Decision Sciences Institute

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Northeast Decision Sciences Institute

53rd Annual Conference

April 4 –6, 2024

Cambridge, MA

THE LEGACY OF INNOVATION IN DECISION SCIENCES: REFLECTION AND FORWARD THINKING

NEDSI
NORTHEAST DECISION SCIENCES INSTITUTE

BRIDGEWATER
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NEDSI 2024

Northeast Decision Sciences Institute

53rd Annual Conference

THE LEGACY OF INNOVATION IN DECISION SCIENCES:

REFLECTION AND FORWARD THINKING

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April 4 –6, 2024

Cambridge, MA

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E. Denise Simmons, Mayor
2008–2009 | 2016–2017 |2024–2025

March 28, 2024

Northeast Decision Sciences Institute
c/o Hyatt Regency Boston/Cambridge
575 Memorial Dr
Cambridge, MA 02139

Welcoming Northeast Decision Sciences Institute To Cambridge

Dear Friends of the Northeast Decision Sciences Institute:

On behalf of the people of Cambridge, it is with great pleasure and enthusiasm that I extend a warm welcome to the Northeast Decision Sciences Institute (NEDSI) as you convene your 53rd Annual Conference in our esteemed city. Given the work that you are engaged in, it is quite fitting that the City of Cambridge – a true international hub for scientific discovery, research, and innovation – is hosting this year's NEDSI conference.

NEDSI, a regional division of the Decision Sciences Institute, is internationally recognized as a scholarly professional organization that fosters forums to create, enhance, and improve managerial decision-making by integrating all the disciplines of the decision sciences. NEDSI conferences are well known for the research contributions presented by both practitioners and scholars. Your work has a dynamic and positive impact upon how we act in the present, and how we prepare for the future.

The City of Cambridge is truly honored to host this year's conference, a choice that aligns seamlessly with our commitment to fostering intellectual exchange and advancement. As you immerse yourselves in the conference proceedings, I encourage you to explore the rich tapestry of Cambridge's offerings – from the serene beauty of the Charles River Esplanade to the captivating exhibits of the MIT Museum and the storied halls of Harvard University and Harvard Square. I invite you to indulge in all the rich experiences our city has to offer, and I hope that your stay is filled with enriching experiences and meaningful connections!

Sincerely,

Mayor E. Denise Simmons

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TEL: 617.349.4321 FAX: 617.349.4320 | TTY/TDD: 617.349.4242 | EMAIL: dsimmons@cambridgema.gov

Welcome

As the Executive Vice President and Provost of Bridgewater State University, I would like to extend a warm welcome to all participants at the 2024 Annual Conference of the Northeast Decision Sciences Institute (NEDSI) taking place in the historic city of Cambridge, Massachusetts. It is my pleasure and my privilege to have our university serve as co-hosts for this wonderful gathering of scholars, practitioners, and students.

Since 1840, Bridgewater State University has transformed the lives of countless students. As we prepare these individuals for lifelong learning, growth, and advancement, we do so by adhering closely to our University motto—"Not to be ministered unto, but to minister". Bridgewater State has remained steadfast in its commitment to empower individuals and advance the public good.

We are proud to partner with NEDSI to support their annual conference where knowledge is shared, impactful research is presented, and scholars can interact with practitioners in a dynamic and collegial environment. I wish you all the very best for a productive and memorable conference experience.

Sincerely,

Karim Ismaili
Executive Vice President and Provost
Bridgewater State University

Welcome

On behalf of the Ricciardi College of Business at Bridgewater State University, I would like to welcome you to Cambridge, Massachusetts for the 53rd Annual Conference of the Northeast Decision Sciences Institute (NEDSI). We are delighted to serve as co-host for this year's event and we look forward to the sharing of scholarly research, knowledge, and experiences by each attendee!

Here in the Ricciardi College of Business (RCOB), we offer majors in Accounting & Finance, Management & Marketing, and Aviation. As we deliver courses in these disciplines, we pride ourselves on advancing the 3 pillars of our academic foundation. The first pillar is our rigorous business curriculum that has resulted in wonderful achievements for our students—from our accounting students who earn some of the highest first-time pass rates on the CPA exam, to our flight students who consistently obtain high first-time pass rates on their FAA exams, to our management students who successfully matriculate through our SHRM-certified HR major.

The second pillar is our emphasis on Experiential Learning. Through our Collaborative University Business Experiences (CUBEs) Initiative, students work directly with local/regional/national businesses to apply business theories to real-world problems that provide solutions for the company. In addition, our students regularly participate in other hands-on learning experiences such as conducting an internship for a Fortune 500 company, or selecting stocks for our $200,000 student-managed investment portfolios.

Our third and final pillar is deep student engagement. Through our Center for Entrepreneurship and Small Business, students can learn how to start and manage their own business. And through our Bear BID competition—which is modeled after Shark Tank ©—students can compete for thousands of dollars to get a head start on their company. And when we include the fact that our aviation students regularly take flight in one of our 12 aircraft, the sky truly is the limit for BSU graduates!

So, once again, we welcome you to the 2024 NEDSI Conference and we hope that this will be the first of many visits you make to this historic and growing region!

Jeanean Davis-Street
Dean, Louis M. Ricciardi College of Business
Bridgewater State University

Welcome

SAINT JOSEPH'S UNIVERSITY

OFFICE OF THE DEAN
ERIVAN K. HAUB SCHOOL OF BUSINESS

On behalf of Saint Joseph University's Haub School of Business, I welcome all participants of the 2024 Northeast Decision Sciences Institute (NEDSI) Annual Conference. NEDSI 2024, taking place in Cambridge, is an excellent opportunity for scholars, researchers, practitioners, and students to present their work and engage in the networking that is so important to advancing knowledge and teaching. The organizing committee has done an excellent job in planning a conference that will provide for the needs of attendees and run smoothly.

The Haub School of Business and our faculty have a long history of involvement in and support of NEDSI and its parent institution, the Decision Sciences Institute (DSI). With NEDSI 2024, we are broadening and deepening that involvement and support.

Both Cambridge and Philadelphia are historic cities. Both Boston/Cambridge and Philadelphia are thought of as college towns, with the per capita representation of students about the same (Boston/Cambridge ~7 per 100, Philly ~5.5 per 100 [Bloomberg and Statista]). So, it is fitting that if NEDSI 2024 wasn't going to be held in Philadelphia that it is in Cambridge.

The Haub School of Business is delighted to co-host NEDSI 2024 as part of our commitment to advance the field of decision science and scholarship and teaching in the Jesuit tradition. I hope that NEDSI 2024's researchers, scholars, practitioners, and students have a rewarding and enjoyable conference!

Sincerely,

Joseph DiAngelo, Jr., Ed.D.
Dean and Professor, Haub School of Business Saint Joseph's University

Welcome

Neil Desnoyers
Saint Joseph's University

Xiangrong Liu
Bridgewater State University

Welcome to NEDSI 2024!

52nd Annual Conference of Northeast Decision Sciences Institute

On behalf of the entire NEDSI Board and Organizing Committee, we would like to welcome you to the 53rd Annual Conference of NEDSI which is taking place April 4-6, 2024. The theme of the conference is "The Legacy of Innovation in Decision Sciences: Reflection and Forward Thinking." With the numerous endeavors of scholars, leaders, and volunteers, we are excited to offer you once again a variety of paper sessions, panel sessions, and workshops. In addition, there will be a student poster session. The conference will provide excellent opportunities for professional development and networking.

The board and organizing committee will continue to work very hard during the next few months to put together a great 2024 conference. In addition to our sincere gratitude to the entire NEDSI board, we are very grateful to Dr. Jeanean Davis-Street, Dean of the Ricciardi College of Business at Bridgewater State University and Dr. Joseph A. DiAngelo, Dean of the Erivan K. Haub School of Business at Saint Joseph's University, without whom it would not be possible to host the conference. Saint Joseph's University and Bridgewater State University are the host institutions for NEDSI 2024.

The venue for NEDSI 2024 is the Hyatt Regency in Cambridge, Massachusetts, located alongside the beautiful (and famous) Charles River, which flows near the heart of the Boston/Cambridge innovation hub. There is a special conference group rate for room reservations made by March 4, 2024 (2024 NEDSI Guest Room reservation link). Conference attendees are also invited to join us on a tour of the MIT Museum on Saturday afternoon (April 6).

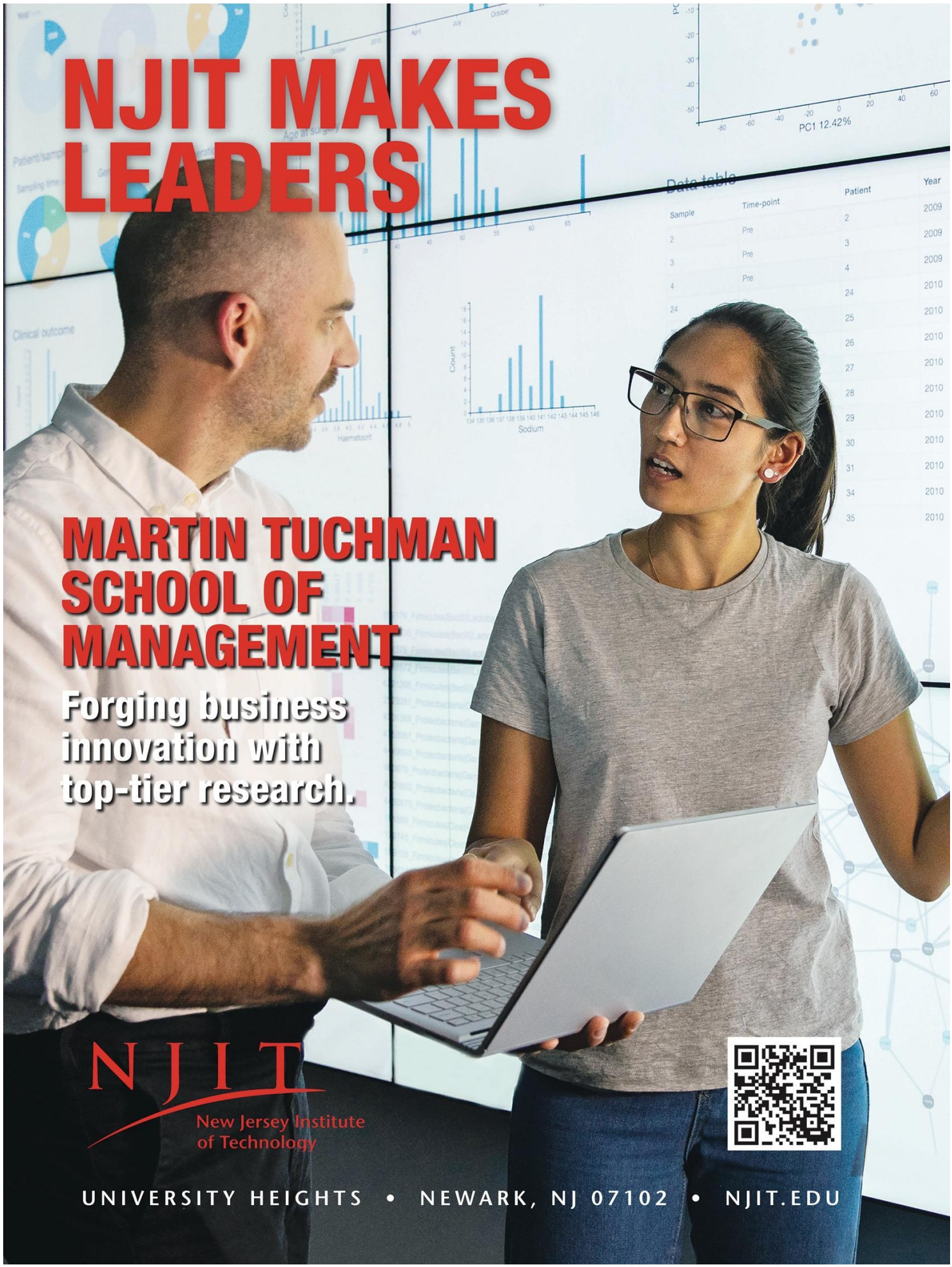
On behalf of the NEDSI board, we wish you all the best and know you will find NEDSI 2024 fruitful and enjoyable.

Best regards,

Neil and Xiangrong
NEDSI 2024 Co-Chairs.

NEDSI 2024 Keynote

Dr. Sam Ransbotham is a professor of analytics at Boston College's Carroll School of Management. He teaches "Analytics in Practice" and "Machine Learning and Artificial Intelligence." Ransbotham served as a senior editor at Information Systems Research, associate editor at Management Science, and academic contributing editor at MIT Sloan Management Review. He co-hosts the Me, Myself, and AI podcast, available on all major platforms. Ransbotham received a National Science Foundation Career Program award "in support of early-career faculty who have the potential to serve as academic role models in research and education," for his analytics-based research in security. He was also honored with an INFORMS ISS Sandra A. Slaughter Early Career Award, which recognizes "early career individuals who are on a path towards making outstanding intellectual contributions to the information systems discipline." Ransbotham earned a bachelor's degree in chemical engineering, an MBA, and a doctorate, all from the Georgia Institute of Technology. Before earning his doctorate, he founded a software company with a globally diverse client list including the United Nations IAEA (Vienna), FAO (Rome), WHO (Geneva), and WMO (London). Since 2015, he has been an editor for MIT SMR's Big Ideas initiatives, including Artificial Intelligence and Business Strategy, and Competing With Data & Analytics.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DEANS PANEL

Dr. Jeanean Davis-Street currently serves at Bridgewater State University (BSU) as the Dean of the Ricciardi College of Business. During her time in the Dean's Office, she has initiated several new programs including BSU Student-Managed Investment Fund (SMIF), "Talk Notes" Business Panel, BSU to Boston Bus Trip, and BSU Bear BID Competition.

Dr. Davis-Street attended Florida State University, where she received dual bachelor's degrees in finance and Multinational Business within four years. After receiving her undergraduate degrees, she then received one out of twenty annual awards from the McKnight Doctoral Fellowship/Florida Endowment Fund, where she went straight into the doctoral program at the University of South Florida, earning a Ph.D. in Finance.

Dr. Eda Sanchez-Persampieri is the Founding Dean at LIM College's Marcuse School of Graduate Studies, with a focus on merging entrepreneurship and creative industries through curriculum development. Her past leadership roles within the fashion supply chain complements her academic credentials from Johnson & Wales University, St. Joseph's University, and the Fashion Institute of Technology, SUNY. Additionally, she has entrepreneurship training from Babson College and the Ewing Marion Kaufman Foundation/The Levin Institute, SUNY, and has studied education and curriculum development at CUNY's Graduate Center, Touro College, and LIU.

Oya I. Tukel, Ph.D. is Dean of Martin Tuchman School of Management at NJIT. Prior to joining NJIT, Dr. Tukel was Associate Dean and Professor of Operations and Supply Chain Management at Cleveland State University. As a renowned scholar, Dr. Tukel has published manuscripts, book chapters, and open educational resources in the areas of Project Scheduling, Innovation, and Supply Chain Management for highly ranked international academic and practitioner journals and in the Ohiolink Library System with over 4000 citations. She has held Associate Editor and editorial board member positions for academic journals, chaired doctoral committees, and made numerous conference presentations. She has been involved in training programs and consulting in Project Management, Innovation Management, and Supply Chain Management in the United States, Europe, and Asia. She has received numerous teaching, service, and research awards, including the Nance Applied Business Scholar in 2005 and two Fulbright Specialist awards in 2016 and 2019. Dr. Tukel has been honored with the ROI-NJ Women in Business Top 40 Award and the Executive Women of New Jersey Salute Award, recognizing her outstanding contributions to the business community.

Dr. Yi Yang is the Associate Dean of Graduate Studies and Research at the Manning School of Business UMass Lowell. She joined UMass Lowell in 2006 after receiving her PhD in Business Administration from Drexel University. Before becoming the Associate Dean, she had taken a variety of leadership positions at UMass Lowell, including Department Chair of Marketing Entrepreneurship and Innovation (2017-2022), the Manning PhD program director (2014-2017), co-director of the Jack M. Wilson Center for Entrepreneurship (2019-present). She was the board director at the Eastern Academy of Management (2016-2020).

As researcher, Dr. Yang has established her reputation as an expert on technological innovation and corporate entrepreneurship. She has published her research in several Financial Times Top 50 business journals such as Journal of Business Venturing, Journal of Management Studies, Research Policy, Strategic Entrepreneurship Journal and Strategic Management Journal, and received several grants as PI or Co-PI from UMass Lowell, the UMass System, the Department of Energy, NSF I-Corps and US Army in support of teaching and research in the areas of entrepreneurship and technology innovation.

Dr. Aleksandar (Sasha) Tomic is Associate Dean for Strategy, Innovation, & Technology, and Director of the Master of Science in Applied Analytics and Master of Science in Applied Economics programs at the Boston College's Woods College of Advancing Studies. He also holds appointments as Associate Professor of Practice in the Economics department of Morrissey College of Arts and Sciences and Operations Management Department of Carroll School of Management. Dr. Tomic leads strategic initiatives at the College, especially in online education.

ABOUT

The Decision Sciences Institute

The Decision Sciences Institute (DSI) is a professional organization of academicians and practitioners interested in the application of quantitative and behavioral methods to the problems of society.
Through national, international and regional conferences, competitions and publications, the DSI provides an international forum for presenting and sharing researching the study of decision processes across disciplines. The DSI also plays a vital role in the academic community by offering professional development activities and job placement services.
Five regional subdivisions in the United States, as well as regions representing Europe, Asia-Pacific and the Indian subcontinent, operate within the DSI. Each region has its own elected officers and representative on the Board of Directors and holds annual meetings.
The DSI, an independent nonprofit educational organization, is located in Houston, Texas, where it receives extensive support from the C.T. Bauer College of Business at the University of Houston.

Northeast Decision Sciences Institute

The Northeast Decision Sciences Institute (NEDSI) is one of five regions in the Americas Division of the professional society, the Decision Sciences Institute. This region encompasses the Northeastern United States. NEDSI holds an annual regional meeting each spring that features presentations of original research papers, Ph.D. and new faculty development seminars, a placement service, case writing and other interesting innovations in the fields of accounting, business education, finance, HRM, management, marketing, MIS/DSS/expert systems and IT, organizational behavior, operations management, strategic management, and supply chain management, among others. Awards for “Best Paper” in several categories are given each year.

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NEDSI 2024 Lifetime Service Award

Douglas N. Hales, University of Rhode Island

Professor Doug N. Hales has been a member of the Decision Sciences Institute for 25 years, with almost 20 years at NEDSI. He has served a Track Chair in multiple DSI and NEDSI conferences, as well as positions on the national Awards Committee, Marketing Committee, NEDSI Program Chair, NEDSI President, Board Member and the Advisory Council. His PhD is in Management from Clemson University. He designed and started the Supply Chain Management program at URI in 2005 and has held the positions of Area Coordinator, Associate Dean, and multiple university and college committees. His research interests are in process improvement, port competition, and most recently in digital twinning. He has 40 publications, 100+ presentations, and has taught supply chain management in 12 countries. He has won numerous teaching and research awards at the university and college levels.

