	55.287	48	.219	.175	.138
Motivation	64.058	64	.474	-.117	.038
Student Interaction	54.664	64	.791	-.166	-.178
Instructor Interaction	66.358	64	.396	-.113	-.058
Discipline	52.486	64	.848	.028	.027
Cheat	40.605	48	.767	.137	.136
Self-directed	91.845	64	.013 *	-.211	-.254
Independence	108.048	64	.000 *	-.197	-.201
Schedule flexibility	82.750	48	.001 *	-.077	-.106
Time investment	53.409	64	.825	.051	.239
Cost investment	10.024	48	.787	.179	-.020
Preference	37.112	32	.245	.035	.075
Happiness	113.418	64	.000 *	-.142	-.143
Appropriateness OL	61.034	32	.001 *	.042	.036

* $p \le .05$, ** $p \le .10$

Table 3. Chi-Square Analysis FTF 2018 by Age

Metric	Pearson Chi-Square Value	Df	Asymptotic Significance (2-sided)	Pearson's R	Spearman Correlation
Difficulty	53.390	52	.421	-.019	.064
Motivation	62.767	52	.146	-.095	-.148
Student Interaction	64.905	52	.108	-.112	-.124
Instructor Interaction	58.281	39	.024 *	-.194	-.157
Discipline	45.355	39	.224	-.233	-.196
Cheat	48.397	52	.616	.002	-.058
Self-directed	54.619	52	.375	.015	-.028
Independence	69.222	52	.055 **	.067	.023
Schedule flexibility	45.252	36	.139	-.011	-.073
Time investment	32.779	52	.983	.010	.036
Cost investment	51.330	52	.500	-.088	-.105
Preference	22.264	26	.674	-.038	-.097
Happiness	79.192	52	.009 *	-.088	-.181
Appropriateness OL	24.282	26	.560	.030	.054

* $p \leq .05$, ** $p \leq .10$

Gender. While participants were not required to answer every question, results that included students who answered the age question yielded 106 useable surveys in 2012 and 146 useable surveys in 2018. As shown in Table 4, in the original 2012 survey, 41 students completed the OL perspective of the survey and 65 completed the FTF perspective of the survey. In the recent 2018 survey, 82 students completed the online perspective of the survey, while 51 completed the FTF perspective of the survey. In both surveys, 66 men participated. While only 40 women completed the original 2012 survey, 80 women completed the 2018 survey.

As shown in Table 5, for the 2012 OL students, a significant difference between men and women exist for difficulty (p=.031). Therefore, with respect to every factor except difficulty, the null hypothesis, H03 is supported. As shown in Table 6, in 2012, men tend to view OL education as significantly easier than FTF than women. Independence (p=.076) and appropriateness (p=.097) are slightly significant. Men tend to enjoy the independence in the OL environment more than the FTF environment, while women tend to prefer independence of the FTF environment more than the OL environment. As for appropriateness of OL, men are more favorable to its appropriateness than women.

Table 4. Number of Students OL and FTF in 2012 & 2018 Surveys

# Students	OL			FTF			Total		
	Males	Females	Total	Males	Females	Total	Males	Females	Total
2012	24	17	41	42	23	65	66	40	106
2018	34	48	82	32	19	51	66	80	146
Total	58	65	123	74	42	116	132	120	252

Table 5. Chi-Square Analysis OL 2012 by Gender

Metric	Pearson Chi-Square Value	Df	Asymptotic Significance (2-sided)	Pearson's R	Spearman Correlation
Difficulty	8.902	3	.031*	.201	.163
Motivation	1.525	3	.677	-1.02	-.099
Student Interaction	1.374	4	.849	-.121	-.119
Instructor Interaction	3.438	4	.487	-.191	-.196
Discipline	5.662	4	.226	.208	.226
Cheat	2.431	4	.657	-.226	-.207
Self-directed	5.661	4	.226	-.183	-.211
Independence	8.450	4	.076 **	-.237	-.177
Schedule flexibility	2.021	3	.568	-.017	.041
Time investment	1.938	3	.585	.124	.134
Cost investment	.222	2	.895	-.073	-.073
Preference	1.913	2	.384	-.211	-.215
Happiness	6.460	4	.167	-.309	-.251
Appropriateness OL	4.671	2	.097 **	.265	.231

* $p \le .05$, ** $p \le .10$

Table 6. Distribution of OL 2012 Student Responses by Gender

	1	2	3	4	5	Total
Difficulty						
Male	6	6	10	2	0	24
Female	0	9	4	4	0	17
Total	6	15	14	6	0	41
Independence						
Male	0	2	7	11	4	24
Female	2	5	1	6	3	17
Total	2	7	8	17	7	41
Appropriateness	1	2	3	Total		
Male	15	7	2	24		
Female	8	3	6	17		
Total	23	10	8	41		

As shown in Table 7, for the 2012 FTF students, there were NO significant differences between men and women on any of the factors and the null hypothesis H04 is supported. With respect to the 2012 survey and the exception of OL difficulty, men and women's perspectives on OL versus FTF education for the factors surveyed were similar.

Table 7. Chi-Square Analysis FTF 2012 by Gender

Metric	Pearson Chi-Square Value	Df	Asymptotic Significance (2-sided)	Pearson's R	Spearman Correlation
Difficulty	2.671	4	.614	-.167	-.161
Motivation	4.601	3	.203	-.161	-.128
Student Interaction	3.074	4	.546	-.079	-.089
Instructor Interaction	3.025	3	.388	-.098	-.153
Discipline	3.854	4	.426	.072	.063
Cheat	3.489	4	.480	-.064	-.111
Self-directed	1.716	3	.633	.063	.038
Independence	5.76	3	.902	.076	.076
Schedule flexibility	3.134	4	.536	.085	.068
Time investment	4.918	4	.296	-.157	-.183
Cost investment	5.638	4	.228	-.066	-.116
Preference	.256	2	.880	.026	.036
Happiness	.478	2	.788	.047	.054
Appropriateness OL	2.397	2	.302	-.134	-.146

* $p \leq .05$, ** $p \leq .10$

By 2018, as shown in Table 8, analysis reveals that significant differences between men and women exist for students in the OL group on schedule flexibility (p=.048) and happiness (p=.026). A slightly significant difference also exists for appropriateness of OL education (p=.100). Regarding schedule flexibility and happiness, women overwhelmingly favor the OL environment, while men are 'favorable' to it. As shown in Table 10, the only slightly significant difference between FTF men and women's perspective exists for independence (p=.098). As shown in Table 11, women tend to favor the independence offered in the FTF environment slightly more than OL, while men tend to favor the independence offered in the OL environment slightly more in the FTF environment.

Comparing the 2012 results to the 2018 results shows that students who never experienced the OL environment do not appear to differ between men and women, and they have not changed their perspective over the 6 years. While significant differences between OL men and women

were noted in 2012 for difficulty and in 2018 for happiness, these factors were insignificant in the opposite year survey. Student perspectives on these factors may have changed over the 6 years for these factors.

Table 8. Chi-Square Analysis OL 2018 by Gender

Metric	Pearson Chi-Square Value	Df	Asymptotic Significance (2-sided)	Pearson's R	Spearman Correlation
Difficulty	1.603	3	.659	-.135	-.132
Motivation	4.184	4	.382	.048	.020
Student Interaction	4.390	4	.356	-.002	-.003
Instructor Interaction	4.920	4	.296	.123	.096
Discipline	3.655	4	.455	.104	.075
Cheat	2.594	3	.459	-.042	-.063
Self-directed	3.018	4	.555	.083	.097
Independence	.939	4	.919	-.040	-.027
Schedule flexibility	7.888	3	.048*	.210	.262
Time investment	.903	4	.924	.013	.026
Cost investment	.950	3	.813	.007	.010
Preference	1.745	2	.418	.146	.144
Happiness	11.095	4	.026*	.087	.104
Appropriateness OL	4.600	2	.100 **	-.127	-.068

* p ≤ .05, ** p ≤ .10

Table 9. Distribution of OL 2018 Student Responses by Gender

	1	2	3	4	5	Total
Schedule Flexibility						
Male	0	0	6	16	12	34
Female	1	0	2	16	29	48
Total	1	0	8	32	41	82
Happiness						
Male	0	6	9	12	7	34
Female	3	0	15	17	13	48
Total	3	6	24	29	20	82
Appropriateness	1	2	3	Total		
Male	27	4	3	34		
Female	40	8	0	48		
Total	67	12	0	82		

Table 10. Chi-Square Analysis FTF 2018 by Gender

Metric	Pearson Chi-Square Value	Df	Asymptotic Significance (2-sided)	Pearson's R	Spearman Correlation
Difficulty	3.510	4	.476	-.122	-.133
Motivation	3.590	4	.464	.256	.254
Student Interaction	5.331	4	.255	.293	.275
Instructor Interaction	2.943	3	.401	.197	.172
Discipline	3.813	3	.282	-.214	-.213
Cheat	2.997	4	.558	.202	.173
Self-directed	2.833	4	.586	.204	.195
Independence	7.834	4	.098 **	.123	.142
Schedule flexibility	4.771	3	.189	.116	.103
Time investment	1.003	4	.909	-.044	-.057
Cost investment	2.481	4	.648	-.052	-.035
Preference	1.953	2	.377	.130	.135
Happiness	5.111	4	.276	.195	.194
Appropriateness OL	1.504	2	.471	.047	.078

* $p \leq .05$, ** $p \leq .10$

Table 11. Distribution of FTF 2018 Student Responses by Gender

Independence	1	2	3	4	5	Total
Male	2	6	13	8	3	32
Female	0	4	4	11	0	19
Total	2	10	17	19	3	51

DISCUSSION

Prior research on the differences between student perspectives on different individual and program factors demonstrated that OL students and FTF students perceived the environments differently on most factors, and both groups tended to favor the FTF environment for the individual factors analyzed (Fish & Snodgrass, 2014). However, recent results showed a shift in student perspectives for a few factors for students who had experienced OL education, but little shift in the perspectives of students who did not experience OL (Fish & Snodgrass, 2019a; Fish & Snodgrass, 2019b).