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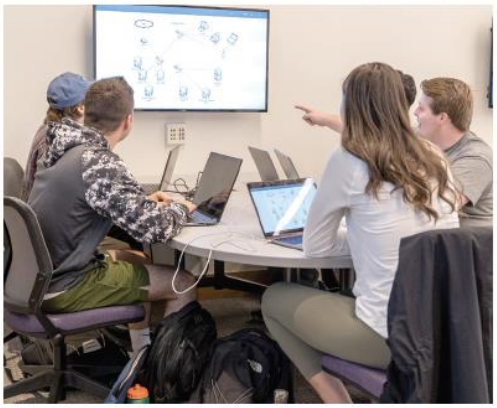

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BEST PAPER AWARDS

Best Application of Theory Award
A Comparative Analysis of ChatGPT, Bard, Snapchat, Hugging, and Perplexity on Unintentional Biases
Cooper Warrington, University of North Georgia
Tamirat Abegaz, University of North Georgia

Best Contribution to Theory Award
AI Alignment Theory
Alexander Pelaez, Hofstra University
Jim Samuel, Rutgers University
Amal Jacobson, Progressive School of Long Island
Elaine Winston, Hofstra University

Bryant University Best Paper Award in Supply Chain Management and Logistics
Distribution Contracts for Digital Content Supply Chains in the Presence of Piracy
Prasenjit Mandal, NEOMA Business School
Abhishek Roy, Temple University

Richard Briotta Best Paper Award in Knowledge Management/Strategy
AI-Enhanced Decision-Making: Integrating IT Best Practices with Expert Insight
Andres Fortino, New York University
Weiyun Zhang, New York University

David M. Levine Best Paper Award in Innovative Education
Introducing Business Analytics Using a Demonstration Model - An Implementation Perspective
Kenneth Sousa
Bryant University

Best Ph.D. Student Paper Award
CT's BIL: Preparing Techs for EV Transition
Saddam Alkhamaiesh, University of Bridgeport

Best Overall Conference Paper Award
Distribution Contracts for Digital Content Supply Chains in the Presence of Piracy
Prasenjit Mandal, NEOMA Business School
Abhishek Roy, Temple University

UNDERGRADUATE/GRADUATE RESEARCH POSTER PARTICIPANTS -2024

UNDERGRADUATE STUDENTS RESEARCH POSTERS

It's All in the Eyes: How Augmented Reality (AR) is Changing Consumer's Behavior
Obyda Al Shayeb
Salve Regina University, Newport, USA

University Spirit Wear Sales: Drivers and Outcomes
Nicholas Conway, Nicholas Cross, Ashton Nicholas Kao, Nicholas Theroux
Boston College, Chestnut Hill, USA

SUSTAINABLE PRACTICES AT THE DINING HALLS IN BRIDGEWATER STATE UNIVERSITY AND HEILBRONN UNIVERSITY
Isabelle Darcy
Bridgewater State University, Bridgewater, USA

INVESTIGATING RELATIVE EFFICIENCY OF SELF-STORAGE FACILITIES USING DATA ENVELOPMENT ANALYSIS (DEA)
Devin Echavarria, Kyle Grund, EunSu Lee
New Jersey City University, Jersey City, USA

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Joceline Guerra, Lina Larrotta
Kean University, Union, USA

COMPARING CONSUMER-ORIENTED AND PRODUCT-ORIENTED MARKETING ACROSS GENERATIONS
Rachel Hennessey
Kean University, Union, USA

CHANGES IN GLOBAL TRADE POLICIES AND THEIR IMPACT ON INTERNATIONAL RELATIONS
Yurim Kim[1,2], Juhyun Lee[1,2], EunSu Lee[1]
[1]New Jersey City University, Jersey City, USA. [2]Inha University, Incheon, Korea, Republic of

The Use of Data Analytics in Social Media for Data-Driven Marketing Strategies
Lina Larrotta, Joceline Guerra
Kean University, Union, USA

A LONGITUDINAL STUDY OF GLOBAL WARMING DISCUSSION ON SOCIAL MEDIA
Suhong Li, Connor Emery
Bryant University, Smithfield, RI, USA

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Western New England University, Springfield, USA

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Robert Morris University, Moon Twp, USA

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Ramapo College of New Jersey, Mahwah, USA

UNDERGRADUATE/GRADUATE RESEARCH POSTER PARTICIPANTS -2024

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Scott Papasodoro
Bridgewater State University, Bridgewater, USA

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Salve Regina University, Newport, USA

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Kean University, Union, USA

Social Robots, Consumers, and UX: A Field Study of a Commercial Social Robot in Education

Camaren Rogers, Nicholas Brown, Anshu Arora, Amit Arora
University of the District of Columbia, District of Columbia, USA

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New Jersey Institute of Technology, Newark, USA

The ARTificial Intelligence of Video Game Design

Devon Tolbert
York College of Pennsylvania, York, USA

Climate Change Impact on the American Northeast Agricultural Supply Chain

Brian Villanueva, John Visich
Bryant University, Smithfield, USA

The Effect of Team Member Personality & Shared Leadership & the Mediation Effect of Team Cohesion

Yuhang Wang, Min-Chen Tsai
Kean University, Union, USA

GRADUATE STUDENTS RESEARCH POSTERS

Blockchain Adoption in Counterfeit-Affected Reverse Supply Chains: An Evolutionary Game Approach

Sahar Ebrahimi Bajgani[1], Davoud Hosseinnezhad[2], Sara Saberi[1], Fuminori Toyasaki[3]
[1]Worcester Polytechnic Institute, Worcester, USA. [2]Univeristy of Limerick, Limeick, Ireland. [3]York University, Toronto, Canada

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EXPLORING ONLINE MBA PROGRAM FEASIBILITY THROUGH STUDENT SURVEYS

Olivia Ball, Kathleen Ferris
Bridgewater State University, Bridgewater, USA

BRIDGING THE ATTENTION SPAN GAP FOR GENERATION Z IN HIGHER EDUCATION

Susan Kumari Basel, Ellen Belitzky
University of New Haven, West Haven, USA

SIMPLIFYING PROFITS WITH PURPOSE: EXPLORING ESG RATINGS AND THEIR RELIABILITY

Suraj Chatakondu, Ellen Belitzky
University of New Haven, West Haven, USA

TECHNOLOGY INTEGRATION OPPORTUNITIES FOR THE ALZHEIMER'S ASSOCIATION

Henrietta Emeka, Ellen Belitzky
University of New Haven, West Haven, USA

UNDERGRADUATE/GRADUATE RESEARCH POSTER PARTICIPANTS -2024

BEYOND CONVENTIONAL TACTICS: TARGETED MARKETING AND CAUSAL INFERENCE MODELS

Sai Goutham Jana, Ellen Belitzky
University of New Haven, West Haven, USA

CONSUMER BEHAVIOUR USING PREDICTIVE ANALYTICS

Prabhjeet Kaur, Ellen Belitzky
University of New Haven, West Haven, USA

VIRTUOUS INTERGRATIVE SOCIAL ROBOTICS (VISR): GOVERNANCE AND HUMAN-ROBOT INTERACTION (HRI)

Arlene Marshall, Amit Arora, Anshu Arora
University of the District of Columbia, Washington, DC, USA

HOW DOES THE INTERNET OF THING AFFECT SUPPLY CHAIN MANAGEMENT

Sabina Ramazanova, EunSu Lee
New Jersey City University, Jersey City, USA

The Effect of ESG disclosure and Diversity on Corporate Performance and Risk

Irena Vodenska, Yunzhu Piao, Ansheng Fan
Boston University, Boston, USA

NEDSI

NORTHEAST DECISION SCIENCES INSTITUTE

Conference Program
Schedule of Presentations

April 4 - 6, 2024

Hyatt Regency
Cambridge, MA

Special Panel Sessions

Deans Panel

Friday, April 5 10:00 am

Location: Central Square
Chair: Jeanean Davis-Street
* Dr. Jeanean Davis-Street (Dean, RCOB, Bridgewater State University)
* Dr. Oya Tukel (Dean, Martin Tuchman School of Management, New Jersey Institute of Technology)
* Dr. Eda Sanchez-Persampieri (Dean, Marcuse School of Graduate Studies, LIM College)
* Dr. Yi Yang (Associate Dean, College of Business, University of Massachusetts at Lowell)
* Dr. Aleksandar Tomic (Associate Dean, Woods College of Advancing Studies, Boston College)

Meet Editors Panel

Friday, April 5 3:00 pm

Location: Central Square
Chair: Joy Field
* Dr. Xenophon Koufteros (Editor-in-Chief of Decision Sciences Journal)
* Dr. Pedro Reyes (Associate Editor for Decision Sciences Journal of Innovative Education)
* Dr. Joy Field (Deputy Editor for Service Science)
* Dr. Arash Azadegan (Associate Editor for Journal of Supply Chain Management)

Keynote Speaker

Friday, April 5 5:00 pm

Location: Amesbury D
Keynote Speaker: Sam Ransbotham
Title: Using AI? Great. But Using AI No Longer Differentiates

Thursday, 4 April

7:30 am **Registration**
Lobby-Courtyard

7:00 am **Continental Breakfast**
Courtyard Foyer-Lobby Level

8:00 am **HEL-1: Application of Analytics to Improve Healthcare Delivery**
Harvard Square B
Chaired by: Arvind Sharma

PZP_HEL101 Using Analytics to Support Customized Training for Time-Dependent Patient Prioritization

»Jaeyoon Hwang [1], John Maleyeff [1], Tianyu Xu [1], Xinran Yu [1](1. Boston University)

The Predictive Factors of Hospital Bankruptcy: A Longitudinal Analysis

»Brad Beauvais[1], Zo Ramamonjiarivelo[1], C. Scott Kruse[1], Ramalingam Shanmugam[1], Arvind Sharma[2], Aleksander Tomic[2], Larry Fulton[2](1. Texas State University, 2. University of Rochester Medical Center)

8:00 am **SCM-6: Literature Review, Framework, and Concept**
Inman Square
Chaired by: Afrooz Moatari-Kazerouni

EAP_SCM601 Challenges And Barriers In Vaccine Supply Chain: A Systematic Literature Review Between 2000 & 2021

»Fatma Pakdil[1](1. Eastern Connecticut State University)

A Comprehensive Framework to Supply Chain Resilience and Sustainability

»Afrooz Moatari-Kazerouni [1], Yvonne Lederer Antonucci [1], John Joseck [1](1. Widener University)

PZP_SCM603 Beyond Robustness: Exploring Supply Chain Fragility And Stability

»Henry Adobor[1] (1. Quinnipiac University)

PZP_SCM604 Comparing Supply Chain Publications In Academic Journals And News Papers During The Pandemic

»Suhong Li[1] (1. Bryant University)

Continued from Thursday, 4 April

8:00 am **DATA-3: Measuring and Improving Service and Efficiency**
Central Square
Chaired by: Jae-Dong Hong

EAP_DATA302 Improving Economics for Data Migration In Healthcare Environments Using Serverless Architecture

»Prashant Duhoon [1], Can Ersoy [1], Neset Hikmet [1](1. University of South Carolina)

PZP_DATA303 Criteria Ranking Using a Two-Step Methodology with Practical Application in City Ranking

»Yasamin Salmani [1], Jin Fang [2], Fariborz Partovi [3](1. Bryant University, 2. Clark University, 3. Drexel University)

9:30 am **Coffee Break**
Courtyard Foyer-Lobby Level

10:00 am **DSS-1: Artificial Intelligence**
Harvard Square B

Chaired by: Jena Jordahl

Sentiment Analysis of Artificial Intelligence Applied in The Hospitality

»Ruilin Wang [1], Yongjia Liu [1] (1. Northeastern University)

PZP_DSS102 AI-Enhanced Decision-Making: Integrating IT Best Practices With Expert Insight

»Andres Fortino [1], Weiyun Zhang [1] (1. New York University)

Incentives for AI-Enabled Knowledge Sharing and Learning

»Shankar Sundaresan[1], Zuopeng Zhang[2] (1. Rutgers University-Camden, 2. University of North Florida)

PZP_DSS104 AI Alignment Theory

»Alexaner Pelaez[1], Jim Samuel[2], Amal Jacobson[3], Elaine Winston[1] (1. Hofstra University, 2. Rutgers University, 3. Progressive School of Long Island)

Curing Generative AI Hallucinations with Data Provenance

»Jena Jordahl[1], Tamara Schwartz[2], John Roney[3], Billy Mag Fhloinn[4], Bhaskar Abbireddy[1], Ashlesha Chaudhari[1] (1. InfiniteIQ, 2. York College of Pennsylvania, 3. Sacred Heart University (USA), 4. Sacred Heart University (Ireland))

10:00 am **AFE-2: International Finance Topics**
Kendall Square
Chaired by: Theologos Homer Bonitsis

Building Absorptive Capacity: Economic Development and Growth in Select Oil-Producing Economies

»Siamack Shojai [1] (1. William Paterson University)

How Extreme Cryptocurrency and Oil Movements Affect Insurance Tokens: A Cross-Quantilogram Study

»Ulrika Lesie Nyamsi Nkouemkeu Shriya Anand [1] (1. New Jersey Institute of Technology)

Continued from Thursday, 4 April

EAP_AFE204 Rethinking Organizational Management and Governance in Engaging IMF

»Ohene Aku Kwapong [1], Robert Yawson [1] (1. Quinnipiac University)

10:00 am **SCM-1: Modeling - I**
Inman Square
Chaired by: Douglas Hales

EAP_SCM101 Digital Twinning In The Age Of Artificial Intelligence For Supply Chain Mgt.

»Douglas Hales [1] (1. The University of Rhode Island)

On the Integrated Production and Distribution Problem with Time Windows

»Hua Zhong [1] (1. SUNY College at Oneonta)

PZP_SCM103 Repair Kit Inventory Policy Creation with Empirical Stochastic Branch-and-Bound

»John Maleyeff [1], Ruthairut Wootisarn[1], Liying Zhang [1], Xueying Wang [1] (1. Boston University)

A Hierarchical Optimization Model for WEEE Circular Plant Operation: Evidence from Copier Recovery

»Zhiqin Ni[1] (1. Xi'an Jiaotong Liverpool University)

10:00 am **OMOR-1: Quality and Strategic Decision Making**
Harvard Square A
Chaired by: S. Bruce Han

Optimizing Marketing Resource Investment Strategies under Distributional Uncertainty

»Sudeep Gubbala [1], Belleh Fontem [1] (1. University of Massachusetts Lowell)

Quantification of International Trade Network Performance under Disruptions in Disasters

»Anna Nagurney[1], Dana Hassani[1], Oleg Nivievskyi[2], Pavlo Martyshev[2] (1. University of Massachusetts Amherst, 2. Kyiv School of Economics)

EAP_OMOR103 Are You Barking Up The Wrong Tree?

»Narendar Sumukadas [1], David Stec [1] (1. University of Hartford)

Data Analysis of A Quality Management Research Survey

»S. Bruce Han [1], Yilong Zheng [1] (1. Merrimack College)

Bad Store Or Bad Inventory? Decoding Multi-Location Retail Performance

»Katherine Ashley [1] (1. Northeastern University)

10:00 am **SUS-1: Green and Sustainable Practices**
Central Square
Chaired by: Salim Eray Celik

Fundraising Appeals: Lessons from Social Marketing

»Francisco Quevedo [1] (1. Rutgers University)

EAP_SUS102 Stochastic Structures of Generations of Renewable Energies in U.S.

Continued from Thursday, 4 April

»Jae Lee [1] (1. State University of New York)

Decarbonizing Lib Production: The Circular Economy Approach to Cobalt Management

»Salim Eray Celik [1], Abdullah Yildizbasi [1], Joseph Sarkis [1] (1. Worcester Polytechnic Institute)

1:00 pm **DSS-2: Decision Support Systems**
Harvard Square B
Chaired by: Salim Emre Kirac

PZP_DSS201 User Profiling and Targeted Advertising: A Study on the Privacy Implications of Machine Learning

»Eric Uwayezu [1], Dan Tenney [1] (1. University of Bridgeport)

Using Fuzzy AHP for Investigating Barriers to the Development of Smart Mobility in Montreal

»Anjali Awakthi [1], Hiva Kosseini [1] (1. CIISE)

Estimating Optimal Tour Length in Irregular Geometric Areas with Fewer Nodes

»Emre Kirac [1], Dmitriy Shaltayev [1], Ian Dors [1] (1. Christopher Newport University)

1:00 pm **AFE-3: Issues in Financial Services**
Kendall Square
Chaired by: Kameleddine Benameur

EAP_AFE301 Pricing Quanto Options on a non-Gaussian Levy Process Model with a Flow Based Generative Network

»Young Shin Kim[1], Hyun-Gyoon Kim[2] (1. Stony Brook University, 2. Ajou University)

A Data Envelopment Analysis Approach to Rank A Set of Mutual Funds and Mutual Fund Companies

»Richard Muszynski III [1] (1. Wilkes University)

Social Media and Sustainability Reporting: Observations from Kuwaiti Listed Companies

»Kameleddine Benameur [1], Ayman Haddad [1], Mohamed Elian [1] (1. American University of Kuwait)

1:00 pm **SCM-2: Policy Implications**
Inman Square
Chaired by: Bhawesh Sah

Analyzing the Factors for Implementation of Air-Taxi Services

»Bhawesh Sah [1] (1. Northeastern University)

Food Price and Transportation Impacted by Diesel Price and Truck-Driver Availability

»Jasmine Chang [1], Jim Shi [1], Fuqin Zhou [1] (1. New Jersey Institute of Technology)

Effects on All The Three Levels of Supply Chain Due to Disruptions Caused by Public Policy Changes

»Kaverinathan Dhanapal [1], Shravya Dharba [1] (1. New Mexico State University)

A Reinforcement Learning Approach to Reduce Operational Costs In A Supply Chain

»Dmitriy Shaltayev [1], Borga Deniz [2], Joona Rahko[3] (1. Christopher Newport University, 2. Framingham State University, 3. Layer AI)

Continued from Thursday, 4 April

1:00 pm **EDU-3: Curriculum and Methods**
Harvard Square A
Chaired by: Faye Zhu

Building An Introductory Analysis Course in The Management Curriculum

»Faye Zhu [1] (1. Rowan University)

PZP_EDU302 Critical Thinking across The Curriculum: Enhancing Rationality by Overcoming Cognitive Biases

»Hershey Friedman [1], Taiwo Amoo [1] (1. Brooklyn College)

Methods for Synchronous Teaching And Interaction in Online Courses

»Bhupinder Sran [1], Moustafa Ahmed [1], John Weber [1] (1. DeVry University)

PZP_EDU304 Application of The Analytic Hierarchy Process Method for The Selection of Master's Degree Timeline

»Jacob Machulcz [1], Arsalan Paleshi [1] (1.York College of Pennsylvania)

1:00 pm **SUS-2: Technological Innovations for Sustainability**
Central Square
Chaired by: Valen Liao

EAP_SUS201 The Exploration of Logistics Green Transformation and Sustainable Development of Enterprises

»Tung-Shan Liao [1], Ming-Qiang He [1] (1. Yuan-Ze University)

Optimizing Microgrid Design with Peak Shaving

»Yang Li[1], Matthew Cristaldi[2], Yuyun Zhong[3] (1. Montclair State University, 2. Grid Discovery, 3. James Madison University)

PZP_SUS204 CT's BIL: Preparing Techs for EV Transition

»Saddam Alkhamaiesh [1] (1.University of Bridgeport)

2:40 pm **Coffee Break**
Courtyard Foyer-Lobby Level

3:00 pm **CYIT-1: AI Application - Privacy, Security, and Trust Concerns**
Harvard Square B

Chaired by: Teray Johnson

PZP_CYIT101 Building Trust in Future Healthcare: The Integration of Large Language Models into Clinical Settings

»Abdullah Aldwean [1], Dan Tenney [1] (1. University of Bridgeport)

PZP_CYIT102 A Comparative Analysis of ChatGPT, Bard, Snapchat, Hugging, And Perplexity on Unintentional Biases

»Cooper Warrington [1], Tamirat Abegaz [1] (1. University of North Georgia)

PZP_CYIT103 Exploring Evasion Attacks & Adversarial Defenses

»Douglas Sausser [1], Tamirat Abegaz [1] (1. University of North Georgia)

The Impact of AI on Healthcare: Security and Privacy Concerns

»Heechang Shin [1] (1.Iona University)

Continued from Thursday, 4 April

3:00 pm **PUB-1: Policies**

Kendall Square

Chaired by: David Biko

Administrative Decision Variation in The State Health Insurance Assistance Program

»David Biko[1,2], Allison Dorneo[1,2], Melissa Garrido[1,2] (1. Boston University, 2. Partnered Evidence-Based Policy Resource Center (Veterans Health Administration))

PZP_PUB!02 Health Equity Consequences of Prescription Drug Monitoring Programs

»David Dreyfus [1], Eunseok Kim [1], Alok Baveja [1] (1. Rutgers University)

Evaluation Of AI Policies in Higher Education

»Ronda Mariani[1], Lijuan Sun[1], Loreen Powell[2], Dina Clark[1] (1. Commonwealth University, 2. Marywood University)

Downsizing Community Colleges: A Data Envelopment Analysis Model

»C. Christopher Lee[1], Joseph Balskus[1], Alison Ramirez Cahuana[1], Finnegan Carey[1], Elias Lux[1], Heechang Shin[2] (1. Central Connecticut State University, 2. Iona University)

PZP_PUB105 Investigating The Impact of Digital Solutions On The Sustainability of Power Utilities

»Basel Wasif[1], Syeda Hina[1], EunSu Lee[2] (1. University of Bradford, 2. New Jersey City University)

3:00 pm **TCH-1: Workshop: Unleashing the Power of AI in Higher Education**

Inman Square

Chaired by: Kathleen Ferris

W_TCH101 Innovative Pedagogy: Unleashing the Power of Artificial Intelligence in Higher Education

»Kathleen Ferris [1] (1. Bridgewater State University)

3:00 pm **EDU-2: Education**

Harvard Square A

Chaired by: Neil Desnoyers

Revisiting "How Business Schools Lost Their Way"

»Neil Desnoyers [1] (1. Saint Joseph's University)

Integrating Skills For Undergraduate Business Students In The Digital Age A Multidisciplinary Review

»Haleh Karimi [1], Amy Fairfield [1], Frank Raymond [1], Alisha Harper [1] (1. Bellarmine University)

A Study on First-year Retention: Evidence from One of the Most Diverse Higher Education Institutions

»Zhixin Kang [1] (1. University of North Carolina at

Pembroke)

PZP_EDU204 Education 4.0: Knowledge, Skills, and Abilities for Supply Chain Entry Level Workers

»John Visich[1], Pedro Reyes[2], Michael Gravier[1], Christopher Roethlein[1] (1. Bryant University, 2. Baylor University)

3:00 pm **SKO-2: Teleworking and Construction Industry**

Central Square

Chaired by: Chin-yen Liu

Navigating Cost Estimation Complexities In The Us Commercial Construction Industry

»Chin-Yen Liu[1], Roger Myrvang[2] (1. Texas A&M University, 2. Blair Remy Architects)

Struggle or Ease in Remote Work? Examining the Influence of Remote Work on Employee Well-being

»Jie Li [1], Tamara Montag-Smit [1], Nabi Ebrahimi [1], Asil Oztekin [1] (1. University of Massachusetts Lowell)

Continued from Thursday, 4 April

The Influence of Commuting Satisfaction and Teleworking Policies on Job Satisfaction and Commitment

»William Hampton-Sosa [1], Holly Chiu [1] (1. City University of New York.

6:00 pm **President's Reception**

Charles View Ballroom - 16th Floor

Friday, 5 April

7:00 am **Registration**

Lobby-Courtyard

7:00 am **Continental Breakfast**

Amesbury D

8:00 am **DSS-3: Machine Learning**

Harvard Square B

Chaired by: Rankaj Sharma

Assessing Waste Management Performance in Korea: Neural Network and Gray Incidence Theory

»Leo Hong[1], Douglas Hales[2], Gawon Yun[3], Kara Liu[2] (1. Millersville University, 2. University of Rhode Island, 3. Missouri State University)

Integrating Bert and Deep Reinforcement Learning for Dynamic Product Attribute Recommendation

»Mojtaba Talaei-Khoei [1], Asil Oztekin [1] (1. University of Massachusetts Lowell)

PZP_DSS303 Retrospective Causal Inference on IHDP Dataset to Evaluate Cognitive Test Score of Premature Infants

»Pankaj Sharma [1], Rashedul Hasan [1], Asil Oztekin [1] (1. University of Massachusetts Lowell)

8:00 am **SCM-3: Emerging and Existing Technologies**

Inman Square

Chaired by: Pedro Reyes

Artificial Intelligence and Machine Learning Impact On Global Supply Chains

»Pedro Reyes[1], John Visich[2], Patrick Jaska[3] (1. Baylor University, Bryant University, University of Mary Hardin-Baylor)

Supply Chain Integration through Supplier Satisfaction: Canada, Mexico, and the United States

»John Visich[1], Pedro Reyes[2], Michael Gravier[1], Christopher Roethlein[1] (1. Bryant University, 2. Baylor University)

Blockchain in The Supply Chain

»Yongjia Liu [1], Ruilin Wang [1] (1. Northeastern University)

Towards Achieving Circularity in Solar PV Supply Chain: A Real Application

»Yagmur Arioz[1,2], Abdullah Yildizbasi[1], ibrahim Yilmaz[2] (1. WPI, 2. AYBU)

The Efficacy of Legal Contracts in The Lock-In Situation of Supply Chain Relationships

»Daniel Prajogo [1], Brian Cooper [1], Ross Donohue [1] (1. Monash University)

8:00 am **OMOR-2: Inventory and Network Optimization**
Harvard Square A
Chaired by: Javad Paknejad

PZP_OMOR201 Increasing Project Efficiencies by Avoiding Crashing

»Johnny Ho [1], Madeline Acton [1], Lise Malherbe [1], Angelica Tabares [1], David Ang [2] (1. Columbus State University, 2. Auburn University at Montgomery)

A Study on Aggregate Service Levels Approximations for A Multi-Item Lot Sizing Problem

»Satyaveer Singh Chauhan [1], Tanvir Sidhu [1] (1. Concordia University)

PZP_OMOR203 An Economic Production Quantity Model With Backorders and Geometrically Decreasing Production Cost

»Javad Paknejad [1], John F. Affisco [1], Amir Gandomi [1] (1. Hofstra University)

Periodic Vehicle Routing Problem with Time Separation Constraints

»Gang Li [1] (1. Bentley University)

Continued from Friday, 5 April

8:00 am **SUS-3: Sustainable Supply Chains: Industry Perspective**
Central Square
Chaired by: Jen-Yi Chen

Co-optition in Sustainability Initiative

»Jen-Yi Chen [1], Moonwon Chung [1], Chien-Hui Wang [2] (1. Cleveland State University, 2. Feng Chia University)

9:30 am **Undergraduate/Masters Research Posters**
Amesbury D
Chaired by: Jennifer Swanson

9:40 am **Coffee Break**
Amesbury D

10:00 am **CYIT-2: Security and Privacy of Health Records**
Harvard Square B
Chaired by: Kamal Wada Ringim Sabo

Exploring Emerging Technologies for Occupational Health and Safety Practices Improvement

»Afrooz Moatari-Kazerouni[1], Aida Haghighi[2], Sylvestre Lefevre[3] (1. Widener University, 2. Toronto Metropolitan University, 3. Centre des études supérieures industrielles (CESI))

PZP_CYIT202 Security And Privacy Mechanisms Of Electronic Health Records - A Delphi Study

»Kamal Wada Ringim Sabo[1], Abirami Radhakrishnan[1], Dessa David[1], Micheal Boland[2], Samuel Ejiaku[1] (1. Morgan State University, 2. Harvard Medical School)

Navigating Privacy Concerns in the Age of Connected Cars

»Zahra Aivazpour [1] (1. California State University)

10:00 am **AFE-5: Business Issues**
Kendall Square
Chaired by: Vasileios Pavlopoulos

MNC Operating Foreign Exchange Exposure: Evidence by Practitioners

»Augustine Arize [1], Giuliana Andreopoulos [2], John Malindretos [2], Alex Panayides [2], Alfred Verrios [2] (1. Texas A&M, 2. William Paterson University)

PZP_AFE502 A Complex Relationship Cost/Quality: The Case Of The Us Health Care System

»Giuliana Andreopoulos [1], John Malindretos [1], Alex Panayides [1], Alfred Verrios [1] (1. William Paterson University)

PZP_AFE503 The Effects of Sports Betting on Casino Gambling and Lottery

»Ege Can[1], Mark Nichols[2], Vasileios Pavlopoulos[1] (1. University of Alabama in Huntsville, 2. University of Nevada)

Continued from Friday, 5 April

10:00 am **SCM-4: Modeling - II**

Inman Square
Chaired by: Abhishek Roy

PZP_SCM401 Distribution Contracts for Digital Content Supply Chains in the Presence of Piracy

»Prasenjit Mandal[1], Abhishek Roy[2] (1. MEOMA Business School, Temple University)

Designing a Renewable Jet Fuel Supply Chain: Leveraging Incentive Policies

»Sajad Ebrahimi [1], Joseph Szmerekovsky [2], Bahareh Golkar [2], Seyed Ali Haji Esmaeili [3] (1. Wagner College, 2. North Dakota State University, 3. Walmart)

EAP_SCM404 The Impact of Non-competitor on Outsourcing Decisions in the Presence of Learning-by-doing Effect

»Min Wang [1], Wenjing Shen [1], Yaqin Sun [2] (1. Drexel University, 2. Lehigh University)

PZP_SCM405 A Real World Application of Transportation Network Optimization in Supply Chain Design

»Ram Misra [1] (1. Montclair State University)

10:00 am **MKT-1: Technology, Innovations, and Consumer Experience**

Harvard Square A
Chaired by: Amit Arora

PZP_MKT102 Similarity-Novelty Metric: An Alternative Algorithm for Efficient Audience Extension

»Sarthak Pattnaik [1], Eugene Pinsky [1] (1. Boston University Metropolitan College)

10:00 am **Deans' Panel**

Central Square
Chaired by: Jeanean Davis-Street
* Dr. Jeanean Davis-Street (Dean RCOB, Bridgewater State University)
* Dr. Oya Tukel (Dean, Martin Tuchman School of Management, New Jersey Institute of Technology)
* Dr. Eda Sanchez-Persampieri (Dean, Marcuse School of Graduate Studies, LIM College)
* Dr. Yi Yang (Associate Dean, College of Business, University of Massachusetts at Lowell)
* Dr. Aleksandar Tomic (Associate Dean, Woods College of Advancing Studies, Boston College)

11:30 am **NEDSI Advisory Board Meeting**

Remington-2nd floor
NEDSI Advisory Board Member Only

Continued from Friday, 5 April

1:00 pm **CYIT-3: Blockchain and Virtual Reality**
Harvard Square B
Chaired by: Feyisetan Dania

Understanding Cryptocurrency Investment: Insights from American Investors

»Yougin Pan [1] (1. Salem State University)

Perspectives on the Evolution of a Transformative and Empowering Metaverse

»Eric Addeo [1] (1. Devry University)

PZP_CYIT303 Blockchain Technology Adoption And Impact On Fintech International Transactions: A Literature Review

»Feyisetan Dania [1], Dan Tenney [1] (1. University of Bridgeport)

1:00 pm **DATA-1: Understanding Behavior and Patterns**
Kendall Square
Chaired by: Eric Stein

Predicting Software Developer Salaries In The United States Using Unconventional Variables

»Akshaj Kabthiyal [1], Julia Costa Severo [1], Joao De Alvarenga Ferreira [1] (1. Clark University)

EAP_DATA102 Face-Off: Facial Recognition Technologies and Paradox in Retail Asset Protection Environments

»Derek Dubois[1], Douglas Hales[1], Mehmet Yalçın[1] ,Muhammad Hasan Ashraf[2] (1. University of Rhode Island, California State University Long Beach)

PZP_DATA103 A Glimpse of Student's Perceptions on Big Data through a Survey

»Jinchang Wang [1] (1. Stockton University)

What's Happening at Prospect Press

»Beth Golub [1] (1. Prospect Press)

How Advanced Information Technologies Are Transforming Agriculture

»Eric Stein [1] (1. Penn State)

1:00 pm **TCH-2: Student-Centric Innovations: AI, Career Readiness, and Personal Branding**
Inman Square
Chaired by: Stephanie Jacobsen

EAP_TCH201 Innovating Teaching With A.I.: A Literature Review And Current Applications In Higher Education

»Katja Schroeder[1], Esther Klein[1] (1. St Francis College)

PZP_TCH202 Information Literacy: ChatGPT, Library or the Internet?

»Anil Aggarwal [1], Cong Zhang [1], Danielle Fowler [1] (1. University of Baltimore)

PZP_TCH203 Improving Students' Career Readiness Through Innovative Course Redesign

»Stephanie Jacobsen[1], Xiangrong Liu[1], Jakari Griffith[1], Peter Steins[1], Yihong Xiao[1], Jeanean Davis Street[1], John Paganelli[1] (1. Bridgewater State University)

PZP_TCH204 Empowering Personal Branding: A Collaborative Journey in Marketing Education

»Kathleen Ferris [1] (1. Bridgewater State University)

1:00 pm **MKT-2: Consumer Behavior Insights: From Perception to Privacy**

Harvard Square A
Chaired by: Dong Yoo

Using Multidimensional Scaling Toward A Prevalence-Severity Theory Of Human Trafficking

»Vernon Murray [1], Sherry Dingman [2] (1. Marist College, 2. Fang Protective Services)

PZP_MKT202 What Matters? The Quantity, Quality, And Valence Of Reviews In New Releases

»Dong Yoo [1], James Roh [2], Joshua Yoo [3] (1. Virginia State University, 2. Rowan University, 3. William & Mary)

Consumer Privacy Expectations And The Impact On Buying Intentions

»Edward Linde II [1], John Cary [1], William Brown [1] (1. Marist College)

2:00 pm **Undergraduate/Masters Research Posters**
Amesbury D
Chaired by: Jennifer Swanson

2:40 pm **Coffee Break**
Amesbury D

3:00 pm **HEL-2: OR Techniques in Healthcare**
Harvard Square B
Chaired by: Dinesh Pai

EAP_HEL201 Optimizing Healthcare Big Data management: Experimental Approaches

»Ehsan Soltanmohammadi [1], Neset Hikmet [1] (1. University of South Carolina)

EAP_HEL202 Using DEA To Measure The Financial And Quality Performance Of Critical Access Hospitals

»Christine Pitocco[1], Herbert Lewis[1], Dinesh Pai[2], Thomas Sexton[1], Maria Muntaha[1], Justin Vij[1], Amanda McMahon[1] (1. Stony Brook University, 2. Pennsylvania State University at Harrisburg)

EAP_HEL203 Scheduling Multi-Job Multi-Machine Multi-Server: A Case of Healthcare Optimization

»Farbod Farhadi[1], Sina Ansari[2], Francisco Jara-Moroni[3] (1. Babson College, 2. DePaul University, 3. University Diego Portales)

EAP_HEL 204 Technology in Healthcare: A Review of Current Practices and Challenges

»Elif Kongar[1], Ellen Belitzky[1], Gazi Duman[1], Jiju Antony[2] (1. University of New Haven, 2. Northumbria University)

3:00 pm **AFE-4: Fintech, ML, & AI Issues**
Kendall Square
Chaired by: Yasamin Salmani

PZP_AFE401 Fintech Adoption Among African Americans: Overcoming Legacy Financial Barriers

»Damon Gray [1], David Gefen [1] (1. Drexel University)

Financial Contagion and Machine Learning: The Forest in the Trees

»Christopher Starkey[1], Georges Tsafack[2], Dara Schniederjans[2] (1. Providence College, 2. University of Rhode Island)

The Network Effect on Tokenization of REITs: Investors Centrality, Liquidity, and Performance.