Our results explore the impact of age and gender on business student perspectives at a Jesuit, Catholic University in the Northeast. Our results offer another 'data point' to very mixed results. For our population of study, OL students differed by age for some – but not all - of the factors that we studied. Therefore, for some factors our research supports that age does not impact upon

student perspective, similar to other researchers (Tanner et al., 2003); however, for other factors, our research supports that age impacts upon student perspectives (Tanner et al., 2004-1; 2004-2). Contrastingly to prior research (Tanner et al., 2003), our research tends to show that for significant factors, younger OL students are more positive toward OL education than older students. For students who have never experienced OL – the FTF students - regardless of age, their perspectives still favor the FTF environment with few exceptions. It appears that FTF students – regardless of their age or gender – have not changed their perspective on OL education over the 6 years. They remain rooted in the belief that FTF education is the preferred educational method for them. Perhaps these students have self-selected themselves into FTF classes, or they are 'closed-minded'. As higher education continues to add online components to the classroom experience, these perspectives should be addressed as they represent real concerns to these students. Explicitly setting expectations and student training sessions on technology may offer potential assistance in changing these perspectives.

In our original study, men and women did not differ on the factors of study (with the exception of the OL group differing on difficulty). In 2012, men tend to view OL education as significantly easier than FTF than women, but this difference was not significant 6 years later. However, by 2018, for the OL students, differences between men and women on schedule flexibility and happiness were significant. For both of these factors, women overwhelmingly favor the OL environment, while men are 'favorable' to it. A comparison of the FTF 2012 and 2018 students shows that these students have not changed their perspectives over the 6 years, as they remained rooted in a preference for the FTF environment. While our original research demonstrated no differences between men and women (Fish & Snodgrass, 2015), our current research shows a few significant changes for the OL group (similar to prior researchers (Tanner et al., 2004-1; 2004-2; Chaturvedi, & Dhar; 2009)), but not the FTF men and women. Perhaps a change b

In 2012, the number of FTF students who participated in our study significantly outnumbered those who took an OL course. Six years later, the number of students who had taken an OL course and participated in our study outnumbered those students who had not. While six years have elapsed and additional online courses are available to students, the results show few differences in perspectives. While this is not 'significant', it demonstrates (1) the clear view that

this population has on the topic of OL education, (2) that men and women in FTF education do not differ in their perspectives of OL versus FTF education, (3) that men and women in OL education do not differ on most factors in their perspectives of OL education but these views may be changing, (4) for students who have experience OL courses, younger students may be more favorable to OL than their older counterparts, and (5) the FTF students do not differ on their perspectives regardless of their age. The FTF group remains steadfast in their perspectives regardless of age or gender. It is important to remember that these results were for a private University whose main focus is teaching and not research. Perhaps the setting impacts upon the results, and other studies may reveal different perspectives depending upon the institutional setting. Future research may seek to explore these differences.

CONCLUSIONS AND LIMITATIONS

Our study represents an analysis of age and gender affects upon student perspectives of OL versus FTF education. The FTF population – regardless of age or gender - remained fairly consistent in its views over the 6-year period as the majority still favor FTF education. For the OL population, the results represent a few mixed results as some factors of study for the OL students differ by age and gender, but most factors did not. Where there were significant differences, younger OL students tended to view OL education more favorably than their older counterparts. However, the number of older participants in the study was small, and therefore, these results should be viewed cautiously. As OL education continues to grow, student perspectives may change and future studies should continue to monitor these changes. With studies of perspectives, one should consider the context of the study, in this case, a private, Jesuit University in the northeast United States with a focus on teaching. Other universities students may perceive OL versus FTF education differently, and the context of the study may be a critical factor to consider.

Limitations. A key limitation for this study was the sample size – particularly for age comparison where the number of older students was small. While the response rate for the population is adequate, in some cases the analysis for each of the demographic factors studied, subdivided the samples into very small groups. In future studies, a larger population, which could include adequate subgroup sizes (n>30), may reveal significant differences in perspectives.

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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 This University?	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 This University?	Yes (SECTION A) (1) No (SECTION B) (2)

SECTION A - AT LEAST ONE ONLINE COURSE AT THIS UNIVERSITY

How many online courses have you taken:	
Have you taken an online course at a school other than This University?	Yes (1) No (2)
How many online courses have you taken at a school other than This University?	
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 Book Other College (1) Publisher(2) (3)
With respect to the online courses that you have taken at This University 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 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 <u>decrease</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_____
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 THIS UNIVERSITY.

With respect to the face-to-face (traditional) courses that you have taken at This University 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 This University?	Yes (1) No (2)

Thank you for your time! It is greatly appreciated.

Appendix B

Age Distribution for OL Students

Self-directed

Age	1	2	3	4	5	Total
19				1	1	2
20		1	4	6	2	13
21		4	4	5	7	20
22	1	2	4	5	6	18
23		1		2	1	4
24				1		1
25	1					1
26				1		1
28			1	1		2
29			2	1		3
30		1				1
31			1	1		2
32			1			1
34	2					2
35		1	1			2
37			1	1		2
60			1	1		2
Total	4	10	20	26	17	77

Independence

Age	1	2	3	4	5	Total
19				1	1	2
20			2	8	3	13
21		3	3	7	7	20
22		3	4	5	6	18
23				2	2	4
24				1		1
25	1					1
26				1		1
28			1	1		2
29				1	2	3
30				1		1
31				2		2
32			1			1
34	2					2
35			1	1		2
37			1	1		2
60			1	1		2
Total	3	6	14	33	21	77

Schedule Flexibility

Age	1	2	3	4	5	Total
19				1	1	2
20			1	7	5	13
21				6	14	20
22			1	9	8	18
23				1	3	4
24					1	1
25			1			1
26				1	1	1
28			1		2	2
29			1			3
30				1	1	1
31				1	1	2
32						1
34	1			1		2
35				2		2
37				2		2
60					2	2
Total	1		5	32	39	77

Happiness

Age	1	2	3	4	5	Total
19				2		2
20		1	3	6	3	13
21		1	5	7	7	20
22	1	1	6	6	4	18
23			1	2	1	4
24				1		1
25		1				1
26					1	1
28			2			2
29				2	1	3
30		1				1
31					2	2
32			1			1
34	2					2
35			2			2
37				1	1	2
60			1	1		2
Total	3	5	21	28	20	77

Appropriateness of OL Education

Age	1	2	3	Total
19	2			2
20	12	1		13
21	15	5		20
22	13	4	1	18
23	4			4
24	1			1
25			1	1
26	1			1
28	2			2
29	3			3
30			1	1
31	2			2
32	1			1
34	2			2
35	2			2
37	2			2
60	1	1		2
Total	63	11	3	77

Appendix C

Age Distribution for FTF Students

Instructor Interaction

Age	1	2	3	4	5	Total
17		1				1
18	1	1		2		4
19		4	3	4		11
20		6	1	4		11
21		2	3	2		7
22		1	1	3		5
23	1		1	1		3
24			1			1
25		1		1	1	3
28		1	1			2
33			1			1
34			1			1
35			1			1
38		1				1
Total	2	18	14	14	1	52

Business Student Perspectives OL vs FTF: Age & Gender

Independence

Age	1	2	3	4	5	Total
17				1		1
18		3		1		4
19		2	5	4		11
20		1	3	4	2	10
21		1	3	3		7
22		1	2	2		5
23		1	1	1		3
24		1				1
25	2		1			3
28				1	1	2
33			1			1
34			1			1
35				1		1
38				1		1
Total	2	10	17	19	3	51

Happiness

Age	1	2	3	4	5	Total
17				1		1
18			1	1	2	4
19			3	3	4	10
20			5	4	2	11
21			5	1	1	7
22			1	4		5
23		1		1	1	3
24			1			1
25	2			1		3
28					2	2
33				1		1
34				1		1
35			1			1
38				1		1
Total	2	1	17	19	12	51

AN OUTCOMES ASSESSMENT OF AN INNOVATIVE INFORMATION TECHNOLOGY EDUCATIONAL FRAMEWORK

Abstract

This paper extends the work of Richter et al. (2019) which propose an innovative information technology framework that creates metaphors for various IT topics using popular music videos. In the present paper we present the results of the implementation and testing phases of the model, which was not part of the original paper. Both an informal assessment of the model as well as an experimental design with statistical results will be presented as part of the research. The proposed model extends the conceptual framework originally proposed by Rappaport et al. (2016, 2018) 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. The model was implemented and tested at a secondary school and the results of an outcome assessment show that various outcomes of learning IT such as attitude and engagement are enhanced by the model.

Keywords: Diversity, Information Technology (IT), Metaphors, Popular Culture, Situated Learning

Introduction

This paper extends the work of Richter et al. (2019), which was presented at the NEDSI Conference last year (2019). In this paper, Richter et al. (2019) propose an innovative information technology framework that creates metaphors for various IT topics using popular music videos. In the present paper we present the results of the implementation and testing phase of the model, which was not part of the original paper. Both an informal assessment of the model as well as an experimental design with statistical results will be presented as a result of this research.