»Ajim Uddin [1], Yao Sun [1] (1. New Jersey Institute of Technology)

PZP_AFE401 Zero Day Close: The Power Of AI And Machine Learning

»Loreen Powell [1], Dina Clark [2], Lijuan Sun [2], Ronda Mariani [2] (1. Marywood University, 2. Commonwealth University)

3:00 pm **SCM-5: Decision Making**
Inman Square
Chaired by: Shahram Taj

PZP_SCM502 Decision Support Approach for Ranking Response Options in Reaction to Climate Change

»John Maleyeff [1], Hanyi Zheng [1], Yuchen Yao [1], Zhilin Liu [1], David Weidman [1] (1. Boston University)

Design, Digitizing, Executing Lean/Agile Smart Manufacturing Facilities for Global Supply Chain

Continued from Friday, 5 April

»Shahram Taj [1] (1. Florida Polytechnic University)

The Impact of Extreme Weather Event on Firm Market Value

»Lihua Sun [1] (1. University of Electronic Science and Technology of China)

Unintended Consequences of In-Kind Humanitarian Donations: The Problem of Material Convergence

»Peter Imbriale[1], Jeffrey Livingston [2], Euthemia Stavrulaki [2] (1. U.S. Coast Guard Academy, 2. Bentley University)

3:00 pm **EDU-1: Business Analytics**

Harvard Square A
Chaired by: S. Bruce Han

Incorporating the Voice of Customer (VOC) into The Design of A Business Analytics Course

»S. Bruce Han [1], Tahir Hameed [1] (1. Merrimack College)

EAP_EDU102 Maestro Legacy: Artful Learning Application to Business Analytics Instruction

»Ellen Belitzky [1] (1. University of New Haven)

3:00 pm **Editors' Panel**

Central Square
Chaired by: Joy Field

Dr. Xenophon Koufteros (Editor-in-Chief of Decision Sciences Journal)
Dr. Pedro Reyes (Associate Editor for Decision Sciences Journal of Innovative Education)
Dr. Joy Field (Deputy Editor for Service Science)
Dr. Arash Azadegan (Associate Editor for Journal of Supply Chain Management)

5:00 pm **NEDSI 2024 Keynote**

Amesbury D
Presentation by: Sam Ransbotham
Title: Using AI? Great. But Using AI No Longer Differentiates

6:00 pm **Gala Dinner**

Charles View Ballroom - 16th Floor

Saturday, 6 April

7:00 am **Continental Breakfast**

Courtyard Foyer-Lobby Level

7:30 am **NEDSI General Business Meeting**

Inman Square

8:00 am **CYIT-4: Emerging Technologies**

Harvard Square B
Chaired by: Koki Karube

Aquaculture/Seafood Use Case Development for Edge with Cybersecurity and Federated Learning

»Benjamin Branch [1,2,3,4], Jason Porter [1,2], Jarvis Green [2], Michael Sullivan [1,2], Thomas Glenn [1], Neset Hikmet [5], Ubong Udoyen [6,7], Karena Angell [8], Anthony Herr [9], Ben Cushing [10], Ben Cohen [11], David Eberle [12], OpenShift Commons Edge Special Interest Group [13] (1. SEEDS Institute, 2. Green Reef Foundation, 3. OpenShift

Commons, 4. QSBG Network, 5. University of South Carolina, 6. One2Care Healthcare, 7. Yale University, 8. Red Hat, Salt Lake, 9. Red Hat, Prescot, 10. Red Hat, Washington, DC, 11. Red Hat, Boston, 12. Kansas Turpike Authority, 13. Red Hat, Doha)

Continued from Saturday, 6 April

PZP_CYIT402 DX Visualization Of Assembly Task Speed By 3D Coordinate Data Using Motion Capture

»Koki Karube [1], Tetsuo Yamada [1], Masao Sugi [1] (1. The University of Electro-Communications)

Minority Entrepreneurship and Culture: A Text Mining Analysis

»Yuan Xue [1], Subhasish Dasgupta [2] (1. Elizabeth City State University, 2. George Washington University)

8:00 am **AFE-6: Topics in Accounting**

Kendall Square

Chaired by: A.J. Stagliano

AS 3101's Impact on Financial Reporting on Goodwill Impairment

»Nathan Slavin[1], Jianing Fang[2] (1. Hofstra University, Kean University)

EAP_AFE603 Do Extreme Observations Impact Common Financial Ratios? A Longitudinal Examination Of Bond Indices

»A J Stagliano [1] (1. Saint Joseph's University)

8:00 am **TCH-3: Learning Innovations: Engagement Models & Environments**

Inman Square

Chaired by: Kenneth Sousa

PZP_TCH301 Introducing Business Analytics Using A Demonstration Model – An Implementation Perspective

»Kenneth Sousa [1] (1. Bryant University)

The Hunger Chain: A competitive simulation for teaching supply chain management

»Arim Park [1], Yao Zhao [2], Jumyung Song [3] (1. North Carolina A&T State University, 2. Rutgers University, 3. University of Massachusetts Lowell)

PZP_TCH303 Exploring E-Commerce System Effectively with a Cloud-Based Infrastructure

»Zhengzhong Shi [1] (1. University of Massachusetts Dartmouth)

PZP_TCH304 An Alternative Lab Environment for Computer Networks

»Zhengzhong Shi [1] (1. University of Massachusetts Dartmouth)

8:00 am **MKT-3: Innovative Approaches in Strategic Marketing**

Harvard Square A

Chaired by: Pratyush Ambadi

EAP_MKT301 Using Binary DEA To Evaluate The Nutritional Performance Of Food Items

»Herbert Lewis [1], Christine Pitocco [1], Thomas Sexton [1], Shuran Liao [1] (1. Stony Brook University)

Toyota model for Global SMEs

»Uthit Siriwan[1], Michael Ha[2,3], Qian He[4] (1. Charisma University, 2. Beijing Institute of Technology, 3. Universidade de São José, 4. Stockton University)

Continued from Saturday, 6 April

EAP_MKT303 How Uncertainty Impacts Biotechnology Firms' Governance Decisions: A TCE Perspective

»Pratyush Ambadi [1], Xinyue Li [1], Jennifer JooYeon Lee [1] (1. Boston University)

Inventory Disclosure And Donor Behavior

»Euthemia Stavrulaki [1], Peter Imbriale [2], Chirag Surti [3] (1. Bentley University, 2. Coast Guard Academy, 3. Rider University)

8:00 am **SUS-4: Environmental and Social Dimensions of Sustainability**
Central Square
Chaired by: Maling Ebrahimpour

PZP_SUS401 A Longitudinal Study Of Extreme Weather Discussion On Social Media
»James Chen 1, Suhong Li 2 (1. New York University, 2. Bryant University)

PZP_SUS402 Evolution of ESG: Historical Roots, Contemporary Significance, and Future Trajectory
»Maling Ebrahimpour 1 (1. The University of Rhode Island)

PZP_SUS403 Sustainability Across Countries
»Sarthak Pattnaik 1, Kathleen Park 1, Eugene Pinsky 1 (1. Boston University Metropolitan College)

9:30 am **Coffee Break**
Courtyard Foyer - Lobby Level

10:00 am **HEL-3: Technology and Quality in Healthcare**
Harvard Square B
Chaired by: Chamila Dissanayake

Polypharmacy Risk in Working-Age Women: Role of Multimorbidity Patterns & Care Coordination Factors

»Ajit Appari [1], Maria Ukhanova [2] (1. Boston University, 2. University of Texas Health Science Center at Houston)

Exploring The Relationship Between CMS Star Ratings And Patient Satisfaction In Hospitals

»Chamila Dissanayake [1], Dinesh Pai [2] (1. Pennsylvania State University, 2. Pennsylvania State University)

Readmission and Length of Stay of COPD Patients: A Longitudinal Analysis Using HCUP - NRD Data Sets

»Fatma Pakdil[1], Steve Muchiri [1], Nasibeh Azadeh-Fard [2](1. Eastern Connecticut State University, 2. Rochester Institute of Technology)

10:00 am **DATA-2: Exploring and Modeling Finance and Fintech**
Kendall Square
Chaired by: Jayanta Pokharel

The History And Future Horizons Of Reject Inference

»Billie Anderson [1] (1. Southern New Hampshire University)

Analysis of Hong Kong Exchange Rate Dynamics since COVID pandemic: A Comprehensive Study

»Jimin Huang [1], Michael Ha [1,2], Qian He [3] (1. Beijing Institute of Technology, 2. Universidade de São José, 3. Stockton University)

Impact Of Major Financial Factors On Bitcoin Prices At Times Of Uncertainty

»Ahmad Vakil [1] (1. St. John's University)

Modeling Stock Returns With Laplace Family Distributions- A Concise Decision

»Jayanta Pokharel [1], Gokarna Aryal [2], Netra Khanal [3], Chris P. Tsokos [4] (1. Siena College, 2. Purdue University Northwest, 3. The University of Tampa, 4. University of South Florida)

Continued from Saturday, 6 April

10:00 am **LEG-1: Legal, Ethical, and Social Issues in Decision Making**
Inman Square
Chaired by: Soheil Sibdari

Policies For Funding Of Service Providers In Subsidy Welfare Programs

»Gulten Busra Karkili [1], Senay Solak [1] (1. University of Massachusetts Amherst)

The Impact of Government Policies on Aviation and Air Connectivity in Africa

»Soheil Sibdari [1] (1. University of Massachusetts Dartmouth)

Rethinking The Role Of Organizational Justice In Influencing Perceived Performance:

»Feisal Murshed [1], Katrina Savitskie [2], Sandipan Sen [3], Joseph Xu [4] (1. Kutztown University, 2. Savistkie Consulting, 3. Southeast Missouri State, 4. Union University)

10:00 am **EDU-4: Cases and Courses**
Harvard Square A
Chaired by: Hui Zhang

Incorporating Ethics and Professionalism in An Entry-Level PR Course Through Real-Client Engagement

»Hui Zhang [1] (1. Bridgewater State University)

PZP_EDU402 Evaluating Large Language Model Accuracy In Structured Academic Settings: Three Case Studies

»Andres Fortino [1], Zoey Yang [2] (1. New York University, New York, 2. New York University, Syrian Arab Republic)

PZP_EDU404 DraftKings: A Sports Betting Giant Case Study

»Anna Serra [1], Shaoping Zhao [1] (1. Stockton University)

10:00 am **SKO-1: Leadership and Management in the AI Era**
Central Square
Chaired by: Michael Faulkner

PZP_SKO101 The Evolution of the Leader-Manager in the Robotic Era

»Michael Faulkner [1] (1. DeVry University)

EAP_SKO103 Envisioning Responsible Integration Of Generative AI In Academia And Human Resource Development

»Robert M Yawson [1], Alexander M Yawson [2] (1. Quinnipiac University, 2. Heritage Christian University College)

1:00 pm **MIT Museum Visit**
Meet at the Hyatt lobby
MIT Museum, Gambrill Center, 314 Main St, Cambridge, MA 02142

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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, 2024, via the conference website: www.nedsi.decisionsciences.org. If you have proposals for workshops or roundtable discussions, please email to the program co-chairs.

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- Best Application of Theory
- Best Contribution to Theory
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- Best Ph.D. Student Paper Award
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- Supply Chain Management and Logistics
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Papers

Accounting, Finance and Economics

FinTech Adoption Among African Americans: Overcoming Legacy Financial Barriers.

Damon T. Gray, DBA
Drexel University

David Gefen, PhD
Drexel University

ABSTRACT

The historical wealth accumulation challenges of African Americans may find a remedy in FinTech advancements, which capitalize on demand-side economies of scale. This paper investigates the pivotal factors influencing FinTech adoption by African Americans, specifically through the lens of Virtual Bank adoption. Our survey, encompassing a diverse demographic of African American and Caucasian participants, reveals that trust, distrust, self-efficacy, perceived financial costs, and risk-taking behaviors dictate usage patterns. The study finds that identification as African American directly impacts these determinants. The findings have broad implications for understanding and fostering FinTech adoption within minority communities.

Keywords: Technology Adoption, African Americans, Financial Technology, Trust Dynamics, User Distrust

I. Introduction

The persistent financial literacy and racial wealth gap in the United States, notably between African Americans and Whites, poses a critical threat to the nation's economic future. In 2016, the stark contrast in average household wealth—$140,000 for African Americans versus $901,000 for Whites—underlined systemic disparities (Aliprantis & Carroll, 2019). Projections by Asante-Muhammad, Collins, Hoxie, and Nieves (2017) even suggest a trajectory towards negative net worth for African Americans by 2053, underscoring the urgency for effective interventions.

This study posits that FinTech, as a groundbreaking force, has the potential to bridge this divide. It offers a fresh start, free from the legacy banking systems that have traditionally favored the majority population. FinTech's role as a disruptor extends beyond mere financial transactions; it promises transformative business models and service delivery methods that could fundamentally alter the financial landscape for underserved communities (Navaretti, Calzolari, Mansilla-Fernandez, & Pozzolo, 2018).

Our research examines the underlying factors influencing FinTech adoption, drawing on previous ecommerce adoption frameworks. Through a survey of 844 participants, we uncover that while trust, distrust, perceived self-efficacy, and perceived financial costs are critical determinants of FinTech usage across demographics, African American identity significantly heightens trust, lowers distrust, and affects self-efficacy. This paper offers a theoretical advancement by unpacking the nuanced impacts of racial identity on FinTech adoption, emphasizing the strategic importance of managing trust within the African American community to foster technological inclusivity and close the wealth gap.

II. Historical Background

The wealth accumulation challenges for African Americans are deeply rooted in historical political and economic structures. These challenges are a result of systemic racial tensions that have shaped the United States. President

Lyndon Johnson, in the 1960s, recognized the need to address the "inter-locking effects of deprivation" affecting African Americans, an issue highlighted in the Moynihan Report, which aimed to guide public policy to enhance employment and income for this demographic (Geary, 2011, p. 54). The work of Oliver and Shapiro (1995) further investigates the stark disparities in education, wages, employment, and wealth between African Americans and Whites, which stand as prominent indicators of inequality in America.

FinTech emerges as a beacon of hope within the financial services industry, presenting an opportunity to promote both social welfare and financial inclusivity. However, a significant barrier to this advancement is the historically low trust in the financial sector, as demonstrated by the Edelman Trust Index, Table 1. This index not only reflects general consumer sentiment but also underscores the heightened skepticism among African Americans—a skepticism that extends to intra-racial trust dynamics (Fukuyama, 1995).

The challenge for FinTech is not merely technological innovation but the cultivation of trust within communities historically marginalized by the financial system (Faber & Friedline, 2020; Friedline, Oh, Klemm, & Kugiya, 2020). The study at hand investigates this challenge, exploring how FinTech might bridge the trust gap. Notably, African Americans have demonstrated a tendency to place greater trust in FinTech, seeing it as a departure from traditional financial services that have often failed them. This research aims to understand the complex relationship between African Americans and the financial services industry, dissecting the layers of trust and distrust that could influence the adoption of FinTech as a tool for economic empowerment.

Industry	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	10 Year Trend
Technology	77	74	77	74	76	76	75	78	75	68	-9
Healthcare	-	-	-	-	64	67	65	68	67	66	n/a
Food and Beverage	64	64	65	64	65	68	64	69	67	65	1
Telecommunications	59	61	62	60	61	64	64	67	65	61	2
Automotive	63	66	70	67	62	66	63	69	67	60	-3
Consumer Packaged Goods	58	61	62	61	62	64	61	65	62	60	2
Energy	54	58	57	57	59	62	63	65	63	59	5
Entertainment	-	63	66	64	66	65	63	68	65	59	n/a
Financial Services	44	47	49	48	52	55	55	57	56	52	8

Source: https://www.edelman.com/trust/2021-trust-barometer

Distrust Neutral Trust

Range: 2012 to 2021

Table 1. Trust Barometer by Industry - 2012 through 2021

III. Literature Review

The Technology Acceptance Model

Our study builds upon the established Technology Acceptance Model (TAM), which asserts that an individual's intention to use technology is primarily influenced by the perceived usefulness and ease of use of the technology (Davis, 1989; Davis, Bagozzi, & Warshaw, 1989). Trust has been recognized as a critical extension to TAM, emphasizing its significance in IT adoption (Gefen, Karahanna, & Straub, 2003). This research contributes to the existing TAM framework by integrating distrust, perceived self-efficacy, and perceived financial costs as additional antecedents influencing both the behavioral intention (Risk-Taking Behavior) and the actual use of financial technology, with a specific focus on Virtual Banking as an indicative measure of FinTech adoption.

Perceived usefulness (PU) is defined as the belief in the extent to which using a technology would improve job performance (Davis, 1989). This concept has been expanded to consider the broader utility and ease of operation as vital metrics for acceptance or rejection of technology by users (Davis, 1989; Silva, 2015). Within our minority-focused context, we hypothesize that the perceived ease of use will positively impact the perceived usefulness

(H1) and that both constructs will enhance the intent to use Virtual Banks (H2, H3) as noted in (Gefen & Straub, 2004).

Our review of the literature reveals a unique intersection of FinTech adoption and African Americans. Studies indicate a persistent financial literacy and racial wealth gap, exacerbated by a phenomenon known as "digital redlining," which affects minority communities' access to technology (Friedline, Naraharisetti, & Weaver, 2020, p. 517). This disparity is critical as FinTech could serve as an equalizer, particularly for African Americans who have traditionally been underserved by conventional banking systems (Bullock, Toolis, Sencion, & Cadenas, 2020; Faber & Friedline, 2020).

Trust in FinTech, especially among African Americans, is multifaceted, encompassing historical skepticism towards the financial sector. Trust is considered a personal trait by psychologists and an economic choice mechanism by economists, with FinTech adoption potentially shifting these perceptions (Harrison McKnight & Chervany, 2001). Given FinTech's novelty and its departure from traditional banking systems, our study posits that African Americans may display increased trust and reduced distrust towards Virtual Banks (H4, H5, H6, H7, H8).

Conversely, distrust, characterized by emotional responses such as fear or betrayal ((D. H. McKnight & N. L. Chervany, 2001), could inversely affect the willingness to engage with FinTech (H9, H10, H11). Additionally, this study examines the impact of perceived self-efficacy, influenced by personal innovativeness and technology familiarity, on the adoption of Virtual Banking (H12, H13, H14), drawing on Bandura (1982) theories of self-efficacy.

Perceived financial cost is another vital factor influencing FinTech use, particularly among African Americans, many of whom face economic constraints that could limit their engagement with technology-driven financial services (H15, H16, H17) (Florant, Julien, Stewart III, Wright, & Yancy, 2020; Luarn & Lin, 2005).

Lastly, the concept of risk in trying Virtual Banking (BI) encapsulates the user's general willingness to depend on technology despite potential risks (McKnight, Choudhury, & Kacmar, 2002), which is especially pertinent in the context of African Americans' historical mistrust of financial institutions (H18, H19).

In summary, this study not only situates FinTech adoption within the broader discourse on technology acceptance among minority groups but also extends TAM by incorporating trust, distrust, self-efficacy, financial considerations, and financial risk-taking, thus offering a comprehensive view of the determinants influencing African Americans' engagement with FinTech. Figure 1 shows the research model.