The following summarizes the underlying framework of the model for the purposes of completeness and clarity.

The proposed framework 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 the model is the addition of a second component to the theoretical framework of the previous models. 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.

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 is 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.

The model was implemented and tested at an inner city unisex charter school of predominantly African American male students. The implementation of the model considered many of the social and cultural manifestations of the real-life experiences of the students that are displayed by the music videos. Some initial focus groups were carried out before the testing and implementation of the model, to ensure that a sense of the COP described above was understood by the students to be necessary for the implementation of the model.

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
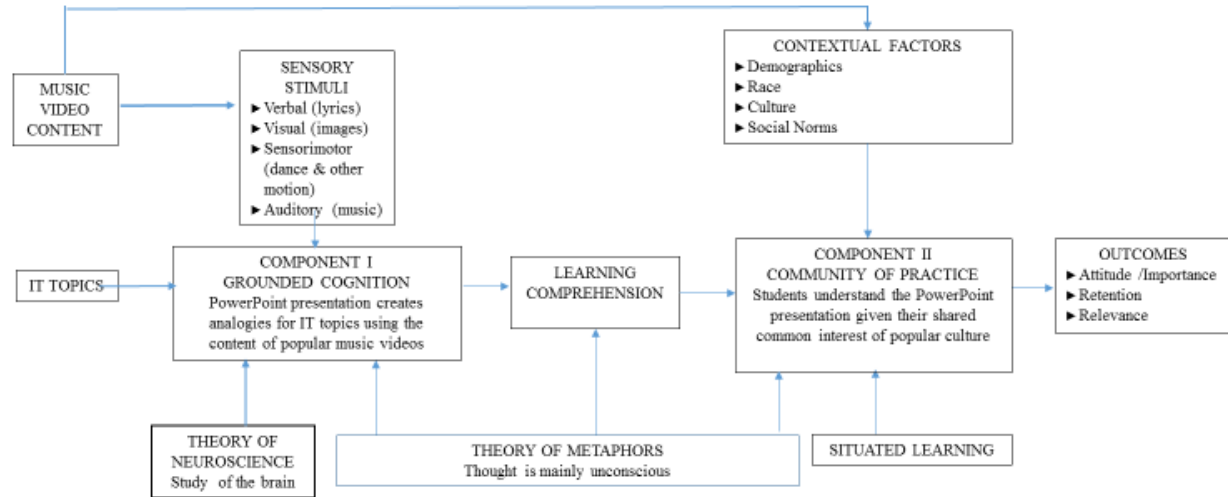
Blending Popular Culture, Diversity and Science Education

In this section we summarize the main points of Richter et. al (2019) with respect to the concerns of many educational experts and policy planners about equitable access to science and engineering occupations and the ways in which our model addresses these concerns.

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.

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).

However, 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, Banks et al. 2007, Lee and Braton 2010, National Research Council 2007, 2009).

One approach that can be used to reach out to a more diverse group of students 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. (Harding 1998, Brickhouse et al. 2000, Calabrese Barton 1998).

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, Lee and Fradd 1996, Warren et al. 2001, Moschkovich 2002, Banks et al. 2007, Brown 2006, Rosebery et al.1992).

Research suggests that personal interest is an important factor in children's involvement in learning science (Hidi and Renninger 2006, Jolly et al. 2004, Luehmann 2009, Calabrese 1998, Tzou and Bell 2010, Tai et al, 2006).

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.

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.

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.

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.

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 of Sierra Leone in Africa and he was able to make a link between researching the country and a specific theme within the rapper Kanye West's song, "Diamonds Are Forever".

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.

IT Metaphors and Popular Culture

Table 2 gives an abbreviated version of the list of music video metaphors for IT topics that was given in Richter et al. (2019). Although the original list was shortened, five important examples were added to the list. As in the previous case, we explain how particular aspects, characteristics and artifacts of popular culture are evinced for each of the metaphors. The reader is referred to Table 2 of Richter et al. (2019) for an extended list.

An important addition to the list is the first one listed in Table 2: using the music video and song "Superstition" as a way to teach and inspire the appreciation of the scientific method. Released in 1972 as the lead single in Stevie Wonder fifteenth studio album Talking Book (1972), it reached number one in the U.S. and number one on the soul singles chart. The lyrics, which describes popular superstitions and their negative effects, can be used to show the importance of the scientific method and scientific inquiry in IT, as well as one of the key ingredients for the evolution of civilization.

Table 2: Music Video Metaphors

IT Topic or Content	Metaphorical Meaning	Characteristics of Popular Culture
The Scientific Method; "Superstition"	The lyrics describe popular superstitions and their negative effects	A hit song of the 70s that is considered part of the funk or funk rock genre
Analysis and Discovery; "What Do You Mean?"	Lyrically, the song describes not being able to figure out the opposite sex	A pop and tropical house song, with its instrumentation consisting of fervent synths and "slick beat" elements
Big Data and Infinite Computing; "No Limit"	Just as in social interactions, data and the ways to process it are seemingly endless	The song, of the R&B and trap genre, with sensational dancing, has been described as

		a "sultry summer jam"
Communicating and Making Decisions based on IT; "Walk It Talk It"	Just as in life, one should be straightforward and consistent in IT	A hip hop, Trap-Soul song by the American hip hop trio Migos, featuring guest vocals from Canadian rapper Drake
Using IT to Stay Competitive; "Still Dre"	Dr. Dre stays competitive by releasing his multi-platinum second studio album after seven years without releasing an album	A Gangsta rap and West Coast hip hop lead single of the multi-platinum studio album 2001
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; "Sorry Not Sorry"	The switching process of a transistor is like a mood swing or a change of opinion	Demi Lovato published a trio of pictures in her Instagram 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
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
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
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
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

Framework for the Presentation

A multi-media PowerPoint presentation is delivered by two instructors that work as a team and complement each other: Instructor 1 focuses on the music videos and Instructor 2 concentrates on the traditional educational material.

The PowerPoint presentation provides the basis or the presentation and facilitates the links between the music videos and the IT topics. Each PowerPoint slide is dedicated to a particular topic and consists of the following eight components:

1. Play and loop a specific section of the 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, while at the same time playing the entire song.

2. Display the relevant parts of the lyrics by scrolling at the bottom of the screen using the appropriate PowerPoint animation functions.

3. Instructor 1 presents pertinent information about the song and/or video and relates the lyrics to the educational material to be discussed in more detail by Instructor 2.

4. Instructor 1 presents a PowerPoint slide that superimposes a visual image representing the particular IT topic on top of music video using the appropriate animation and transparency functions. Alternatively, this image could be superimposed on top of a still picture from the music video.

5. Instructor 1 presents a short description of the IT topic and an explanation of the metaphorical construct used to link the topic to the music video.

6. Instructor 2 presents 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.

7. Instructor 2 also discusses the lyrics in his part of the presentation, but with more focus on the IT topic.

8. Coordinate the above elements so as to achieve the maximum educational value. For example, the instructors can control the volume of the iTunes song, increasing the volume to induce the appropriate emotional response from the students and decreasing the volume during the traditional part of the presentation.

Instructor 1 is responsible for developing the COP (community of practice) of the students based on their shared interest in popular culture. In many cases it would be appropriate to elicit their critique of the various videos, including their personal tastes of the music and the individual artists. Instructor 2 is mainly responsible for delivering the traditional part of the presentation and making sure that the students achieve the highest possible educational value from the presentation.

Both instructors should work as a team, so that each one adds value to the other's part of the presentation, thus creating synergy between their individual parts of the presentation.

Implementation and Program Evaluation

The model was implemented with small groups of secondary school students (mainly 9th grade) from the Philadelphia School District. An outcomes assessment consisting of both an informal assessment and an experimental design with statistical results are obtained and presented as follows.

Informal Assessment

In this section we present the results of an informal assessment of the program 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 are presented as follows.

Knowledge

This impact category emphasizes what a participant consciously knows including facts, awareness or understanding that can be stated by the participants in their own words. It can be defined as the measurable demonstration of, assessment of, change in, or exercise of awareness, knowledge, understanding of a particular scientific topic, concept, phenomena, theory or careers central to the project (Friedman, 2008).

Potential Indicators: Students self-reporting statements; comments by faculty observers.

Evidence of Impact

Students were randomly questioned after each of the sessions to assess the impact of the presentation on their acquisition of knowledge. The general reaction from the students indicated that the videos increased their level of concentration and attention. There was a strong consensus that their knowledge acquisition was enhanced by the music videos.

Several university faculty attended the presentations as impartial observers and gave feedback as part of the informal assessment process. Based upon their experience, they observed that the interest shown by the students to many of the technical topics seemed much greater than normally displayed in traditional lectures. Their observations support the claim that the cognitive process of understanding complex technical topics was enhanced by the music videos.

The motivation and acquisition of knowledge by the students was observed to be a direct result of

the identification of the popular culture celebrities performing in the videos. Seemingly, the celebrity performers played an integral role in the learning process. Indeed, the presentation made strong use of direct links between the lyrics and the knowledge to be conveyed. Specific pieces of knowledge were conveyed based upon linking the lyrics to the information content. Seemingly, the acquisition of knowledge was enhanced by the engagement of students in a community of practice involving popular culture.

Engagement

This impact category captures the excitement and involvement of the learners in a topic or area of STEM. This impact is often the focus of projects that aim to engage under-represented participants in STEM.

Potential Indicators: Spontaneous reaction and comments from students; willingness of students to volunteer their time to advance the project; commitment of after school time to the project.