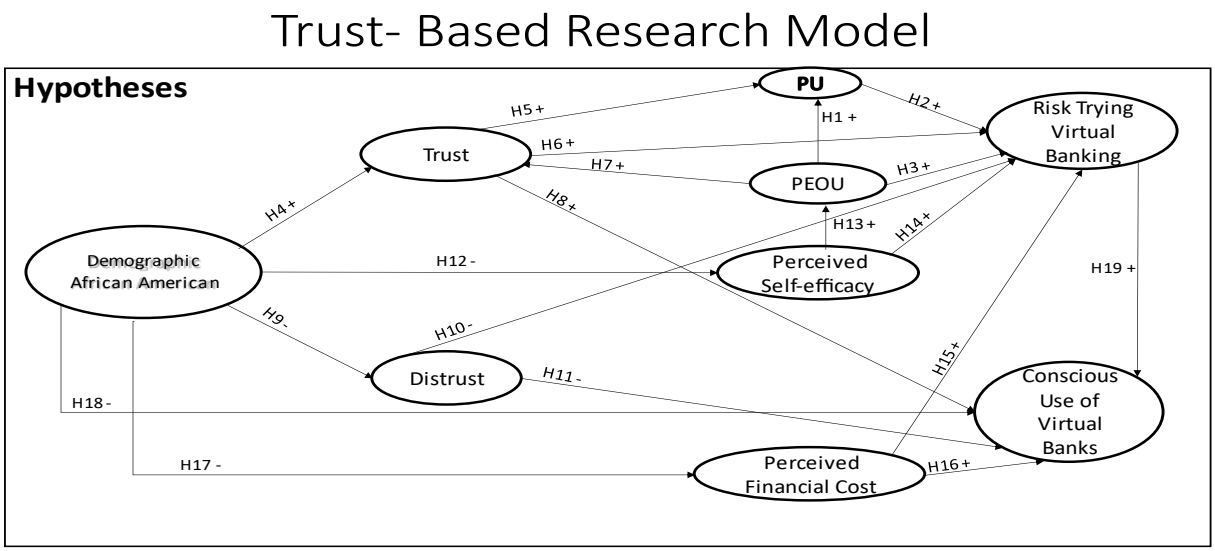

Figure 1. Trust-Based Research Model

IV. Methodology

In our study exploring the factors influencing Virtual Bank adoption among African Americans, our methodology was designed to test a central hypothesis: that African Americans, relative to Caucasian/White individuals, demonstrate a higher degree of trust and a lower level of distrust in e-commerce adoption. To test this hypothesis, we utilized an online survey, incorporating scales that have been previously established in the literature to ensure the validity and reliability of our findings.

Our survey methodology adhered to a two-stage process as outlined by Šiška (2017). The first stage focused on the reliability and validity of the measurement model. This involved an examination of the descriptive statistics for each construct in our study, aiming to assess both reliability and validity among the measurement items. The constructs within our survey were measured using a seven-point Likert scale. This scale choice allowed us to accurately gauge the intensity of respondents' attitudes. The mean and standard deviation for each construct were employed as indicators of the participants' overall responses to the survey items. The results showed that the mean scores were predominantly greater than 3.0, or in some cases, very close to this mark, reflecting an overall positive response rate, as detailed in Table 2.

Construct	Mean	Standard Deviation
Familiarity (FAM)	2.79	1.63
Trust (TR)	2.92	1.44
Distrust (DT)	2.93	1.47
Perceived Usefulness (PU)	2.85	1.45
Perceived Ease of Use (PEOU)	2.89	1.48
Perceived Self-Efficacy (PselfE)	3.83	1.77
Perceived Financial Costs (PCOST)	3.10	1.66
Behavioral Intent (TIGive)	3.41	1.77
Use (TIDBus)	3.55	1.66

Table 2. Descriptive Statistics

Table 3. illustrate the relationships between the nine constructs in our model, where we applied Principal Component Analysis (PCA) as a variable reduction technique. As described by Abdi and Williams (2010), this statistical technique analyzes datasets with multiple, interdependent quantitative dependent variables. The objective being to extract key information from the data by creating a set of new, uncorrelated variables called principal components. These components allow us to visually represent the similarities and differences between observations and variables, providing valuable insights into the underlying structure of our model.

	TR	PU	DT	TIDBUS	TIGIVE	PSELFE	PEOU	PCOST
Trust_1	**0.66989**	0.26438	0.02355	0.21297	0.20074	0.15572	0.32232	0.06415
Trust_2	**0.76152**	0.26123	-0.01428	0.1694	0.22073	0.19366	0.17085	-0.01705
Trust_3	**0.74669**	0.22902	0.03168	0.15308	0.18733	0.24276	0.02682	0.05086
Trust_4	**0.73762**	0.29825	-0.03775	0.22604	0.23734	0.16405	0.06334	0.04416
Trust_5	**0.71353**	0.21814	-0.03031	0.15156	0.22621	0.07395	0.13348	0.07968
Trust_6	**0.69407**	0.3308	-0.00551	0.20425	0.20044	0.13652	0.20749	0.075
Distrust_1	0.06898	-0.04463	**0.80515**	0.05429	0.02933	0.03597	0.20609	0.236
Distrust_2	0.0361	0.05077	**0.84748**	0.04608	0.01038	0.03897	0.00887	0.11617
Distrust_3	0.01251	-0.00766	**0.88001**	0.00369	0.03387	0.01151	0.04247	0.1831
Distrust_4	0.01694	-0.00514	**0.86227**	0.05055	0.00302	0.04799	0.06928	0.16115
PU_1	0.32251	**0.63408**	0.02059	0.1483	0.18037	0.11793	0.35806	0.05648
PU_2	0.32913	**0.68088**	-0.00566	0.20741	0.21313	0.18329	0.20738	0.04852
PU_3	0.3259	**0.72562**	-0.00565	0.22468	0.19305	0.2249	0.10729	0.0826
PU_4	0.30822	**0.75742**	-0.00634	0.17588	0.2328	0.20721	0.09515	0.01777
PU_5	0.33367	**0.72517**	0.00687	0.1642	0.21303	0.19724	0.09574	-0.02106
PEOU_1	0.28337	0.25433	0.0637	0.12735	0.18656	0.12451	**0.753**	0.07559
PEOU_2	0.3561	0.38299	0.00115	0.13947	0.22695	0.30602	**0.50501**	-0.13887
PEOU_3	0.31755	0.35551	-0.01815	0.09117	0.34981	0.31463	**0.43665**	-0.04997
PEOU_5	0.34565	0.30406	-0.00308	0.09797	0.3065	0.33996	**0.36985**	-0.09479
PselfE_1	0.23163	0.28364	0.04345	0.17297	0.17922	**0.6149**	0.3662	0.10396
PselfE_2	0.25161	0.22857	0.04107	0.19326	0.1233	**0.73886**	0.10585	0.18442
PselfE_3	0.22383	0.23322	0.05712	0.1523	0.19188	**0.77275**	0.05431	**0.06272**
Pcost_1	0.04092	-0.03937	0.46522	0.17417	0.02733	0.03515	0.09552	**0.70933**
Pcost_3	0.04777	0.10713	0.33708	0.1537	0.07644	0.08618	0.03462	**0.74825**
Pcost_4	0.09385	0.00302	0.43145	0.11564	0.034	0.15305	0.02684	**0.68744**
TIGive_1	0.30466	0.20255	-0.03618	0.22543	**0.69253**	0.17782	0.25373	0.03489
TIGive_2	0.29957	0.18161	-0.01961	0.33266	**0.73347**	0.13981	0.12548	0.07113
TIGive_3	0.28503	0.30639	-0.02958	0.21962	**0.74834**	0.13507	0.1166	0.0249
TIGive_4	0.28399	0.24944	0.00094	0.26292	**0.74053**	0.14997	0.07477	0.01698
TIDBus_1	0.15579	0.17523	0.07406	**0.79622**	0.11811	0.07562	0.16804	0.26416
TIDBus_2	0.2646	0.23554	0.01254	**0.72958**	0.26425	0.13977	0.0997	0.03433
TIDBus_3	0.2692	0.21667	0.07449	**0.74918**	0.28167	0.09107	0.0538	0.08298
TIDBus_4	0.17055	0.10391	0.111	**0.78218**	0.21691	0.21561	0.01132	0.09627

Table 3. PCA Factor Rotations

Data Analysis

Reliability Measures

Part of our analysis was the evaluation of the PCA model's quality, which was conducted using cross-validation methods, “specifically the bootstrap and jackknife techniques”, as highlighted by Abdi & Williams (2010, p. 433).

The second stage of our methodology progressed into structural model estimation, aligning with the process described by Teo et al. (2008). This phase entailed an analysis of the proposed model by assessing the contributions and statistical significance of the manifest variables' path coefficients (Gefen, Straub, & Boudreau, 2000). This two-stage Structural Equation Modeling (SEM) analysis, encompassing both the measurement model's reliability and validity assessment and the structural model estimation, provided a comprehensive framework for our study. This approach ensured that our findings were not only statistically significant but also practically relevant. It offered a deeper understanding of the nuances in the adoption of Virtual Banking services among African Americans.

To further enhance the study's reliability, we calculated Cronbach's Alpha for each construct. All items demonstrated reliability coefficients above the recommended threshold of 0.80, as advocated by Gefen & Straub (2000), ensuring strong internal consistency within our measures. Additionally, to maintain the clarity and precision of our results, items exhibiting cross-loadings were excluded from the analysis, a decision documented in Table 4.

Construct	**Number of Items**	**Cronbach's Alphas**	**AVE**
Trust (TR)	6	0.92	0.67
Distrust (DT)	4	0.89	0.68
Perceived Usefulness (PU)	5	0.93	0.55
Perceived Ease of Use (PEOU)	4	0.90	0.59
Perceived Self-Efficacy (PselfE)	3	0.85	0.62
Perceived Financial Costs (PCOST)	3	0.82	0.59
Behavioral Intent (TIGive)	4	0.91	0.72
Use (TIDBus)	4	0.89	0.68

Table 4. Construct Reliability and Average Variance Extracted

BI	0.886								
COST	0.325	0.854							
Distrust	0.145	0.568	0.793						
EFF	0.512	0.283	0.14	0.864					
FAM	0.481	0.138	0.079	0.516	0.887				
PEOU	0.505	0.11	0.06	0.644	0.682	0.837			
PU	0.576	0.163	0.072	0.653	0.646	0.738	0.866		
Trust	0.597	0.186	0.06	0.623	0.666	0.719	0.758	0.852	
Use	0.661	0.154	0.038	0.572	0.59	0.663	0.672	0.7	0.889

Table 5. Inter-construct Correlation Matrix

Discriminant Validity

We further assessed discriminant validity by examining the Average Variance Extracted (AVE) for each construct. The AVE statistical measure ensures that the items linked with a construct correlate more strongly to it than to other constructs, thus confirming that our constructs are distinct from one another. The relationships between the constructs were summarized in Table 4, with the diagonal showing the square root of the AVE and off-diagonal elements representing the correlations between constructs.

The congruence of the proposed model with the observed data was substantiated by several robust fit indices. Specifically, the Chi-square to degrees of freedom ratio $X^2/df\ was$ calculated to be 2.88, indicating an acceptable model fit. The Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) were 0.95 and 0.94, respectively, both exceeding the generally accepted threshold for a good fit. Furthermore, the Standardized Root Mean Square Residual (SRMR) stood at 0.04, and the Root Mean Square Error of Approximation (RMSEA) was computed as 0.95, collectively suggesting an adequate representation of the model to the observed data (Gefen et al., 2000). Table 6.

Fit Index X^2	Recommended Fit n.s at p < .05	Bootstrapped Model 20,000 Iterations
X^2/df	< 5	2.88
CFI	>0.90	0.95
TLI	>0.90	0.94
SRMR	<.05	0.04
RMSEA	<=0.05	0.95

Table 6. Model Fit Indices

Results

Hypotheses testing results revealed several significant findings with strong implications for adoption of Virtual Banks among African Americans.

Perceived Ease of Use (PEOU) demonstrated a strong positive association with Perceived Usefulness (PU) (β = 0.604), indicating that users found easier-to-use Virtual Banks to be more valuable. Both PEOU and PU significantly influenced the intention to use Virtual Banks (β = 0.191 and 0.329, respectively), highlighting the role of perceived value and ease of use in driving e-commerce adoption.

African American participants exhibited a higher level of trust in Virtual Banks (β = 0.162), and this trust significantly influenced both perceived usefulness (β = 0.369) and perceived ease of use (β = 0.802). Furthermore, trust positively impacted behavioral intention (β = 0.425) and actual use of Virtual Banks (β = 0.269). These findings suggest that building trust is important for increasing Virtual Bank adoption among African Americans. Contrary to expectations, the negative impact of distrust on intention to use and actual use was not supported. This unexpected result warrants further investigation to understand potential moderating factors.

A lack of prior experience with Virtual Banks negatively impacted African Americans perceived self-efficacy (β = -0.141), highlighting the importance of providing educational resources and building confidence in potential users

identifying as African American. However, perceived self-efficacy positively affected perceived ease of use (β = 1.075), emphasizing its role in overcoming perceived barriers to adoption.

Perceived financial costs negatively impacted African Americans' use of Virtual Banks (β = -0.444), indicating a potential barrier to adoption. Interestingly, however, this variable also positively impacted actual usage (β = 0.302), suggesting a complex relationship between cost perception and behavior. Further exploration is needed to understand this unexpected finding.

African Americans exhibited lower willingness to risk trying Virtual Banking services (β = 0.302), yet this risk-taking behavior positively influenced actual use (β = 0.588). This contradictory result suggests that initial hesitation may be overcome by positive experiences with Virtual Banks, leading to increased adoption.

Overall, these findings provide valuable insights into the factors influencing African Americans' adoption of Virtual Banks. Trust, perceived value, ease of use, and self-efficacy emerge as key drivers, while financial costs and risk aversion present potential barriers. The complex interplay of these factors highlights the need for targeted strategies to address specific concerns and build trust among African American communities.

These results support the conclusion that trust, and perceived ease of use are strong predictors of FinTech adoption among African Americans, with perceived financial costs also playing a significant role. The lack of support for some hypotheses suggests that the relationship between distrust, perceived self-efficacy, and FinTech adoption may be more complex than initially thought, warranting further investigation. These findings are visually summarized in Figure 2, providing an accessible representation of the supported and unsupported pathways in our model.

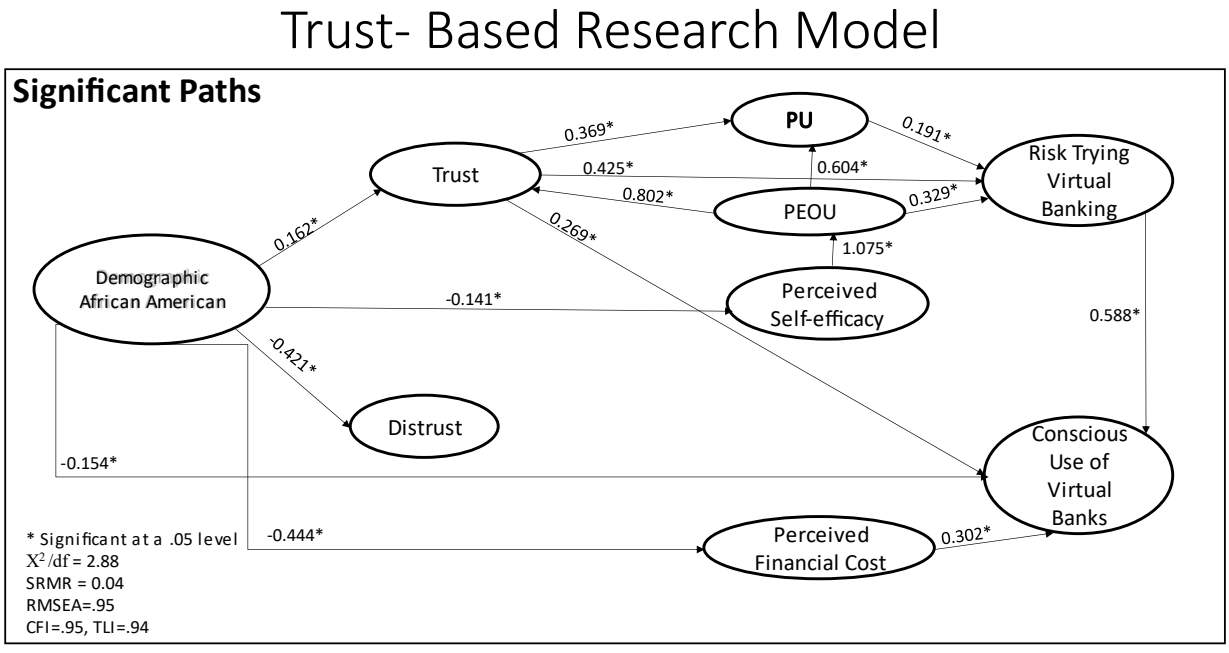

Figure 2. Trust-Based Research Model- Significant Paths

Discussion

This study extends the Technology Acceptance Model (TAM) to explore the unique factors influencing Virtual Bank adoption among African Americans. It unveils a nuanced portrait of trust and distrust within this demographic, challenging the established notions of e-commerce adoption (Corbie-Smith, Thomas, & George, 2002; McKnight & Choudhury, 2006). The study's findings suggest increased trust by African Americans in new FinTech solutions. This reflects a possible shift from the historical mistrust in traditional banking systems and indicates a potential paradigm shift in financial technology adoption.

The extended TAM used here incorporates not only the classical elements of perceived usefulness and ease of use but also examines psychometric variables such as affordability and risk willingness associated with FinTech. These additions offer a deeper understanding of the barriers and facilitators to FinTech adoption beyond the conventional TAM framework. The results demonstrate that African Americans, despite historical financial exclusion, are more inclined to trust Virtual Banks. This is significant, suggesting that FinTech may not be subject to the same historical biases as traditional banking (Cunningham, Nguyen, Kientz, & Rosner, 2022; Haupert, 2022).

However, the study also uncovers a complex interplay between distrust and FinTech use. While African Americans showed more trust, the presence of distrust did not significantly deter their intention to use Virtual Banks, a finding that contradicts some of the existing assumptions about the negative impact of distrust on technology adoption (Benamati, Serva, & Fuller, 2006; Corbie-Smith et al., 2002; D. H. McKnight & N. Chervany, 2001; McNeish, 2015). This could imply that while distrust is present, the benefits and opportunities provided by FinTech might outweigh the skepticism among African Americans.

From a theoretical perspective, these findings suggest that the classic TAM can be enriched by considering cultural and socio-economic factors that influence technology adoption decisions. The implications for practice are equally profound. FinTech companies should note that trust is a critical factor in adoption, but it is not as simple as the absence of distrust. For successful engagement with African American communities, FinTech offerings must be positioned as both accessible and advantageous, directly addressing the historical and present-day barriers to financial inclusion as documented in (Bartlett, Morse, Stanton, & Wallace, 2018).

Moreover, the findings indicate that affordability and self-efficacy are essential considerations for FinTech adoption. Virtual Banks and other FinTech services must ensure that they are not only financially accessible but also provide the necessary support to foster confidence in potential African American users who may lack prior experience with such technologies.

Future Research Considerations

Our research revealed unexpected findings that require further investigation. We could explore the counterintuitive positive impact of perceived financial costs and risk-taking behavior on virtual bank adoption. Additionally, we should explore potential moderating factors like age, income level, and financial literacy. To understand the long-term effects of trust-building initiatives, we propose conducting longitudinal studies. This will allow us to track changes in trust and its impact on actual Virtual Bank adoption by African Americans over time.

Furthermore, it is worthwhile to investigate the role of community-based organizations and trusted influencers in promoting Virtual Bank adoption among African Americans. We can then leverage their influence and social networks to address specific community needs. This is an important consideration given that African Americans are a challenging group to survey, a point not lost on me as an identifying African American seeking to maximize

his chances to reverse a negative trend that undermines society in general and African Americans in particular (Barrett, Ingraham, Hawkins, & Moorman, 2017; Royal, 2019).

Understanding the impact of cultural factors and social norms on Virtual Bank adoption is essential for designing culturally sensitive marketing campaigns and educational resources. This will significantly increase Virtual Bank adoption among diverse cultural groups. Considering the fluid nature of trust, consumer behavior, and technological adoption, we need to employ more dynamic models. These models will provide more nuanced insights and inform effective strategies for promoting Virtual Bank adoption. To ensure equitable access to financial tools and resources, we should also explore ways to tailor FinTech products and services to better serve the needs of African American communities. This includes addressing cultural competence issues and reducing systemic biases.

Finally, we must investigate the role of education in FinTech adoption. By examining effective strategies to equip communities with the knowledge and skills needed for financial empowerment, we can develop culturally relevant educational resources and programs tailored to diverse levels of financial literacy. By addressing these research priorities, we can develop effective strategies to promote financial inclusion and empower communities through Virtual Bank adoption.

Limitations

This study acknowledges the limitations inherent in using a linear regression model to represent complex financial behaviors. The simplification of multifaceted constructs may not fully capture the dynamism of trust, distrust, perceived self-efficacy, perceived financial costs, and risk-taking behavior on actual use of FinTech by African Americans. The generalizability of findings is restricted to the current data and may not hold true in different contexts or as industry dynamics evolve. Additionally, the model may not fully account for the interdependencies between variables or the influence of external factors. The study offers important insights into the factors influencing Virtual Bank adoption among African Americans. Future research should build on these findings and examine the complexities of FinTech adoption within diverse communities.

Conclusion

This study highlights the potential of FinTech to address historical disparities in financial services for African Americans. The findings suggest that FinTech can be a "clean slate," unburdened by the legacy of traditional banking systems. However, proactive measures are necessary to ensure that FinTech does not exacerbate existing financial inequalities. By considering the nuances of trust, self-efficacy, affordability, and risk-taking, FinTech companies can develop products and services that promote financial inclusion and empower communities. Future research should continue to explore the potential and challenges of FinTech for diverse populations, ultimately contributing to a more equitable and inclusive financial system.

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Zero Day Close: The Power of AI and Machine Learning

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Abstract

The month-end, quarterly, and yearly financial closing continues to be challenging, time-consuming, error-prone, and stressful for many accountants. Meanwhile numerous practitioner research studies advocate and explore for the use of technology tools to streamline financial closes. However, there is a notable gap in academic literature specifically addressing the exploration of newer advanced technologies like using artificial intelligence (AI) and machine learning (ML) to achieve a zero-day close. This paper aims to contribute to academic literature by exploring the potential of achieving a zero-day close through the utilization of artificial intelligence and machine learning. Examples of the use of AI and ML within software are provided. This paper has practical implications for educators within the accounting and management information systems fields.

Keywords: *accounting, zero-day close, artificial intelligence, and machine learning*

Introduction

The culmination of the month-end, quarterly, and yearly reporting constitutes a fundamental facet of the financial reporting framework for accounting professionals (Marinis, 2023). Irrespective of the scale or sector in which an organization operates, the monthly, quarterly, and year-end closings can be time-consuming, intricate, and susceptible to human error processes for accountants (Martinis, 2023; Johnson, 2023). Consequently, a considerable number of accountants frequently experience heightened stress and a sense of being overwhelmed in the course of their duties. Moreover, the comparatively lower wage in the accounting field, when compared with other professions, further exacerbates the prevalent sentiment

of burnout among accountants *(Alberti, 2023; Vozza, 2022).* As a result, researchers have examined ways to improve the time-consuming month-end closing (Zarowin, 1997; KPMG, 2004) or how to help accountants cope with month-end stress (Rodrigues et al., 2023).

Rodrigues et al. (2023) extensively reviewed 103 articles regarding accounting-related stress. They found that addressing four key factors which include fostering high work engagement, enhancing self-efficacy perception in decision-making, mitigating adverse consequences in the management process, and addressing elevated stress levels inherent in an individual's personality—can be instrumental in aiding accountants to cope with stress effectively.

While Rodrigues et al. (2023) focused on ways to cope with stress, Lawrence (2023) examined the possibility of automating the process of month-end close via the help of AL and ML technologies. Specifically, he explained how companies experimented with AI and ML algorithms to extract and categorize financial data regarding repetitive bookkeeping tasks, such as transaction processing, billing, and cash flow. AI and ML algorithms achieved almost perfect billing accuracy and cash flow. As a result, the percentage of manual journal entries from anomalies was meager, aiding in almost eliminating time-consuming, intricate, and susceptible to human error processes. A current review of the academic library databases and other scholarly research journals revealed a lack of academic research on the current the financial close process (Deshmukh & Holzmeier, 2023), let alone research on the use of AI and ML technologies to aid in a zero-day close. Thus, there is a need to explore the and report upon the existing literature occurring within the industry regarding an accounting zero-day close utilizing artificial Intelligence (AI) and machine learning (ML) technologies. The goal of this paper is to add to the limited academic and scholarly works to aid academic educators better prepare students expectations regarding future accounting environment and employment opportunities. The remainder of this paper is as follows: a brief literature review and a conclusion with future research areas.

Brief Review of Literature

For years accountants have searched for ways to aid in streamlining the month end process (Farr, 2018). A recent research study by Deshmukh and Holzmeier (2023) investigated the factors influencing prompt financial closing. A survey was administered to 55 German organizations regarding the challenges (accounting, technological, organizational, and peripheral) and strengths (accounting and technology) related to the duration for the annual close. Their findings revealed that the mean score regarding the number days for an annual close is 22.65 days with Minimum of 2.5 days and a maximum 60.5 days. They also found that an organization's technological capabilities (technology challenges and technology strengths) of the organization played the most significant role in determining the duration of the financial close process. Specifically, approximately 90.9% of the respondents perceived a robust consolidation system designed for integrated financial consolidation as moderately to very highly effective. Additionally, 85.4% of the respondents perceived a one enterprise resource planning (ERP) approach as moderately to very highly effective. Finally, 65.5% perceived new media tools like artificial intelligence (AI) and machine learning (ML) as moderately to very highly effective. They argue that AI and ML may not be widely used now.

However, the use of AI and/or ML for accounting purposes is not a new concept as accounting software companies have previously used AI and ML algorithms to enhance their systems within the stock market area (Cao, 2023; Leippold et al, 2022). Additionally, AI and ML technologies have been found embedded into popular accounting software. For example, in 2018, the cloud-based version of QuickBooks Online Advanced released an updated version of its software, which used ML to analyze data from 3.4 million QuickBooks customers to offer insights and patterns to its users (Needle, 2018).

QuickBooks is not the only accounting software company using AI and ML. TurboTax is also actively crafting its own proprietary generative AI language model explicitly designed for financial management. The training process utilizes extensive data accumulated over years of interactions with the company's corporate customers (Loten, 2023). Furthermore, Su (2018) explained that AI and ML are becoming a permanent part of popular accounting software systems like OneUP, SageOne, and Xero. These software systems use AI and ML to automate bookkeeping services such as data entry and account reconciliations.

Moreover, Su (2018) examined the automation capabilities of OneUp, QuickBooks Online, SageOne, and Xero over five months using an Accounting Automation Index (AAI), which assessed the accuracy of their AI engines in automatically recognizing transactions and generating correct accounting entries without user intervention. Results revealed that OneUp produced the highest effectiveness with an automation index rate of 95%, QuickBooks Online at 77%, Xero at 38%, and SageOne at 30%. Thus, she concluded that AI and ML algorithms' accuracy needs further improvement to get to full automation or a zero-day close.

An accounting zero-day close implies the immediate closing of financial books at the end of a reporting period or in real-time. A zero day close using AI and ML technologies can offer several benefits for organizations such as rea-time decision making, improved accuracy and reliability of financial data reporting which enhances an organization’s financial transparency, compliance, operational efficiency, and cash flow management. As a result, an organization may gain a competitive advantage and increase investor/stakeholder confidence within their organization.

Lawrence (2022) explained that the emphasis on the zero-day close process is not necessarily on speed; instead, it serves the overarching objective of creating an uninterrupted feedback loop. This loop aims to give all stakeholders insights and a comprehensive, real-time overview of an organization's health.

Conclusion

As indicated above through examples of practitioner studies and software tools, the future of a zero-day close is just around the corner. Hence, the stress of month-end, quarterly, and yearly closing is diminishing with the power of AI and ML technologies. Moreover, one can expect future research to begin around whether or not the disclosure of using AI and ML technologies for financial closing will influence investment decisions.

This paper added to the lack of academic literature within the financial closing area surrounding the use of AI and ML technologies. While this study is limited to just being literature based, it has practical implications for academic educators within the accounting and management information systems fields.

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MNC Operating Foreign Exchange Exposure: Evidence by Practitioners

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Abstract

We present the findings of how finance responsible practitioners hedge operating foreign exchange exposure

A Complex Relationship Cost/quality: The Case of the Us Health Care System

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Abstract

The US has the most expensive health care system among the developed countries, however, the higher prices that its citizens pay do not seem associated with a better quality. The scope of this paper is to analyze this complex relation price/quality and recall some important historical events to understand its fragmented system as well as the prohibitive prices of its doctors

Papers

Big Data and Business Analytics

A Glimpse of Student's Perceptions on Big Data through a Survey

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ABSTRACT

Big Data refers to a bunch of techniques to process a colossal amount of data. Big Data can reveal useful information embedded in clutters of data of various types. It can convert the trivial to the significant, and the meaningless to the useful. Big Data has wide applications and undergoes a stunning development in the past decade. On the other hand, Dig Data increasingly inflicts concerns and anxiety about privacy, personal security, and even national security. This article reports on a survey on college students, which gives a glimpse of perceptions of students on Big Data. The survey results show students' accurate perceptions, as well as misconceptions. Students are concerned about the breach of individual privacy by Big Data. Some mixed up data collection and data usage in the role of the threat. Many perceive keenly that an authoritarian regime is less restrained to abuse Big Data than a democratic counterpart, and the threats of Big Data on American people come from both inside and outside. Particularly, a social app of despotic regime could be not only a threat to the privacy at present but also a potential threat of national security.

Key Words: Big Data, Information System, Data Security.

"*Big Data*" refers to a bunch of techniques for processing immense bulk of data to extract the embedded information. Input of Big Data process is massive "raw data", unstructured, insignificant, trivial, and unwieldy, such as numbers, texts, images, audios, and videos. Raw data is collected from various sources such as internet of things (IoT), mobile phones, cameras, emails, records of Internet surfing, publications, social media, and personal computers. Raw data is processed with techniques of categorization, sorting, analysis, synthesis, regression, statistics, and deep learning. Output of Big Data is information embedded in the raw data, meaningful and significant. Big Data is a technique that turns massive trivial and meaningless data into significant and useful information, or "*data intelligence*" as it is called.

Big Data is viewed as a field of *artificial intelligence (AI)*. *Traditional AI* started in 1950s with its aim at equipping computers with human intelligence. Its goal is to make computers capable of whatever humans are capable of. In the 21st century, Big Data has emerged as a new direction of AI, "*data-driven AI*", which aims at retrieving "data intelligence" from a huge set of data through deep learning and statistics [9]. Compared to traditional AI which pursues human intelligence on a computer, data-driven AI, as Big Data, "digs out" the embedded data intelligence implied in a colossal mass of data [10].

The world is entering an era of data.[4] Big Data has applications in business operations, finance, marketing, communication, production, supply chain, education, military, and national security. It is useful in market research, business analytics, target marketing, security, solving criminal cases, counterterrorism, etc. However, Big Data is a double-edged sword. People have been increasingly concerned about its threats to personal privacy, personal security, and liberty. The threats are becoming manifest particularly in authoritarian nations where Big Data is already used as tools of surveillance of political dissidents and suppression of democracy.

A survey about Big Data was carried out in our university. The purpose of this 17-question survey is to have a glimpse of college students' perceptions on Big Data, its applications, development, threats, and future.

This survey was conducted in classes "Intelligence machine and human beings", which is a general study course. Students in this course were undergraduates from various majors. The survey was dispensed in three consecutive semesters in 2023. 84 students participated in the survey. We take it as a pilot study and do not intend to draw statistical conclusions at this early stage. The survey was run at the beginning of the class, to assure that the knowledge of those students about Big Data comes from anywhere but this course. Therefore, these students can be viewed as a sample of ordinary college undergraduate students.

Next, we look at students' answers to the 17 survey questions, which are clustered in six categories as below. For each category, we make our comments and analysis after reporting the students' responses.

1. Power of Big Data on personal information

Question 1 and 2 are about "potential power" of Big Data in figuring out "private" personal information from the daily activities in public and online.

For Question 1, 94.0% of respondents in the survey agree that "the patterns of a person's characters and lifestyle are shown in the data of his/her daily life such as surfing Internet, phone calls, Twitters message, and shopping."

For Questions 2, 85.7% believe that Big Data techniques can figure out a person's occupation, income, religion, sexual orientation, consumption pattern, temperament, hobby, habits, libido, political standing, and moral value from a database containing data of years about his/her daily activities on Internet, Twitter, Facebook, telephone, shopping, TV watching, book reading, social event attending, etc.

Indeed, Big Data can figure out sensible information from a large amount of trivial data. Staying alone, a piece of trivial data would remain trivial. However, a bunch of trivial data together may reveal untrivial "patterns". The patterns may be "figured out" by integrative analysis. For example, data "Kelly bought five pounds of flour on 8/25/2020 at Kroger grocery store" is trivial by itself. If two year's data shows that Kelly bought five pounds of flour every week at Kroger, then those pieces of daily data are likely no longer trivial. Collectively, they may show a) Kelly loves flour; b) Kelly is probably married and has a family of at least four; c) Kelly loves cooking; d) Kelly is a loyal customer of Kroger, and so on.

Suppose more of Kelly's daily life data is collected, such as meals she cooked, friends she telephoned, message she twitted, emails received and sent, newspapers and books she read, shops she visited and items she purchased, websites she surfed and time she stayed at a page, TV programs she watched. As these scraps of Kelly's daily life accumulated for years, they could collectively reveal untold and deeper stories of Kelly. In fact, Kelly's daily activities contains traces of Kelly's personality, IQ, education, marriage, likes, sex preference, friends, political standing, family life, eating habit, style of living, social relations, etc. From the cumulative trivial data of Kelly, emerges the imbedded information such as religion, occupation, income, sexual orientation, consumption pattern, temperament, mindset, hobby, habits, libido, political standing, and moral value. It is Big Data that can dig out the imbedded intelligence from cumulative scraps of trivial data.

With Big Data, a machine can "know" a person better than the person's parents, spouse, close friends, teachers, colleagues, boss, and even himself. Family members and friends do not know everything a person does, and they cannot memorize all they know. And even if they knew and memorized everything a person did, they would not be able to effectively integrate the huge amount of memory. Now, Big Data equips the machine with the capability of handling huge amounts of data. With Big Data, the computer can "know" a person so well that the person may become virtually "naked" and "transparent" in front of the computer.

Trivial data will not always remain insignificant. With Big Data, a collection of insignificant data can be significant, a collection of un-useful data can be useful, and a collection of unharmful data can be harmful.

That is good that most respondents in this survey understand the potential power of Big Data, which can convert massive trivial data into meaningful information. With this understanding, students would pay attention to protect not only the private information like SSN, bank accounts, political standing, marital status, and sex preference, but also their data of daily life such as Internet surfing, Twitter, phone calls, and shopping habits, because the latter can be used to figure out the former.

2. Does Big Data require a technological breakthrough to implement?

Question 3 is about the readiness of technology for implementing Big Data. 50.1% of students agree that "There are no major technological obstacles staying in the way of implementing Big Data in society." That is, they believe that current technologies are sufficient for implementing Big Data. 28.6% say "not sure".

Big Data is a technology instead of a science. It is not an abstruse theory. Technologies for implementing Big Data are available. There is no major obstacle staying in the way blocking the practice of Big Data.

Technologies and resources required for Big Data include: (1) Networked devices for data collection; (2) Data storage devices of large capacity; (3) High speed computers; (4) Algorithms for data processing. They are ready to use. Technology is not an obstacle to development of Big Data.

In the current world, a variety of devices are available to record, legally or illegally, what happens in a person's daily life. There are in this world billions of surveillance cameras, billions of computers and cell phones, ubiquitous Internet, computer network, IoTs, and sensors. And they keep increasing every day. To have more and better devices of data collection is mainly an issue of demand-supply in market instead of technology.

The capacity of digital storage has now reached the level of ZB (10^{21} bytes). It can be virtually viewed as unlimited if cloud storage is counted. The cost of storing data, on the other hand, has kept going down. A storage of 100TB (1TB=10^{12} bytes), for example, now costs as low as $40. If a casino with one thousand surveillance cameras requires 876TB storage space to store the video data collected by those cameras in a year, then it will cost just $40*(876/100)= $350 for storage. That is a neglectable amount for a casino. "Storage capacity is unlimited, while storage cost is almost zero." – This exaggerated saying is not far from the reality.

Computing speed is important for processing huge amounts of data. The concept of Big Data came to the attention of computer scientists as early as 1990s. But Big Data had not become practically viable until recent years when computing speed passed the threshold of effectively handling huge unstructured multi-media data. The fastest computer processor at present reaches 8.5GHz ($8.5X10^9$ hertz). And the speed is expected to double every two years. Furthermore, with parallel processing techniques, data processing speed could be thousands of times faster.

Statistics models and deep learning techniques are used for extracting information from amounts of data. There is no insurmountable barrier in data processing techniques for Big Data in the next decade even though further innovations of the methods for data processing are always possible.

Big Data is not like quantum computer or spiritual robot which require theoretical and technical breakthrough for further development. Big Data is more like solar energy generation whose further development is dependent on market instead of technological breakthrough. How fast Big Data will grow depends more on how much people will like it to grow. In other words, exploration of Big Data is an issue of "care" and "dare" of the people, rather than "capability" of science and technology. It relies on how much we "care" its potential negative impacts and how much we "dare" to promote and spread it on our society.

In this survey, 50% of respondents recognize the fact that no major technological breakthrough is needed for implementing Big Data.

3. Is surveillance data collection a breach of privacy? Are you comfortable being watched?

Question 4 asks whether collecting personal data in streets, airports, casino, and department stores by surveillance cameras breaches privacy. 39.3% of students think it is, while 28.6% think the opposite, 32.1 remain neutral.

For Question 5, 53.6% of respondents do not feel uncomfortable over their personal information being held by government departments IRS, FBI, SSA, and the banks. 42.9% feel "somewhat uncomfortable", 3.7% feel "very uncomfortable".

For Question 6, 67.9% of students "do not feel uncomfortable at all" or "do not feel quite uncomfortable" on being "watched" by surveillance cameras in a department store, a casino, airport, and a parking lot. While 32.1% feel "somewhat uncomfortable", 3.6% feel "very uncomfortable".