Evidence of Impact

This was probably the easiest and most transparent of the categories to assess. The students generally displayed an active engagement in listening to the music and watching the videos, often tapping to the beat, as well as expressing satisfaction in identifying of many their favorite celebrities and songs. Since the presentation was carefully crafted to link the music videos to the topics, the engagement in the music videos was extended to the broader educational content.

The presenters played a key role in enhancing the engagement process. The interest of the students was propelled by the enthusiasm of the presenters. The novelty of the presentation also contributed to the engagement process. The experiment supported the view that trying innovative approaches in STEM education should be tried more often.

Attitude

Although this category is similar to engagement, it goes beyond engagement to encompass longer term stances that students take toward the topics.

Potential Indicators: Linkage of popular music videos and pop stars to the promotion of STEM topics.

Evidence of Impact

The possibility of enlisting the support of the pop stars to the project was discussed with the students. The students showed an unqualified level of support for such a plan. They were very enthusiastic in suggesting specific pop stars that might be interested in supporting the program,

taking into account their personalities and persona.

The student feedback strongly suggested that involving the pop stars in a STEM related program could have a long-term impact on the attitude of students on STEM topics and career choices.

Behavior

One cannot expect to measure the impact of the model on the long-term behavior of the students from such an informal assessment process. However, in the next section, we present the results of a questionnaire to assess the impact of the project on the motivation of students to pursue careers and studies in IT.

Skills

This impact category is concerned with the procedural aspects of knowing on the part of the students.

Potential Indicators: Observations of faculty in follow up skills labs.

Evidence of Impact

Hands on computer skills labs were scheduled as a follow up to the presentations. Faculty observed a greater than usual level of interest and enthusiasm of the students than normally shown in these kinds of labs.

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 used a randomized post-only design in which participants are randomly assigned to a treatment group (i.e. one that experiences the TP and BAP presentations using the proposed model and to a control group (i.e. one that experiences TP and BAP presentations without the music videos.

A questionnaire was 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 questions on the survey (as stated in Tables 3, 4, 5 and 6) correspond to these three categories as follows: (a) Interest/Curiosity: Questions 3,4,5,7,8,9,10; (b) Skills/Properties: Questions 1,3,4,5; (c) Importance/Attitude: Questions 2,6,7,8. Note that we assume that each question can be assigned to several categories.

The results of the questionnaire for the TP presentation for the treatment and control group are given in Tables 3 and 4 respectively, whereas the results of the questionnaire for the BP presentation are given in Tables 5 and 6 in a similar fashion. Note that the same questionnaire is used for both groups and for both the TP and BP presentations.

In almost of the cases, the ratings for the question for both presentations (TP and BAP) were greater with the music videos. Both music video presentations showed significant increases for questions 4,5,9 and 10, which mainly corresponds to category (a) Interest/Curiosity. In addition, the BAP with music videos showed a significant increase for question 6, corresponding to (c) Importance/Attitude, and the TP with music videos showed a significant increase for questions 2 and 3, reflecting all of the categories.

Interestingly, the percentage increases for the TP were greater than the increases for BAP, reflected in the fact that the overall average rating increased from 2.64 to 3.39 as opposed to an increase from 3.11 to 3.53 for the BAP. The music videos had a significant impact on both presentations but had a relatively greater impact on the TP. Note that the ratings for the TP were consistently lower than those for the BAP, but that the impact of the music videos lessened the differences. Apparently, the music videos had a special impact in terms of enhancing the learning of the technical side of the topic.

This result can be explained from both a psychological/neuroscience and a sociological/anthropological perspective. From a psychological perspective it confirms the idea that the process of embodied cognition can provide meaning to abstract and complex concepts that may on their own lack the proper depth of understanding on the part of the participants. In our example, the concepts of the TP presentation are generally more abstract and complex than those of the BP presentation. From a sociological perspective it confirms that the process of situated learning can be particularly helpful to give the study of complex and abstract concepts.

Table 3: Ratings for TP with Music Videos (n=38)

Questions	STA	MA	SLA	N	D	Average Score
1. The presentation expanded my knowledge of science and information systems	12	10	8	4	4	3.58
2. The presentation showed the value of IT in our society	11	9	4	3	5	3.82
3. The presentation spurred my interest in IT	8	7	9	8	6	3.08
4. The presentation motivated me to learn more about IT	10	11	5	6	6	3.34
5. The presentation reduced my anxiety about learning science or engineering	18	9	3	4	4	3.87
6. The presentation increased my perception of the importance of science and engineering in our society	8	10	8	8	4	3.26
7. The presentation increased the likelihood that I might pursue a career in IT	4	7	13	6	6	2.76
8. I am more likely to encourage a friend to study IT	5	8	10	7	8	2.87
9. The presentation affected me in a personal way	12	10	5	7	4	3.5
10. The presentation was enjoyable and engaging	16	10	4	4	4	3.79
STA(5)=Strongly agree MA(4)= Moderately agree SLA(3)= Slightly agree N(2)= Neutral D(1)= Disagree						Overall Average 3.39

Table 4: Ratings for TP without Music Videos (n=26)

Questions	STA	MA	SLA	N	D	Average Score
1. The presentation expanded my knowledge of science and information systems	6	6	7	5	2	3.35
2. The presentation showed the value of IT in our society	6	6	6	4	4	3.23
3. The presentation spurred my interest in IT	2	4	6	6	8	2.46
4. The presentation motivated me to learn more about IT	2	5	8	6	5	2.73
5. The presentation reduced my anxiety about learning science or engineering	2	5	6	6	7	2.58
6. The presentation increased my perception of the importance of science and engineering in our society	3	5	6	6	6	2.73
7. The presentation increased the likelihood that I might pursue a career in IT	2	4	5	7	8	2.42
8. I am more likely to encourage a friend to study IT	2	4	6	7	7	2.50
9. The presentation affected me in a personal way	0	2	6	8	10	2.00
10. The presentation was enjoyable and engaging	2	3	6	8	7	2.42
STA(5)=Strongly agree MA(4)= Moderately agree SLA(3)= Slightly agree N(2)= Neutral D(1)= Disagree						Overall Average 2.64

Table 5: Ratings for BAP with Music Videos (n=32)

Questions	STA	MA	SLA	N	D	Average Score
11. The presentation expanded my knowledge of science and information systems	10	8	7	4	3	3.56
12. The presentation showed the value of IT in our society	14	10	6	4	4	3.68
13. The presentation spurred my interest in IT	6	9	7	5	5	3.19
14. The presentation motivated me to learn more about IT	10	9	4	5	4	3.5
15. The presentation reduced my anxiety about learning science or engineering	16	10	4	1	1	4.22
16. The presentation increased my perception of the importance of science and engineering in our society	8	10	7	3	4	3.47
17. The presentation increased the likelihood that I might pursue a career in IT	4	8	9	6	5	3.00
18. I am more likely to encourage a friend to study IT	3	8	9	5	5	2.78
19. The presentation affected me in a personal way	14	10	4	2	2	4.00
20. The presentation was enjoyable and engaging	13	10	5	2	2	3.94
STA(5)=Strongly agree MA(4)= Moderately agree SLA(3)= Slightly agree N(2)= Neutral D(1)= Disagree						Overall Average 3.53

Table 6: Ratings for BAP without Music Videos (n=30)

Questions	STA	MA	SLA	N	D	Average Score
1. The presentation expanded my knowledge of science and information systems	8	10	5	4	3	3.53
2. The presentation showed the value of IT in our society	8	12	5	3	2	3.70
3. The presentation spurred my interest in IT	4	6	10	6	4	3.00
4. The presentation motivated me to learn more about IT	4	6	8	7	5	2.83
5. The presentation reduced my anxiety about learning science or engineering	6	8	7	4	5	3.20
6. The presentation increased my perception of the importance of science and engineering in our society	5	6	10	6	3	3.13
7. The presentation increased the likelihood that I might pursue a career in IT	4	5	10	5	6	2.87
8. I am more likely to encourage a friend to study IT	4	8	10	4	4	3.13
9. The presentation affected me in a personal way	2	6	12	5	5	2.83
10. The presentation was enjoyable and engaging	4	5	9	7	5	2.87
STA(5)=Strongly agree MA(4)= Moderately agree SLA(3)= Slightly agree N(2)= Neutral D(1)= Disagree						Overall Average 3.11

A separate questionnaire was assigned 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 questionnaire attempts to measure the effectiveness of the presentation involving a COP based upon popular culture. The results are given in Tables 7 and 8 and show that the students felt a greater personal connection with the information content, the instructors and the other students than in a traditional presentation. The questionnaire also implied that the presentation increased the interest of the students in STEM.

Another implication from these results is the potential benefit of engaging popular music and dance celebrities in the support of education. This can open new vistas for the delivery of education that can be mutually beneficial for schools and the music industry.