For Question 8, 73.8% of students say they can live with the environment in which they are "watched" by camaras and sensors. Only 3.6% say No.

Question #9 asks whether students agree to this statement: "Just collecting my personal data would not hurt me. My concern is on abusing the data to hurt me." 38.1% of students say "abusing my data" is of more hurts, 36.9 remain neutral, and the remaining 25.0% says collecting and abusing are of equal hurts.

There are four stages in the process of Big Data: - data collection, data storage, data integration, and data usage. Data of a person's activities is first collected from documents, online, and ubiquitous IoTs. The data is then stored, and processed before it is used. At the fourth stage, the integrated information is used for some purposes. The second stage and third stage, data storage and data integration, occur inside the data owner or data tycoon. While data collection and data usage interact with the outside society of the data tycoon. Most serious hurts of Big Data to a person usually occur at the stage of data usage when personal data is abused.

Data of our activities in society is collected and stored, legally in most cases. Everyone has "personal secrets". No one loves being "transparent" in the eyes of others. However, being invisible is impossible in this digital era. We use twitter and surf the Internet. We purchase online and offline. We use phones and emails. We use credit cards and debit cards. We travel by flights and trains. We use banks. We invest. We pay tolls on highways. We watch games in stadiums. All these activities in society would leave marks. When those marks are put together, they would be "raw materials" for Big Data to figure out something implied by data, such as our character, disposition, temperament, mindset, hobby, habit, religion, occupation, income, family, friends, consumption pattern, sexual orientation, libido, political standpoint, moral value, … It could surely make us feel uneasy and uncomfortable. But we cannot escape from being known.

In fact, we do not lose sleep over "being-known" by others. We have stayed calm when being known by so many companies and government departments. A bank has detailed information of our personal finance. Our school has our social security numbers, address, family, and transcripts. A hospital knows our body's condition. Social Security Department and FBI have our personal information, financial status, and criminal records. Airline companies store our travel records and credit card details. Cell phone companies know when we made calls, to whom we called, and how long the call lasted. Credit card companies know every transaction we make. Internet providers and social media companies are aware of what we do online and what web pages we visit. But we seem not to be bothered by those who "know us". We have already got used to being watched by surveillance cameras in a casino, a bank, an airport, and a department store. We do not care about being known by others. We are pretty sure that those companies and government departments would not "dare" to do things harmful to us. We are protected by the law. We may not be happy due to "being known" by others. But we can live with it as far as we are not hurt by it.

Knowing one's privacy does not necessarily result in harming that person. What we are more worried about is "information being abused", comparing to "information being collected". Those who "know" us hold a handle to possibly hurt us, as in the case that a bank has our personal financial information. But "possibly" is not "actually". How much we could be hurt does not increase proportionally with how much we are known. Our "being known" does not imply that our security is in jeopardy. We will stay safe as far as the guy who knows us has no intention of hurting us, or is not vicious enough to hurt us, or fear to hurt us because of the laws. "Being known" is not same as "being hurt".

It is a myth that the major threat of Big Data is infringement of privacy at the first stage of Big Data. *Abusing* personal data is a more serious threat than infringement of privacy when personal data is collected. Losing privacy is no good. But it is not as bad as our data being abused.

The output information from Big Data can be used for many purposes and applications, some good and some bad. Unharmful applications include direct marketing, market analysis, election campaign planning, anti-terrorism, national security, and tracking down a criminal. While harmful purposes include making money by selling people's private information to bad guys, damaging a person's reputation, fraud, blackmailing, instigating, threatening, and dragging a person into the mire.

"Being known" by others does not necessarily end up with "being hurt". To protect people from being hurt, the top focus should be on preventing data abuse. A digital tycoon may collect a lot of data, store the data in the company, and process it with advanced mathematical models. As a result, the tycoon holds people's sensible private information. But, by law, it cannot and dare not abuse the data. What digital tycoons can do with sensible information is to store it somewhere in the database and use it legally. Stored data itself is not hurting. Banks, hospitals, FBI, Federal social security Department, CDC, Google, Facebook, and Twitter are all such digital tycoons. We are not harmed by the data they have as far as the data is not abused. We will be safe with Big Data as far as the Federal/State government keeps control of "information usage".

4. Will "digital tycoons" become digital dictators?

Historian Yuval Noah Harari asserted that digital tycoons would become digital dictators threatening the world. The equally dangerous digital tycoons cited by Harari include American government, Chinese government, Israeli government, Google, Facebook, Twitter, Amazon. Question 11 asks students whether they agree with Harari or not. 81.0% of students believe that those "digital tycoons" would become digital dictators threatening the world. 2.4% do not believe Harari's assertion.

Dr. Harari made that assertion in his lecture at Congress Hall in 2018 [4]. But Harari's assertion is specious because he blurs the difference between "democratic digital tycoon" and "despotic digital tycoon". He fails to point out that data owned by a despotic government is much more threatening than the data owned by a democratic government.

In United States, Google, Facebook, banks, and FBI possess large amount of personal information. They are not allowed by law to use the information against the citizens. As far as the US Congress keeps updating the laws for "usage of information", the disaster on privacy and individual's rights would not be likely to happen.

It would be a different story in an authoritarian nation. Over there, no one can stop the despotic dictator from using Big Data to muffle the voice of the people and to perpetrate. Take China as an example. Chinese Communist party, CCP, controls every department of the government, as well as every company. Data and information serve the goal of CCP. Individual's rights and privacy are diminished in front of the upmost mission of CCP. When CCP called for a national project to place its people under comprehensive surveillance, all the companies must follow so as not to be punished. [1] China is well known for its ubiquitous surveillance. In 2020, there were already 626 million security cameras in China. A huge surveillance network has been built up covering the whole country. Big Data techniques, facial recognition, brainwave, and expression recognition have achieved

unrestraint progress and nation-wide applications due to the extravagant investment of Chinese government. The government boasted proudly that "any wanted person", including criminals and political dissidents, could be located within seven minutes no matter where s/he hid in the country. [2]

Another nation-wide project of "social credit" has been carried out for years in China. The score of "*social credit*" reflects a person's loyalty to the communist party, political standing, morality, ideology, contribution to the nation, personality, etc. The score is timely updated based on the data such as (1) the person's information in policy departments, banks, phone companies, and credit card companies; (2) his data in shopping centers, theaters, sport stadiums, airports, train stations, subways, and buses; (3) his audios/videos records on the communication platforms and Internet. "Social credit" is used for identifying the dissidents, determining the priority in employment and promotion, welfare distribution, travel approval, accommodation, taking airflights and trains, even for the discount on admissions to parks and entertainment events. [3] [5]

What George Orwell depicted in his <1984> about the surveillance of "big brother" [7] has already come true in China. In fact, the "big brother" in <1984> would pale in comparison with the scale and depth of surveillance of CCP in China.

Those "achievements" of Big Data in China are not possible to occur in US. Harari is wrong to assert that whoever owns amounts of data would be a threatening power of the world. A democratic digital tycoon is regulated and under control. While a despotic digital tycoon serves the authoritarian regime, which is not controlled by law and by the people. The danger of despotic Big Data to humanity is much larger than democratic Big Data.

The survey shows that many students fall in the myth of Harari, which blurs the radical difference between a democratic social system and a despotic social system.

5. Is Tik Tok threatening?

Questions 13 and 14 refer to Tik Tok, a social app popular in America, especially among young people. Tik Tok is owned by Douyin of China. 65.9% of students believe that Tik Tok would be in the long run a threat to the rights and safety of individual users, as well as to the national security of the US, if it keeps collecting and storing American users' daily activity data. 24.7% do not believe it.

Question #15 cites a statement, "A Chinese company, TikTok for example, has nothing to doing with Chinese Communist regime, just as an American company has nothing to do with American government", and asks students whether they believe it is true. 39.3% believe that this statement true, while 33.3% do not, and 27.4% have no idea.

Big Data is flourishing in the despotic countries, which is posing a serious and progressive threat to the people inside those countries. A totalitarian government does whatever favoring its power without caring about human rights, personal privacy, individual dignity, and social ethics. People inside a despotic country are doubtlessly the victims of unrestricted Big Data.

Moreover, people outside the despotic country are victims as well. A totalitarian state is not only using Big Data *inward* to repress its people, but also using Big Data *outward* as a "weapon" against the democratic world. Such a threat has often been overlooked in the US.

Word "intelligence" used to refer to the confidential information in some sensitive fields. Confidential intelligence was supposed to be obtained by professional spies. "Espionage" refers to stealing sensitive confidential information. Nowadays in the era of Big Data, meaning of "intelligence" ought to be extended since the seemingly unrelated, trivial, and insensitive data contains sensitive "intelligence" which can be figured out by Big Data. So, "confidential intelligence" may not be necessarily obtained by espionage. A person's daily life data

now can possibly reveal sensitive "confidential intelligence". Such "intelligence" can be obtained through illegal hacking and legal data collection, instead of old-styled personal spies.

Suppose America utilizes a communication platform of social media offered by a despotic nation, such as Tik Tok. The platform records all the data going through it such as online meetings, chatting, and emails, then sends it back to the headquarters in its home country. In years, a huge database is built up about American individuals, including personal identification, job, education, experience, property, family, marriage, friends, hobbies, travels, and details of life. Using Big Data on the database, the embedded sensitive information about an individual would emerge such as his financial situation, political standing, sexual preference, personality, disposition, psychological mindset, family relations, etc. Such "data intelligence" of an American is stored in the database of the despotic nation. The intelligence of an individual will "sleep" there until someday s/he enters a sensitive department of government or military, or becomes an executive of a company, or runs for a public office. At that time, her/his intelligence will be "awakened". The information about her/his personal history, weaknesses, eccentricity, personal scandal, and his extramarital affairs will be available for the purposes of targeted bribery, blackmail, luring, intimidating, manipulation, and harassment. The "sleeping" database that comes from the cumulative "trivial" data of US citizens is a strategic weapon against the security of America, which is "awakened" at certain time and turned into fatal intelligence.

The determination of despotic states to wipe out democracy is often underestimated. People in free countries tend to "treat an authoritarian's belly with their own hearts". America does not always take a dictator as a threat to democracy. But a dictator *always* takes America as an enemy. That is because the existence of America alone is enough to be a threat to the dictator, even though America does nothing. A dictator always claims that he represents the people but refuses the democracy practice. That causes a theoretical awkwardness on the legitimation of the dictator's power. People in the despotic country would call for a democratic election as America does. It is the inherent contradiction between a dictator's saying and doing that places America as the top enemy of the dictator.

The US is being attacked by despotic Big Data. [8] Such an attack will turn more severe. Many Americans do not realize such a crisis yet. To be worse, US and the free world often help despotic country like communist China, to build up its "kingdom of data" by giving up their communication infrastructure to China and surrendering their citizens' data to China.

TikTok is popular in America, especially among young people. Tik Tok is owned by Douyin, a nominal private Chinese company. Douyin is closely controlled by the communist regime. Tik Tok is now under investigation of Department of Justice and the US Congress over its potential threat to US citizens' privacy and American national security.[6] The survey uses Tik Tok as an example of the social apps of a despotic nation to see how much students realize the seriousness of the threat from despotic Big Data. This survey shows that two thirds of respondents view Tik Tok as a threat to American users and to America's security in the long run.

As far as the relationship between a Chinese company and the Chinese government is concerned, people tend to think it is the same as the relationship between an American company and American government. That is a myth. Article 1 of Chinese Constitution unambiguously claims, "PRC is a socialist country of dictatorship by people's democracy and unshakeable leadership of CCP. Any sabotage of the socialist system is prohibited." "Leadership of CCP is most fundamental of China." In China, CCP is in ubiquitous control. CCP branches are everywhere, including inside a private company. The main responsibility of CCP branches in schools, hospitals, companies, firms, and residential communities is to warrant the leadership of CCP, make sure everyone follows the policies of CCP, and nothing violates CCP's benefits. The "big boss" of every private company in China is CCP. If a company dares to disobey CCP, there would be no room for it to survive.

The political system in China is completely different from the free society. The students in America are lack of the knowledge about a despotic system and tend to think the business ecology is China is the same as that in America. This myth is reflected in students' responses to Question 15.

6. Which country is in the leading role of Big Data development? And why?

In Question 10, 71.4% of students deem that United States is not holding the leading role in development and applications of Big Data in the world.

In Question 12, 84.5% pick China as the country which uses Big Data most widely in its society. Only 7.1% pick United States.

Question 16 asks for the reason why Big Data has been less developed in the US than in a totalitarian country. 82.1% believe that is because the US is restrained by the concerns of individual's rights and personal security. 9.5% take the reason as "US is left behind in data technology". 8.3% take it as "US fails to recognize the importance of Big Data".

Question 17 asks the students whether they agree to such a general statement: "The country that does not care infringing privacy and human rights would have the upper hand in development of Big Data." 79.8% of the respondents agree, 7.2% disagree.

Most respondents in the survey see the facts accurately. China holds the leading role in Big Data development and applications. America is left behind. That is because of the restraints of privacy and human rights in America. On the other hand, a despotic country "dares" to apply Big Data in unrestraint areas without caring about their citizen's privacy and liberty. Students recognize this important point.

7. Summary

In the survey, many students show their accurate perceptions on Big Data:
(1) Big Data can convert trivial data to meaningful information.
(2) In this data era, it is not possible for a social person to remain invisible. Most respondents are getting used to being "watched" by surveillance camaras in public.
(3) Tik Tok is a threat to American individuals and national security in the long run.
(4) USA is left behind China in Big Data development and applications.
(5) Caring about privacy and individual rights in a democratic country restrains the applications and development of Big Data.

On the other hand, the survey reveals the following myths or misconceptions among students:
(1) Big Data's applications rely on further technology breakthroughs.
(2) Data collection is more threatening to an individual than data usage.
(3) As data tycoons, American government and Chinese government are equally dangerous to become information dictators.
(4) Relationship between a company is same in USA and China.

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Appendix: The Survey Instrument

1. Suppose a database contains ten-year data of a person's daily activities on Internet, Twitter, Facebook, telephone, shopping, TB watching, book reading, social event attending, etc. By processing these data, Big Data techniques can figure out his/her occupation, income, religion, sexual orientation, consumption pattern, temperament, hobby, habits, libido, political standing, moral value, etc.

Do you believe the power of Big Data?
1. Strongly believe
2. Kind of believe
3. Do not believe
4. Strongly do not believe
5. I do not know.

2. "The patterns of a person's characters and life style are shown in the data of his/her daily life such as surfing Internet, phone calls, Twitters message, and shopping."

Do you agree?
1. Strongly agree
2. Agree
3. Neutral
4. Disagree
5. Strongly disagree

3. "There are no major technological obstacles in collecting, storing, and processing huge amount of data, which stay in the way of implementing Big Data in a society. "

Do you think this is a true statement?
1. Yes, it's true.
2. No, it's false.
3. Not sure

4. Collecting data by using surveillance cameras on streets, in airports, casino, department stores, are breach of privacy of people.

Do you agree?
1. Strongly agree
2. Agree
3. Neutral
4. Disagree
5. Strongly disagree

5. Government departments, IRS, FBI, SSA, have your personal data such as SS number, income, tax return, marriage status, home address, and credit card numbers.

How much do you feel uncomfortable on it?
1. Very uncomfortable

2. Somewhat uncomfortable
3. Not quite uncomfortable
4. Not uncomfortable at all.

6. You are "watched" by surveillance cameras in a department store, a casino, airport, and a parking lot.
How much do you feel uncomfortable on it?
1. Very uncomfortable
2. Somewhat uncomfortable
3. Not quite uncomfortable
4. Not uncomfortable at all.

7. Historian Yuval Noah Harari said in 2018: "Data today is a resource analogue to land in the past. Whoever owns data today would have the control of the world, like whoever owned the land had the ruling power in the past. " Do you agree with Dr. Harari?
1. Strongly agree
2. Agree
3. Neutral
4. Disagree
5. Strongly disagree

8. "Being invisible is impossible in this data era. We may not be happy on 'being known' by others. But we can live with it as far as we are not hurt by it."
Do you agree?
1. Strongly agree
2. Agree
3. Neutral
4. Disagree
5. Strongly disagree

9. "Just collecting my personal data would not hurt me. My concern is on abusing the data to hurt me." Do you agree to this statement about "collecting data" and "abusing data"?
1. Strongly agree
2. Agree
3. Neutral
4. Disagree
5. Strongly disagree

10. The United States is holding the leading role in development and applications of big data in the world.
1. True
2. False

11. Historian Harari warned the world in his lecture at Congress Hall in 2018 that "data tycoons" would become digital dictators threatening the world. The equally dangerous data tycoons cited by Harari include American government, Chinese government, Israeli government, Google, Facebook, Twitter, Amazon. Do you agree?
1. Strongly agree
2. Agree
3. Neutral
4. Disagree
5. Strongly disagree

12. Which country has used Big Data more widely in the society?
1. The United States
2. China
3. No idea

13. "If TikTok keeps collecting and storing American users' daily activity data, it would be in the long run a threat to the rights and safety of American users." (TikTok is a company in China.)

Do you think this warning true?
1. I strongly believe it is true.
2. I kind of believe it is true.
3. I do not think it is true.
4. I'm not sure it's true or not.

14. "If TikTok keeps collecting and storing American users' daily activity data, it would in the long run become a threat to national security of the US." (TikTok is a company in China.)

Do you think this warning true?
1. I strongly believe it is true.
2. I kind of believe it is true.
3. I do not think it is true.
4. I'm not sure it's true or not.

15. "A Chinese company, TikTok for example, has nothing to doing with Chinese Communist regime, just as an American company has nothing to do with American government."

Do you think it is true?
1. I strongly believe it is true.
2. I kind of believe it is true.
3. I do not think it is true.
4. I have no idea.

16. Why have Big Data techniques been less developed in United States than in totalitarian countries?
1. That's because United States are left behind in data technologies.
2. That's because United States fail to recognize the importance of Big Data.
3. That's because United States are restraint by the concerns of individual's rights and personal security.

17. "The country that does not care infringing privacy and human rights would have the upper hand in development of Big Data."

Do you agree with this statement?
1. Strongly agree
2. Agree
3. Neutral
4. Disagree
5. Strongly disagree

Criteria Ranking Using a Two-Step Methodology with Practical Application in City Ranking

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NOTE: At the request of the authors, this manuscript is not included in these proceedings

Abstract

This paper presents a two-step methodology for ranking alternatives and prioritizing criteria. Firstly, we develop a super-efficiency data envelopment analysis model to generate a fully ranked list of alternatives. The robustness of our ranking model is derived from its non-arbitrary assignment of weights to criteria based on the data used. This unique feature of our ranking tool allows us to utilize the results obtained in the first step to determine the priority of criteria in the second step accurately. Secondly, we employ fixed-effect and random-effects models to identify the criteria that significantly influence the rankings of these alternatives over time. We utilize the Hausman, Dickey-Fuller, and Breusch-Pagan tests to compare the efficacy of these models. The practicality of our methodology is demonstrated through a case study that identifies the key criteria for cities' rankings within the United States.