Table 7: COP Ratings for TP with Music Videos (n=38)

Questions	STA	MA	SLA	N	D	Average Score
1. The instructors played the videos of many of my favorite music celebrities	20	10	5	2	1	4.21
2. The music metaphors played an important role in understanding the material	16	10	6	4	2	3.92
3. I personally related to many of the music videos and celebrities	15	12	5	3	3	3.87
4. My concentration was increased by relating the information to the videos	17	13	6	1	1	4.16
5. I felt more connected to my classmates during the presentation	12	10	8	5	3	3.61
6. I felt a more personal connection than during a traditional presentation	17	11	6	2	2	4.03
7. I felt a greater sense of self confidence than during a traditional presentation	10	12	9	4	3	3.58
8. The instructors connected more with the students than in a traditional presentation	23	10	4	1	0	4.45
9. I felt more confident about my potential to succeed in IT	20	12	3	2	1	4.26
10. I felt that science and engineering is more relevant to me	19	10	5	2	2	4.11
STA(5)=Strongly agree MA(4)= Moderately agree SLA(3)= Slightly agree N(2)= Neutral D(1)= Disagree						Overall Average 4.02

Table 8: COP Ratings for BAP with Music Videos (n=32)

Questions	STA	MA	SLA	N	D	Average Score
1. The instructors played the videos of many of my favorite music celebrities	17	10	3	1	1	4.28
2. The music metaphors played an important role in understanding the material	16	10	6	4	2	3.92
3. I personally related to many of the music videos and celebrities	14	10	5	2	1	4.06
4. My concentration was increased by the metaphors and the music videos	17	10	4	1	0	4.34
5. I felt more connected to my classmates during the presentation	12	9	7	3	1	3.88
6. I felt a more personal connection than during a traditional presentation	16	9	4	2	1	4.16
7. I felt a greater sense of self confidence than during a traditional presentation	12	10	7	2	1	3.94
8. The instructors connected more with the students than in a traditional presentation	21	8	2	1	0	4.53
9. I felt more confident about my potential to succeed in IT	18	10	3	1	0	4.40
10. I felt that science and engineering is more relevant to me	16	11	3	1	1	4.25
STA(5)=Strongly agree MA(4)= Moderately agree SLA(3)= Slightly agree N(2)= Neutral D(1)= Disagree						Overall Average 4.17

Conclusions

In this research, we developed an innovative educational model using metaphors linking IT topics with popular music videos. The model extends the frameworks proposed and implemented by Rappaport et. al (2016, 2018) which are based the principles of sensory marketing, grounded cognition and various theories of neuroscience. In this research we build upon these frameworks by adding a component based upon the theory of situated learning, first proposed by Lave and Wenger (1991). Social interaction and collaboration are essential components of situated learning-learners become involved in a "community of practice" (COP) with certain behaviors and beliefs to be acquired. In our model, the students are assumed to form a COP based upon their shared interest in popular culture as exhibited in popular music videos.

Both an informal assessment and a statistical experimental design showed that the proposed model significantly increased the effectiveness of the learning process on a variety of criteria, reflecting skills, attitude, interest and engagement. A separate questionnaire was also used to measure the validity of using the situated learning model based on the COP involving popular culture. The results of the survey showed strong evidence that justified using situated learning approach as a basis for the educational model and was a reliable way to describe the learning process.

'Situated cognition" has become an educational buzzword in recent years. While some aspects of the concept have emerged from the realm of cognitive science, a major movement in the field is grounded in anthropological research (Reynolds et al. 1996). This is a fundamental and major shift form the more traditional psychological views of learning. In the context of this research, the sociological view of the term cognition (Lave, 1988; Lave and Wenger, 1991) has been adopted as a basis for the situated learning component of the model.

Interestingly, our model combines both the psychological (i.e. including cognitive science and neuroscience) and anthropological approach to learning. The first component of the model (proposed by Rappaport et al. 2016, 2018) is based upon the psychological approach via the theory of grounded cognition and various theories of neuroscience. In the second component of the model the sociological view of the term cognition (Lave, 1988; Lave and Wenger, 1991) has been adopted as a basis for the situated learning component of the model.

Anthropologists Lave and Wenger (1991) state that "learning is an integral part of generative social practice in the lived-world". Indeed, the influence of popular music videos on the social practice

of our youth 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 "crank" are now used by teenagers in everyday conversations.

Our educational experiment also validates some of the more general ideas of learning that are similar and supportive of the concept of situated learning. For example, much of the work of John Dewey (1974) is based upon his view of education as a process of living and not as preparation for the future. Modern theorists such as Brooks and Brooks (1993) and the constructivist movement encourage a community approach to the construction of new knowledge. Lastly, Gardner's (1993) extensive work of multiple intelligences is relevant as individuals are encouraged to learn in ways that are "natural" to their type of intelligence. All of these theories fit very well with our educational model whereby the "lived" experience of popular culture form an integral part of our model. It is also consistent with the view that the "professor as a dispenser of knowledge" is too confining and potentially exclusionary to some learners (Schell and Black, 1997).

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INCORPORATING CLOUD COMPUTING INTO COURSE INNOVATIONS

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Abstract

As cloud computing service providers dramatically improve the capacity and variety of their cloud services at the global scale, more and more companies are planning to migrate or are in the process of migrating their information system (IS) infrastructures to the cloud. The uptrend dynamics in cloud computing supply and demand makes it imperative for business schools to incorporate the cloud innovation into their curricula. In this paper, I describe the efforts made and initial experiences with incorporating cloud computing into both the Master of Technology Management (MSTM) Program and the undergraduate MIS program in a business school.

Key Words: Cloud Computing, Course Innovation

Introduction

With the increasing capacities of cloud computing from service providers such as AWS, Azure, Google cloud, and Alibaba cloud in a growing number of fields such as big data analytics, streaming, IOT, machine learning, block chain, etc., all sizes of firms in a variety of industries are getting on the bandwagon of migrating their information system infrastructures to one or multiple public clouds. Acloudguru[1], a cloud computing training company has utilized both google cloud and AWS cloud services to build up their video streaming services in order to take advantage of offerings from both providers. To help physicians not only to treat patients more quickly to reduce costs but also to improve treatment effectiveness, GE Healthcare works with Amazon Web Services (AWS) to implement machine learning solutions at scale using the Amazon SageMaker machine learning platform[2]. Bühler Group, a global leader in food processing equipment, leverages the Bühler IoT Insights platform (a solution based on Microsoft Azure IoT enabling users to record real-time data directly from their machines) to provide critical food safety and performance data

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[1] https://acloud.guru/

[2] https://aws.amazon.com/machine-learning/customers/innovators/ge_healthcare/, Accessed on Dec. 13, 2019.

for its groundbreaking microbial decontamination technology[3]. Color (a 2013 born company focusing on population health service using genomics) uses the Google Cloud Platform to empower its scientists to analyze huge volumes of human genomic data in seconds, assess the risk of common hereditary cancers and hereditary heart conditions, and generate insights about how genes may impact how certain medications are processed[4].

Naturally, along with the uptrend of migrating to the cloud by many firms in various industries, the demand for cloud computing talents is dramatically increasing. One measure for this demand is the job opportunities and the other is the compensation provided to employees in the cloud computing area. A brief search of Monster.com shows that there are 90707 cloud computing jobs found site wide[5]. Further, in the 2019 IT Skills and Salary Report from Global Knowledge[6], for the category of cloud computing, the average salary in North America is $138,320 based on 302 responses. In EMEA, the number is $99,290 based on 211 responses and in the Asia-Pacific region, the number is $89,209 based on 82 responses. Worldwide, the average salary is $115,889 based on 622 responses. This report also indicates that IT professionals with AWS certifications earn an average salary of $ 129,868 in North America.

With the growing supply and demand of the cloud computing services, it is imperative for technology related programs in universities to embrace these changes. In this paper, I would like to discuss my efforts and experiences with incorporating cloud computing services into courses in the undergraduate MIS program and the Master of Science in Technology Management (MSTM) program.

Selected Cloud Computing Labs

There are three major cloud computing service providers in US including AWS, Google Cloud, and Microsoft Azure. All of them provide a very comprehensive list of cloud computing services. For example, AWS, in its web site, lists 24 groups of services including such as machine learning,

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[3] https://customers.microsoft.com/en-us/story/731840-buhler-group-consumer-goods-azure-iot-switzerland, Accessed on Dec. 13, 2019.

[4] https://cloud.google.com/customers/color/, Accessed on Dec. 13, 2019.

[5] Accessed on Dec. 13, 2019.

[6] https://www.globalknowledge.com/us-en/content/salary-report/it-skills-and-salary-report/, Accessed on Dec. 2019.

block chain, computing, storage, IOT, mobile, media services, etc. As class time and faculty energy are always limited, only a limited number of services can be selected as examples to teach in classes. The following is a list of AWS based labs I used for a MIS introduction course at the undergraduate level and a MSTM program major course[7].

1. Setting up a web server in AWS using an EC2 Instance[8]. This lab is to demonstrate the concept of virtual machine/virtual instance in the cloud and gives students an opportunity to get familiar with the cloud computing management console. The key in this lab is to start a virtual instance and install the Apache web server, the mysql database, and the php software systems and configure these systems to set up simple web site. This lab should be the first one to get students excited with the cloud computing topic.

2. Setting up an image processing infrastructure (Wittig and Wittig, 2019) in AWS. This lab covers unique features of a message queue, object stores, and NOSQL database in AWS. This lab investigates different approaches to integrate various cloud computing services.

3. Setting up a WordPress Infrastructure (Wittig and Wittig, 2019). This lab is to demonstrate the concepts of scalability and file sharing through the AWS cloud computing platform. The services such as virtual private cloud, load balancing, autoscaling, relational database in the cloud, shared file system, cloud metrics, stateless web servers, security groups, access control list, content delivery network, DNS, infrastructure as codes, etc. are applied. Through this lab, students will be able to better appreciate the service-oriented architecture in cloud computing.

4. NoSQL database demonstration and discussion[9]. In this lab, the key is to elaborate differences between the traditional relational database and the increasingly popular NoSQL

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[7] A few labs are used in the undergraduate class and the rest are used in the graduate class. AWS educate (https://aws.amazon.com/education/awseducate/) provides free services to students.

[8] https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/ec2-ug.pdf#ec2-lamp-amazon-linux-2, Accessed on Dec. 14, 2019.

[9] https://www.slideshare.net/AmazonWebServices/amazon-dynamodb-deep-dive-advanced-design-patterns-for-dynamodb-dat401-aws-reinvent-2018pdf, Accessed on Dec. 14, 2019.

database with the AWS DynamoDB as the example. Emphasis is given to NOSQL database concepts such as horizontal scalability, the need to configure read/write throughout, the need to eliminate normality in table design, the feature of each row in a NOSQL database table being not necessarily consisting of the same fields (except the need for the same primary key), and the need to predesign instantiated queries. The demonstration and discussion of AWS DynamoDB broaden students' vision and deepen their understanding of the concept of database management.

5. Setting up the IOT monitoring lab (Nienlhuis, Horton, Sareen, 2019). In this lab, a program running in a local computer or a virtual instance will simulate sensors and generate a stream of sensor temperature data. Streaming services in the cloud are used to deliver the streaming data into the AWS S3 storage and process the data for the visualization in a dashboard. Through this lab, students should have a good understanding how sensors as IOT devices push data to the cloud for analytics in the cloud.

6. Setting up an AI-driven dashboard to visualize the real time social media data (Snively, 2019). In this lab, an virtual instance is used to retrieve twitter data and deliver the data to the object store (AWS S3) using AWS cloud streaming services such as Kinesis Firehose. Further, AWS serverless Lamda functions are applied to retrieve tweets data from the storage and send them to AI services including AWS Translate and AWS Comprehend in order to translate tweets into English (if they are not written in English) and produce tweets sentiment scores. These translated tweets and sentiment scores are then presented in charts dynamically using AWS services such as Athena, Glue, and Quicksight. Through this lab, students should have a good understanding of real time analysis of large amount of data and the role of artificial intelligence in big data analytics.

7. Setting up a serverless service (Poccia, 2017): in this lab, the focus is on the use of serverless infrastructure to simplify the management of information system infrastructure. Serverless services (such as AWS Lamda managed by AWS) have the scalability and security built-in without the need for the application team to manage the underneath IS infrastructure. Using serverless services, developers can focus more on value-added

activities. Through this lab, students should be in a better position to appreciate the information system infrastructure management aspect of system development.

8. AWS Big Data Analytics with Spark and Hadoop[10]. in this lab, the very popular big data analytic engine Apache Spark and the distributed file system Hadoop are discussed and demonstrated. Further, the open source Flintrock[11] software is used to demonstrate how to manage the size of the Spark/Hadoop cluster. This open source tool makes the management of Spark/Hadoop cluster very cost effective and efficient (compared with those tools directly provided by AWS). Through this lab, students can practice with big data analytics in a computer cluster and deepen their understanding of the concept of big data analytics and open source software systems.

Class Experiences

The eight labs discussed above cover many IT topics including such as virtualization, NOSQL database, security, scalability, abstraction, serverless, IOT, AI, infrastructure as code, and open source software. Graduate students with working experiences are indeed very excited and highly appreciate the value of the selected labs from the above. Some students are motivated to take the very valuable AWS certification tests. For undergraduate students, especially those who are not in the MIS major, they feel somewhat frustrated due to the complexity of architectures in the above labs. It is certainly more challenging to incorporate cloud computing into the undergraduate class and more experimentation is needed.

In my graduate classes, in addition to cloud computing labs, we also have readings related to topics such as cloud computing, IS outsourcing, IS architecture, open source software community, knowledge transfer from consultants to clients, big data analytics and its integration with enterprise systems, and the implementation of enterprise systems. Further, we have two course projects emphasizing the use of various cloud computing services and integration of big data analytics and enterprise systems in a variety of industries.

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[10] https://spark.apache.org/, https://hadoop.apache.org/, Accessed on Dec. 14, 2019.
[11] https://github.com/nchammas/flintrock, Accessed on Dec. 14, 2019.

With a solid understanding of various supporting cloud computing services, graduate students indeed develop a deeper understanding of the capabilities of cloud computing and can better appreciate the challenges in managing the migration of information system infrastructures from in-house data centers to the public clouds. Their understanding is demonstrated in both the quality of their course projects and their presentations and class discussions. The following are a few sample topics from graduate students' course projects:

- Amazon Web Services (AWS) Application to Healthcare Information Systems (HIS)
- XCELLANCE Healthcare Corporation: Data Center Migration to AWS
- Integrating Internet of Things (IoT) in ERP Systems

Conclusion

As cloud computing is increasingly becoming more and more powerful, reliable, secure, scalable, durable, and available, to incorporate cloud computing into our curriculum is imperative. In this paper, I summarize my efforts in doing so by using AWS services. First, labs are selected and developed for the purposes of demonstration and practice. Second, related readings selected from academic research are used to elevate graduate students' conceptual understanding of cloud computing related concepts (such as scalability, availability, abstraction, security, sourcing choices, and architecture (Venters and Whitley, 2012) and help them build up in their mind theoretical frameworks regarding cloud computing infrastructure design, implementation, and management. Third, course projects are developed to give graduate students a chance to integrate their conceptual understanding and practical experiences to investigate existing cases and explore potentials in a variety of industries in terms of applying cloud computing services to achieve competitive advantages. From the feedback from graduate students, I do see this effort of incorporating cloud computing into our curriculum is worthwhile and deeply appreciated. However, for undergraduate classes, more exploration with teaching cloud computing is needed.

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4. Snively, B. (2019) AI-Driven Social Media Dashboard. https://s3.amazonaws.com/solutions-reference/ai-driven-social-media-dashboard/latest/ai-driven-social-media-dashboard.pdf

5. Poccia, D. (2019) *AWS Lamda in action: Event-driven serverless applications*. Manning.

REINFORCING SPREADSHEET SKILLS THROUGH AN ONLINE INSTRUCTIONAL PLATFORM WHEN TEACHING A FACE-TO-FACE MIS COURSE

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ABSTRACT

The purpose of this paper is to share our experience with utilizing a customizable online instructional platform to help students refresh and reinforce their spreadsheet skills while taking an introductory course in Management Information Systems. In particular, the paper focusses on discussing the effectiveness of embedding an online self-paced Microsoft Excel training module in a face-to-face course in comparison to utilizing a traditional computer lab. We outline some of the challenges and benefits of utilizing this module and share a few insights based on our experience.

Keywords: Instructional Methods; Self-paced Learning; Assurance of Learning; Spreadsheet Skills

INTRODUCTION

The widespread use of the Internet and Web-based communication technologies has provided the impetus for educational institutions to encourage their faculty to deliver parts or full content of their courses online [1, p5]. According to a survey of more than 2500 colleges and universities in the US, "sixty-five percent of all reporting institutions said that online learning was a critical part of their long-term strategy" [2]. The same source reports that "thirty-one percent of all higher education students now take at least one course online." The availability of online learning management systems and e-learning tools has enabled the instructors to expand their instructional practices beyond the boundaries of traditional classrooms by mitigating the impact of time and space constraints [3]. Traditional means of delivering educational content are increasingly enhanced or supplemented by digital learning tools [4, p1]. To that end, the number of blended (also known as hybrid) courses offered by colleges and universities in various disciplines seems to grow accordingly as educators seek to enrich student learning environments by embedding online learning tools in traditional face-to-face classrooms [5, 6]. According to one source, blended courses are known for delivering "between 30 and 80 percent" of their content online [2]. While opinions about the ratios of online and face-to-face activities that comprise a blended course can vary, the majority of experts seem to use the term blended to describe a course where the face-to-face contact time is replaced by online content, and students are provided with the opportunity to experience an individually-paced and self-guided learning environment. [7, p2].

A glance at the literature reveals that considerable research has been conducted on the merits of online learning environments. A report published by the US Department of Education in 2010 cited "more than a thousand empirical studies of online learning" conducted between 1996 and

2008 [8]. While earlier studies of online learning seem to have reported "conflicting results about the performance of online students" ([9]), more recent meta-analyses have concluded that "on average, students in online learning conditions performed modestly better than those receiving face-to-face instruction" ([8]), and "the experimental probability of attaining higher learning outcomes is greater in the online environment than in the face-to-face environment" [10]. In 2013, sixty-seven percent of "academic leaders rated the learning outcomes in online education as the same or superior to those in face-to-face," whereas one-third among the same group believed "that the learning outcomes for online education are inferior to those of face-to-face instruction." [2]. Similarly, another meta-analysis published in 2013 highlights the mixed results reported in the literature as "on some of the measures, the students in the online or hybrid format did better, but on others they did worse, relative to students in the face-to-face format" [11]. In other words, the meta-analysis concluded that "on some measures the online- or hybrid-format students did significantly better or worse than the students in the face-to-face format, but on other measures there was no significant difference between the two groups." One study, in particular, asserts that "the positive effects associated with blended learning should not be attributed to the media, per se," noting that "blended conditions often included additional learning time and instructional elements" provided to students [8]. Given the variety of technological tools used and instructional methods explored by instructors in blended and online courses, it appears that more research will need to be conducted to draw definitive conclusions about the effectiveness of e-learning environments ([7, p4], [9]).

Blended courses have become increasingly prevalent within the framework of flipped classrooms where instructors free more class time for conducting face-to-face experiential and active learning exercises by delivering parts of course content online. In other words, a flipped classroom is commonly referred to as "a teaching method that delivers lecture content to students at home through electronic means and uses class time for practical application activities." [12]. Accordingly, a flipped classroom can serve as a conduit for creating a learning environment where students perform "school work at home and homework at school" and instructors implement various pedagogical methodologies [13]. Besides, the confluence of blended and adaptive learning environments has led to the emergence of adaptive blended learning environments where synchronous and asynchronous educational tools are used to identify and adapt to the instructional needs and pace of individual learners ([14,15,16]).

This paper outlines the main takeaways from an instructional effort aimed at incorporating a blended learning environment into an introductory undergraduate course in Management Information Systems (MIS). More specifically, the effort involved using an online self-paced instructional platform provided by the textbook publisher – in place of face-to-face instructions in a traditional computer lab – to refresh, reinforce, and enhance students' Microsoft Excel skills.

MOTIVATION

A recently conducted multifaceted exploratory study asserts that there is a "very real need for BSBA[1] students to have stronger Excel skills" [17]. The same source suggests that "this need is widespread and potentially a national need," especially in light of rapidly growing interests in data analytics in modern business decision-making applications. Hence, it is well understood that the

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[1] Bachelor of Science in Business Administration

ability to work with Excel spreadsheets is undoubtedly among the fundamental skills that business majors are expected to possess upon graduation to succeed in the job market. Accordingly, business students often find it necessary to demonstrate their proficiency in Excel while performing coursework in various subjects such as Accounting, Business Analytics, Finance, or MIS, among others.

Many business schools require students to take an introductory course in computer and Microsoft Office applications during their freshman or sophomore years to meet the common prerequisite requirement before being allowed to enroll in upper-level courses. While the extent of students having to utilize Excel in upper-level courses may vary from one subject to another, students usually find themselves in need of refreshing and reinforcing their knowledge of Excel as they work their ways through their programs of study. This can prove to be a particularly challenging task for most students, and result in failing to achieve the intended learning goals, unless supporting instructional mechanisms are put in place to help students keep up with the workload and meet the expectations while taking upper-level courses. To that end, designating specific class periods as Excel review sessions, conducting tutorial sessions in the computer lab, peer-tutoring, providing illustrated review materials, and/or sharing links to video instructions available online are among the common methods used in traditional classroom environments to help students overcome this learning challenge. However, differences in students' backgrounds, knowledge deficiencies, learning abilities, and schedules are likely to restrict the utility or effectiveness of such remediating solutions. Fortunately, the emergence of blended learning environments coupled with the popularity of pedagogical strategies such as scaffolding and constructive learning have promoted the idea of utilizing self-guided, adaptive, and autonomous online learning platforms to instill, refresh and elevate working knowledge of Excel spreadsheets among students.

SCENARIO

Introductory MIS courses are often considered as appropriate conduits to verify and fortify students' competency and proficiency in basic computer skills which include the ability to work with Excel spreadsheets. We teach a junior-level course on the fundamentals of e-Business and information systems as part of the BSBA core curriculum in an AACSB-accredited college of business. The purpose of the course is twofold; namely, to introduce students to MIS as a business discipline aligned with achieving organizational goals, and to enhance students' problem-solving skills using popular off-the-shelf software applications. These two tracks are covered in parallel throughout the semester, and students' competency to work with Microsoft Excel is targeted as an important learning outcome of the course – which is taught in multiple sections by different instructors. All sections require the same two textbooks and contain the same content. Students are required to complete several hands-on Excel assignments on an individual basis during the semester. Furthermore, students are required to take an exam consisting of multiple-choice questions based on Excel-related topics covered in class upon completing the hands-on assignments.

Historically, when teaching the course in a face-to-face format, we scheduled tutorial sessions during the regular class periods throughout the semester to cover Excel and provide students with the opportunity to interact with the instructor and ask questions about their hands-on assignments. While this method offered students the advantage of having synchronous interactions with the

instructor and their peers as well as receiving one-on-one instructions as needed; nevertheless, it involved some limitations. For example, securing a computer lab that could accommodate an entire class of 35-45 students in one session often posed a scheduling challenge. Relying on students to bring their computers to class did not provide a viable solution as some students did not own or have access to such devices. Students who missed the tutorial sessions faced a much harder time completing the assignments and performed poorly on the test. Furthermore, students who attended the tutorial sessions differed widely in terms of the depth and extent of their familiarity with Excel as well as their ability to follow and keep up with the flow of hands-on instructions. These observations led us to adopt a blended format for delivering the course content. More specifically, about three years ago, the course structure was modified to replace the face-to-face tutorial sessions with an online instructional platform provided by the textbooks' publisher. The online platform enables students to complete Excel training sessions and perform hands-on assignments in a self-guided and individually-paced learning environment outside the classroom while receiving feedback about attempted or completed tasks. In addition to an electronic text and step-by-step instructions for completing the assigned lessons in a simulated Excel environment, the embedded platform contains instructional videos, PowerPoint slides, and assessment tools such as hands-on project assignments and quizzes. The platform is highly customizable thereby allowing the instructor to tailor the instructional and assessment materials to students' needs and targeted learning outcomes. It also offers automated scoring functionality for assignments.

TAKEAWAYS

This section outlines the main takeaways from our experience with using the online platform described above. In addition to drawing upon our observations and course assessment results, these conclusions reflect students' feedback and anecdotal evidence gathered from conversations with other instructors using the same or similar platforms in their courses:

- Many students faced technical challenges when attempting to sign-up and access the online platform for the first time when the platform was adopted. Students were often frustrated with faulty/erroneous access codes and unsatisfied with the responses offered by the publisher's technical support. While the issue with access codes seems to have been resolved based on our most recent experience with the platform, students often find themselves in need of additional technical support. Conducting demo sessions in class and using office hours to help students with troubleshooting common technical problems have proven to be somewhat effective in this regard; nevertheless, students view access to reliable and timely technical support throughout the semester as an essential requirement.

- Students find the ability to complete and repeat the lessons at their own pace and convenience to be a very appealing feature of the online platform. Furthermore, having the option of invoking interactive lessons on specific topics as needed while working on assignments seems to be very beneficial to students.

- Inability to interact with the instructor (or the teaching assistant) in real-time while completing the hands-on lessons is frequently noted by students as a major downside of the online training module. Providing students with illustrated notes and/or supplementary instructional videos can help with mitigating the potential negative impact of asynchronous interactions.

- The online training module limits the instructor's ability to utilize peer-assisted and team-work learning strategies that are readily achievable in classroom or lab environments.

- The automatic scoring of assignments was not received favorably by students. The scoring mechanism appeared to be too rigid and incapable of accounting for all possible expositions of correct responses. Furthermore, students often found the feedback provided by the platform unclear or confusing. As a result, grading challenges occurred frequently and students' confidence in the fairness and accuracy of the assessment mechanism diminished accordingly.

CONCLUSIONS

The paper outlined our observations related to embedding an online self-paced Excel training module, in place of face-to-face tutorial sessions, in a blended MIS course. These observations suggest that mixed outcomes are to be expected from such endeavors. Accordingly, conducting a data-driven structured analysis of assessment results and students' feedback emerges as the next step of this ongoing pedagogical research project.

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Revisiting: Visual Business Intelligence Course

ABSTRACT

As social network diffuses so does the data generated through them. This data contains much variety like text, videos, graphs, pictures etc. Data is generated at the speed of light and organizations must take advantage of it. Organizations are demanding graduates who can understand, manage and make sense of such data. Universities are obligated to provide such skills to their graduates. This paper is an attempt in that direction. A new course which combines visualization and intelligence was developed. Developing a new course always creates challenges and opportunities. We discuss challenges that were encountered and how we resolved them. Institutions planning to develop such a course can learn from our experiences and modify it based on their needs.

THE COURSE

The course was developed for MBA students at a mid-western university. Most students work and go to school part time. This was an on-line class. After several iterations the course definition evolved as:

Business Intelligence (BI) equips enterprises to gain business advantage, helping turn data into knowledge. Business Intelligence refers to the use of the information technology to analyze complex information about an organization and its competitors for use in business planning and decision making. The objective is to create more timely and higher quality input to the decision process. BI makes an organization agile thereby giving it a competitive edge. The course details BI components, important techniques as well as the critical variables needed to implement an effective BI program. This course takes a managerial approach to Business Intelligence, and therefore emphasizes the BI applications and implementations. This exposure allows students to truly understand how Business Intelligence works so they can adopt it in their future managerial roles.

In addition, following course learning objectives (LO) were identified:

- Become familiar with BI concepts and frameworks using visualization
- Identify BI components
- Understand data warehouse
- Understand how to develop BI applications
- Understand and use analytical techniques
- Know the business uses and value of BI

Course Implementation

Once the course was designed the next step was to deliver it online. Each LO was mapped into an individual assignment. There was forum discussion on both visualization and BI related topics and especially on interpretation of results.

We will discuss our experiences at the conference.

CONCLUSION

This new phenomenon merges two fields visualization and BI. It is important that our students understand the combined approach instead of existing isolated concepts of visualization and analytics. Opportunities are emerging as software like SAS, JMP and Tableau are making business intelligence and visualization a reality. There will always be challenges due to business background of students. This, however, should not be a drawback but an opportunity to bring different students together to get different inputs. The course, itself, is evolving and the next step is to study JMP for visual suitability and maybe remove data warehouse from the learning objective. This will allow professors to concentrate on data visualization and resulting story to 'discover' opportunities in the classroom.

Undergraduate Student Posters

Artificial Intelligence, Humanized Technology, and Robotic Anthropomorphism: How Do Robots and Humans Interact?

Undergraduate Student Poster

Ms . Brea Ellis [1], **Ms . Mayumi Fleming** [1], **Ms . Rosslynne Terry** [1], **Dr . ANSHU ARORA** [1]

1. *University of the District of Columbia*

The personality traits of introversion and extroversion significantly affect how individuals perceive the world around us. In this new era of artificial intelligence, humanized technology, such as robots, has become ubiquitous. This research seeks to investigate how artificial intelligence (AI) influences marketing and consumer behavior. AI will enhance the marketing function by collecting all unstructured consumer-curated data that has continuously grown in volume, velocity, and variety. In this paper, we seek to examine whether AI technologies can utilize consumer data to determine each customer's emotions and personality, in order to provide the right products at the right time.

Best Practices in Sustainable Procurement

Undergraduate Student Poster

Mr . Ben Strauss [1], **_Dr . John Visich_** [1]

1. _Bryant University_

This research stream will on identifying best practices in sustainable procurement carried out by leading global Food & Staples Retailers. 28 companies were selected from the Newsweek Green Ranking 2017 Best in Industry Global list. The project will entail benchmarking the company code of conduct with the Global Reporting Initiative (GRI) standards. By benchmarking the supplier code of conduct with the GRI standards we hope to identify best practices in social and environmental procurement. In addition, statistical comparisons between companies will be conducted using non-parametric statistics.

Blockchain Applications in Business: Bringing Businesses and Consumers Together with Trust and Confidence

Undergraduate Student Poster

Mr . kyle kelley [1], *Ms . Mayumi Fleming* [1], *Dr . ANSHU ARORA* [1], *Dr . Jiajun Xu* [2]

1. *University of the District of Columbia ,* **2.** *University of the District of*

Blockchain application system utilizes a decentralized peer-to-peer network that details the exact history of custodianship, ownership, and location of transactions and exchanges; thereby removing the need for third-party institutions, breaks down barriers, instills trust, and provides interoperability across the globe. In this research, we investigate blockchain applications across two industries that have benefitted suppliers and consumers alike. Furthermore, we examine the potential of blockchain technology in bringing the global market together in a decentralized, transparent, and immutable network. This research is funded by **NSF Grant# 1912070** and **NASA's Center for Advanced Manufacturing in Space Technology & Applied Research at UDC.**

Company Actions and Alignment with the UN Sustainable Development Goals

Undergraduate Student Poster

Ms . Jamie Fischer [1], *Mr . Jonathan Hagenow* [1], *Dr . John Visich* [1]

1. *Bryant University*

This research will connect sustainability science with sustainable business practices, thereby broadening the perspective of sustainability. The objective will be to identify company sustainability practices that meet the UN Sustainable Development Goals. This research will highlight the science behind the sustainability problem to be solved and the science behind the solution to solve the sustainability problem. This work will highlight the importance of science and business working together to address a variety of sustainability issues in our current global economy.

Effect of Collaborative Learning for Production Line Design using LEGO MindStorms

Undergraduate Student Poster

Mr . Shingo Umehara [1] *, Mr . Hiroshi Kuroki* [1] *, Mr . Tomoki Oshima* [1] *, Prof . Aya Ishigaki* [1] *, Dr . Seiichi Yasui* [1]

1. *Tokyo University of Science*

Recently, Japanese universities provide experience-oriented specialized education. This study discusses the method of the class content design for collaborative learning for a "Production Line Design" using LEGO MindStorms. In this study, the efficiency of e-learning system with a communication tool of non-language information and a real-time monitoring function was shows.

IMPLEMENTING PRODUCTION CO-OPs TO MAINTAIN COMMUNITY SUSTAINABILITY

Undergraduate Student Poster

Ms . Ivie Enagbare [1], *Ms . Diana Sanchez* [1], *Ms . Melanie McAllister* [1], *Mr . Mcdonald Etrue* [1], *Mr . Eamonn McGuiness* [1], *Prof . Heidi Hughes* [1]

1. *Central Connecticut State University*

This project will evaluate and address the importance of Production Cooperatives and how it increases sustainability among communities. The Cleveland Model, and how this process creates new jobs, expands businesses, boosts the economy, etc. The research will specifically help states the advantages and disadvantages, as well as allowing us to come up with conclusions and recommendations. Information will be obtained from NCBA CLUSA which focuses on why and how Cooperatives provide a more inclusive economy that benefits different parties. We will also contrasting the different benefits they provide against sources that disagree with their implementation.

Keywords: Cooperatives, Inclusive Economy, Community

Inventory optimization in a supermarket warehouse feeding a single cell poke-thru production line

Undergraduate Student Poster

Ms . Jenna Moreira [1], *Ms . Emily Vieten* [1], *Dr . Fatma Pakdil* [1]

1. *Eastern Connecticut State University*

The purpose of this project is to analyze the replenishment points in the supermarket in order to meet the demand in the cell at a manufacturing firm that implemented lean principles. The problem that causes delay in the production line is the inefficiency to fulfill the demand of parts needed in the cell. This system functions by operators replenishing the bins to meet the demand of the inventory in the cell. This project develops a system that has the ability to input the demand for each product/part and relay the estimated amount of parts that need to be ordered.

Machine Learning Applications In Image Recognition

Undergraduate Student Poster

Mr . Michael Matkowski [1] **_, Ms . Audrey Chase_** [1]

1. _Bryant University_

This project applies machine learning techniques to image recognition to identify yield signs and traffic signs, demonstrating a potential real world application of these models and how powerful they can be. After consideration of ten different models, the best was a tuned Random Forest with a testing accuracy of .82.

Non-linear Spatial Analysis of Ambulance Service Location in Jersey City

Undergraduate Student Poster

Ms . Natalia De La Fuente [1] **_, Dr . EunSu Lee_** [1]

1. _New Jersey City University_

Jersey City is widely recognized as a major American city and is the third largest city in the New York area. This study proposes a non-linear methodology to attempt to solve the problematic of travel distance response time with the ambulance services in Jersey City, proposing a new location for the services and restricting the response time to 9 minutes. In the research, valuable information confirmed the need of another location close to low income areas. This study recommends adding another location, thus the response time can be optimized.

The Ask and the Offer: Insights from Shark Tank

Undergraduate Student Poster

Mr . William Riherd [1], *Ms . Kristina Schmidt* [1], *Ms . Julia Howell* [1], *Ms . Victoria Newell* [1]

1. Boston College

Is an entrepreneur's gender related to the desirability of the deal they receive? We explore 423 entrepreneurial groups and individuals who sought funding via the TV show "Shark Tank". Our analysis determines that although an entrepreneur's gender does not have a statistically significant impact on whether a deal is received, 1) female entrepreneurs ask for lower funding while giving up more ownership and 2) mixed-gender entrepreneurial groups ask for higher funding than all-female groups.

The Combined Effects of Design-Tech Synergy + Country-of-Origin on Consumers' Willingness to Buy: A Neoteric Approach to Innovation

Undergraduate Student Poster

Ms . Mayumi Fleming [1] **, Mr . kyle kelley** [1] **, Dr . Jiajun Xu** [1] **, Dr . ANSHU ARORA** [1]

1. *University of the District of Columbia*

We conceptualize 'design-tech synergy,' and introduce the concepts of design newness and innovation, as well as technological newness and innovation. We examine how emerging economies and developed economies respond to these design and technological innovations differently, given the distinct differences in their countries of origin (COO). We investigate whether incongruent or conflicting COO scenarios affect consumers' purchase intentions with respect to radical versus incremental innovations for everyday consumer products and brands. This research is funded by **National Science Foundation Grant # 1912070**and **NASA's Center for Advanced Manufacturing in Space Technology & Applied Research at UDC.**

The Impact of Quota System of Forage: A Case Study of International Trade between Korea and the United States

Undergraduate Student Poster

Ms . Yeongchae Yoo [1] *, Dr . EunSu Lee* [1]

1. *New Jersey City University*

Recently, Oregon state and NH HAY has discussed ways to expand agricultural cooperation. The main reason of their cooperation is the quota system for import of forage will be periodically abolished by 2026. South Korean farmers tend to use of imported forage than domestic-forage, due to the cost of production is higher than import prices. United states and Australia are two big countries that have the largest portion of importing Forage in South Korea. This study investigates the impact of the change of quota system.

THE LITERATURE REVIEW OF SIX SIGMA PROJECT PRIORITIZATION AND SELECTION PROBLEM

Undergraduate Student Poster

Dr . Fatma Pakdil [1], Ms . Bethel Teshome [1]

1. *Eastern Connecticut State University*

The success or failure of delivering expected outcomes in Six Sigma projects may relate to the quality of project prioritization and selection methods and processes. In practice, the majority of the organizations implementing Six Sigma have no systematic project selection methodology involved in their Six Sigma activities. In theory, given the complex nature of problem, multi-criteria decision making methods have been utilized over the last decades. the goal of this undergraduate research project is to review Six Sigma selection approaches and methods used in practice and literature and comprehensively analyze the pros and cons of the existing approaches and methods.

Waste Management

Undergraduate Student Poster

Mr . Brandon Dipierdomenico [1]

1. *Central Connecticut State University*

Over production is a growing issue in work places as they do not compare numbers and look at previous sales in order to come tight to inventory numbers. The findings from this project will be a case study of Local Production (pseudonym). During the spring 2020 semester, the research student will keep a waste log to analyze the percentage of waste the organization accumulates. Based on the log, suggestions will be made for ways in which we plan to combat the problem are with smaller batches made to ensure fresher product. Formulate plans for future sales and keep waste minimum.

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