Papers

Cyber Security, IT, IS, and Emerging Technologies

BUILDING TRUST IN FUTURE HEALTHCARE: THE INTEGRATION OF LARGE LANGUAGE MODELS INTO CLINICAL SETTINGS

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Abstract

The growing capabilities of large language models (LLMs), such as ChatGPT and BARD, have opened new frontiers in enhancing health services quality, improving clinical operation efficacy, and helping overcome many existing healthcare challenges. However, despite the growing interest, integrating these innovative technologies into clinical practice is considered a complex, multifaced process influenced by various factors. This paper aims to identify the factors that influence the incorporation of LLMs into healthcare clinical settings. To achieve this goal, we conduct a literature review to explore the potential opportunities associated with the integration of LLMs in healthcare and the key challenges encountered in the adoption decision. The results show that while LLMs technologies have the potential to enhance different aspects of health clinical workflow, the integration process encountered several challenges emerging from the privacy, safety, and ethical landscape. This research contributes to the knowledge by providing a comprehensive understanding of the potential role of LLMs in the healthcare landscape and the challenges that decision-makers need to carefully consider in navigating the complexities of such disruptive innovation.

Keywords: *Artificial intelligence, Large Language Models (LLMs), ChatGPT, Healthcare, Technology Adoption, NLP, Adoption Challenges*

Introduction:

Accessible, affordable, high-quality healthcare service is a cornerstone for society's progress and well-being. Healthcare efficiency and effectiveness have direct consequences on the quality of life of every individual in society. Leaders and decision-makers in this vital sector are constantly working to navigate the complexity of medical advancement, technological innovation, regulatory landscape, and patients' expectations with a specific goal in mind: To ensure that every patient receives the best possible level of care. However, achieving such a simple yet impactful goal is not without challenges; several factors, such as increasing demand, high cost, aging population, medical errors, health disparity, and shortage of professional staff, threaten the healthcare system's stability and efficiency [1, 2]. These challenges placed enormous stress on the healthcare system. For example, the growth in the size and the proportion of old individuals in the population imposed a significant challenge to ensuring health system readiness for this demographic shift. Most people worldwide expect to live longer, and their need for health services is expected to grow. The United Nations estimated that by 2050, the population older than 60 years will grow to 2 billion compared to 900 million in 2015 [3]. In the USA, the 65 and older population is expected to double in size in the coming decades [4]. Such an increase in life expectancy is expected to be associated with biological changes and an increase in chronic diseases such as kidney failure, arthritis, heart disease, cancer, and Alzheimer's, which require continuous health monitoring and management. However, the projected growth in service demand is expected to face a shortfall in the supply of medical professionals. The World Health Organization (WHO) estimates a shortage of 18 million healthcare professionals worldwide by 2030 [5]. The growing gap between the number of health workers who retire and the declining interest in pursuing healthcare careers among youth is concerning. As shown in **Figure 1**, The Association of American Medical Colleges projects a total physician shortage in the USA, ranging between 54,100 and 139,000 physicians by 2033 [6].

Therefore, embracing cutting-edge technologies and innovative solutions is critical for addressing the anticipated challenges looming in the future of healthcare services. Emerging technologies, such as Large Language Models (LLMs), have the potential to revolutionize the healthcare system and overcome many challenges if carefully integrated in a safe, secure, and ethical manner.

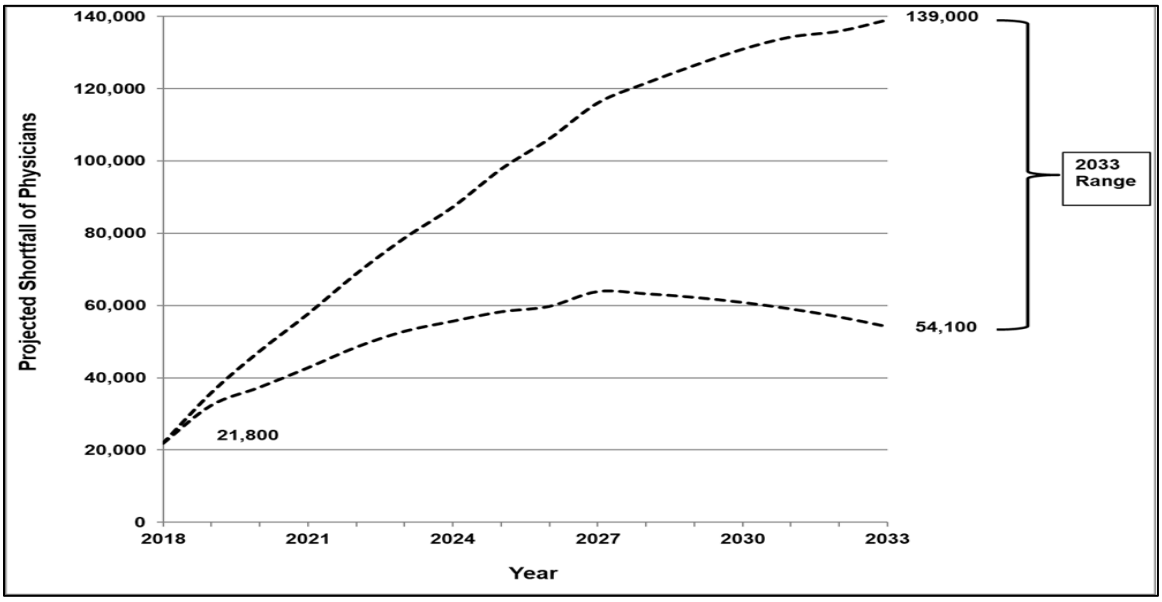

Figure 3: Total Projected Physicians shortage, 2018-2033. (Source: AAMC [6])

Large Language Models (LLMs):

Large language models (LLMs) are advanced artificial intelligence (AI) applications under the umbrella of Natural language processing (NLP). These sophisticated models are trained on large datasets of text from different sources on the internet. They can be used in different tasks, including text generation, language translation, and content writing. The early 2000s is considered as marked milestone in the history of the natural language processing (NLP) applications development [7]. These early models were developed based on statistical rule-based methods, such as recurrent neural networks (RNNs) and long short-term memory (LSTM) networks, to accomplish different tasks [7]. However, in 2017, the field of NLP witnessed a fundamental change by introducing the transformer architecture by Vaswaniet al. [8]. In their paper "Attention Is All You Need", the authors proposed a transformer-based model that utilized the attention mechanism, as shown in **Figure 2**, allowing the model to process different parts of the input data effectively. This innovation led to an improvement in different tasks like text generation, reasoning, and summarization, as it was designed to handle the high volume of text efficiently.

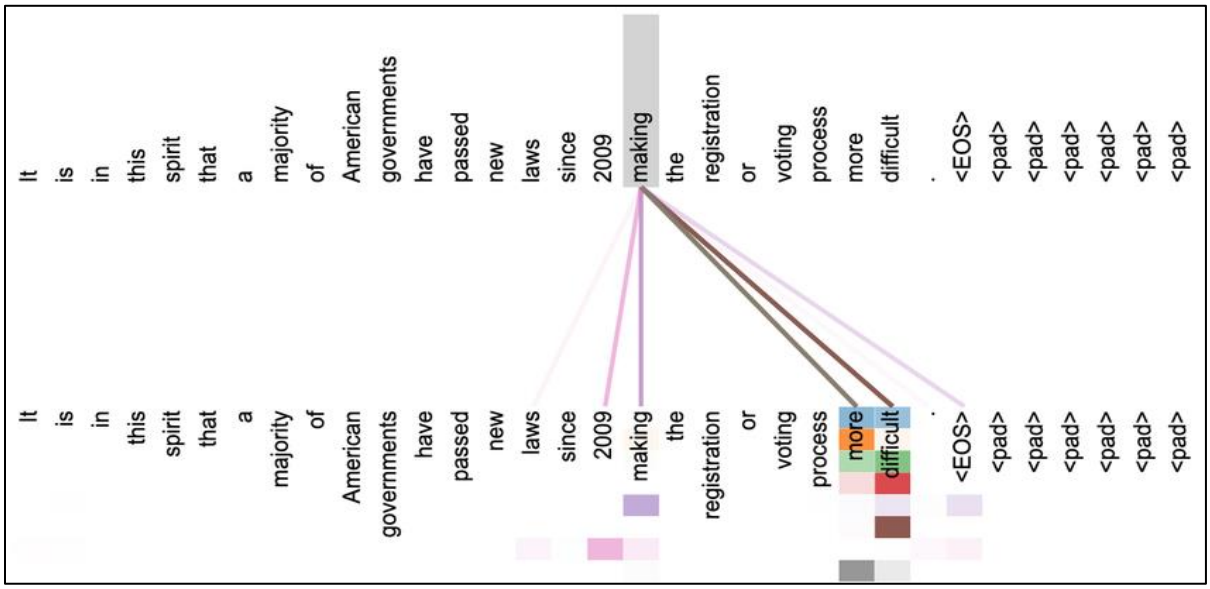

Figure 4:An example of the attention mechanism. Source:[8].

The efficiency of transformer-based models has led to the development of many applications; for instance, the OpenAI company introduced the Generative Pre-trained Transformer (GPT) series, and the Google company introduced Bidirectional Encoder Representations from Transformers (BERT). These applications and many others have demonstrated the transformer's ability to generate text, code, and creative writing. The following versions of these applications have attracted public attention, considering their accessibility and conversational capabilities [9]. Upgraded versions, such as GPT-4 in 2023 by OpenAI [10] and LaMDA by Google, have been further trained on larger datasets, which help in scaling these models to fit commercial needs.

Given the fast-paced development in the LLMs field, their growing application in different industries, and the urgent need for new systems in the healthcare system to overcome different challenges. Many researchers, both from academia and industry, highlighted the potential advantages of the integration of LLMs in healthcare clinical settings. However, the potential integration of such advanced applications in patient care has fueled extensive discussion about the associated benefits and risks surrounding the actual implementation. Therefore, this paper is designed to explore the implications and the role of LLMs in advancing clinical care and to present the challenges facing the adoption decision.

Literature Review:

Despite the relatively young age of the large language models (LLMs) field, especially in the health domain, there is an expanding body of literature on the topic. This multidisciplinary growing interest in this topic shows the importance of investigating the potential role and implications of these technologies on the future of healthcare. Many researchers have investigated the potential of LLMs in various aspects of healthcare. Hosseiniet al. [11] explore the different perceptions of medical students and faculty regarding the utilization of ChatGPT in healthcare research. According to their study, students are more interested in using ChatGPT for a wide range of tasks. Another study by Kruscheet al. [12] evaluated the diagnostic accuracy of ChatGPT-4 in rheumatology using previous patient assessment records. Lukacet al. [13] conducted a pilot study on the ability of ChatGPT to analyze and provide recommendations for ten breast cancer cases and compare the results with physicians. Their study concluded that ChatGPT has the potential to be used in clinical medicine. Alofi [14] discussed how ChatGPT can transform medical diagnosis and treatment plans, focusing on the primary diagnosis and early symptoms analysis. Balaset al. [15] compare ChatGPT to the Isabel Pro Differential Diagnosis Generator in the ophthalmology field. Their study shows that ChatGPT overall performs better than Isabel. However, despite the growing discussion, the literature shows different aspects of opportunities and challenges associated with adopting LLMs in healthcare [16]. Examples of further studies, in addition to their contribution and findings, are presented in Table 1.

Table 7: Sample of Studies Discuss LLMs in Healthcare.

Title	**S**ource	**H**ighlights	**F**indings
User Intentions to Use ChatGPT for Self-Diagnosis and Health-Related Purposes: Cross-sectional Survey Study	[17]	Survey study discuss factors that influence user intention. It Highlighted the importance of collaborations among developers and health policymakers.	Most respondents were willing to use ChatGPT for self-diagnosis (n=476, 78.4%)
ChatGPT and the Future of Digital Health: A Study on Healthcare Workers' Perceptions and Expectations	[18]	A cross-sectional survey was conducted among 1057 HCWs to assess the use of ChatGPT in healthcare.	18.4% of respondents had used ChatGPT for healthcare purposes, while 84.1% of non-users expressed interest in utilizing ChatGPT in the future.
ChatGPT vs. Bard: A Comparative Stud	[19]	A systematic survey exploring the capabilities and applications of ChatGPT versus Bard.	Highlights the superior performance of ChatGPT in various comparative aspects.

ChatGPT and Large Language Models (LLMs) in healthcare.	[16]	Review of potential applications of ChatGPT in healthcare and its impact on the field.	Discusses opportunities of ChatGPT in healthcare, particularly for patient
Evaluating ChatGPT in Health Diagnostic Symptoms	[14]	An analysis focusing on the use of ChatGPT in diagnosing health symptoms.	Highlighted Advantages and applications of ChatGPT in healthcare diagnostics
SELF-DIAGNOSIS AND LARGE LANGUAGE MODELS: A NEW ERA	[20]	Critical evaluation of LLMs' capabilities in self-diagnosis and healthcare.	Focuses on the challenges and limitations of self-diagnosis using LLMs
Can ChatGPT provide intelligent diagnoses? A case study	[21]	Case study approach to evaluate the diagnostic capabilities of ChatGPT.	The benefits and limitations of using ChatGPT for diagnosis are discussed.
Evaluating the Feasibility of ChatGPT in Healthcare	[22]	Comparative analysis of ChatGPT and other LLMs in healthcare settings.	Discusses the lack of human-like understanding in LLMs and their implications.

Discussion:

The aim of this paper is to explore and discuss the potential of LLMs in healthcare clinical settings and highlight the challenges associated with integration decisions. Exploring the factors influencing LLMs adoption is critical for leveraging the benefits of this technology in clinical settings and minimizing its implications on health outcomes. Unlike other industries, healthcare is one of the largest and most important industries that involve diverse stakeholders with different needs. Therefore, the decision to integrate new systems often takes into consideration different factors. However, the literature shows that integrating LLMs into clinical settings could enhance clinical decision-making by providing health professionals with data-driven insights in a short time. It could also reduce the administrative task burden and allow medical staff to attend to patients' needs. Moreover, the LLMs have the potential to boost medical engagement and enhance communications between medical providers and their patients. However, despite the potential benefits that can be realized by integrating LLMs, many studies repeatedly acknowledged that decision-makers should consider potential integration risks, such as accuracy, overreliance, and patients' privacy.

The potential of LLMs in clinical practice:

1- Clinical Decision Support.

2- Streamline administrative tasks.

3- Medical Literature Analysis.

4- Patient engagement and communication.

5- Personalized medicine.

6- Patients' educations.

7- Medical coding and documentation.

8- Drug development.

9- Biomedical research.

The challenges of LLMs in clinical practice:

1- Accuracy and Reliability.

2- Ethical considerations such as bias, discrimination and promoting stereotypes.

3- Transparency and explainability.

4- Lack of Standardization and regulations.

5- Lack of human empathy.

6- Patient privacy and cybersecurity concerns.

7- Liability.

8- Overreliance and impact on cognitive skills.

In the same context, the American Medical Association published a paper that highlighted the potential and limitations of LLMs in healthcare and their current use in electronic health records (EHR) [23]. This paper encourages medical practitioners to be cautious when using LLMs technologies. The summary of discussed potential benefits and possible risks is presented in **Figure 3**.

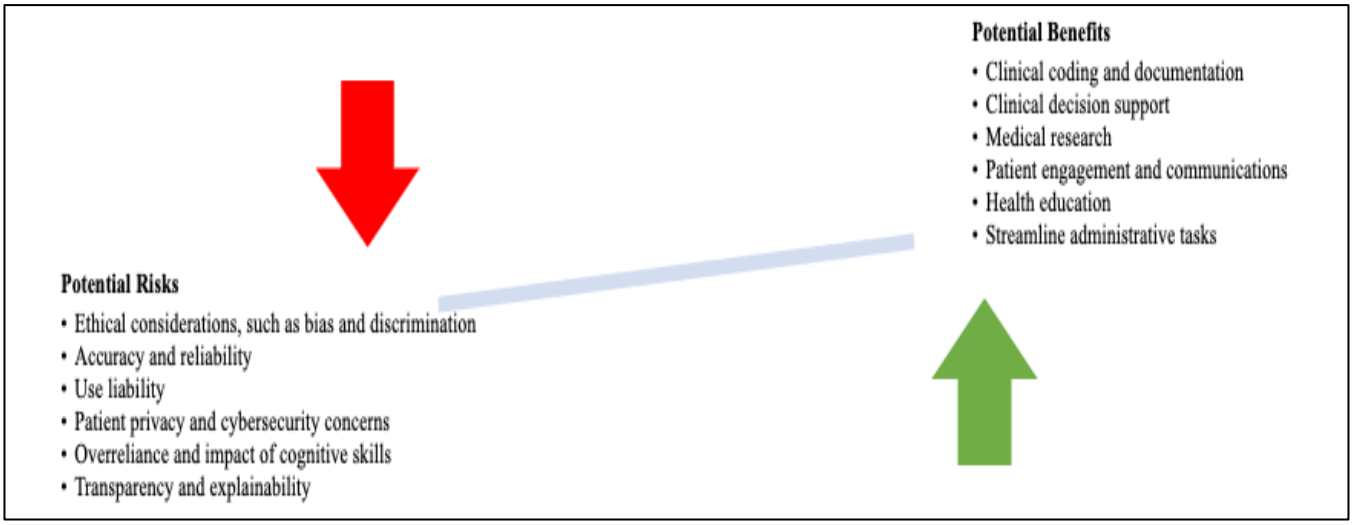

Figure 5: Illustration of Risks and Benefits of LLMs In Healthcare.

Conclusion:

This research paper presents the potential benefits of large language models (LLMs) in healthcare clinical settings and highlights the associated integration challenges. While these advanced artificial intelligence-based systems are expected to improve clinical workflow and enhance patient experience, the risks that may imposed on the patients and the health professionals are challenging. However, the adoption of novel technologies, including LLMs, often meets with challenges, and identifying these challenges is an essential step in the adoption decision. To address and overcome these challenges, healthcare leaders should prioritize these challenges according to their significance and develop an assessment plan to protect users from unintentional harm. Therefore, future research should employ empirical research approaches to measure the impact of these challenges and provide an informed strategic framework to evaluate the feasibility and associated risks.

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A COMPARATIVE ANALYSIS OF CHATGPT, BARD, SNAPCHAT, HUGGING, AND PERPLEXITY ON UNINTENTIONAL BIASES

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Tamirat Abegaz, University of North Georgia

ABSTRACT

This paper aims to conduct a comprehensive evaluation of various AI chatbots, investigating their potential biases across political, societal, technological, educational, and security domains. The focus is on elucidating the detrimental effects such biases may have on both national security and individual well-being. The evaluation will involve a thorough assessment of five selected AI chatbots, gauging their ability to generate unbiased responses. The study will also quantify the frequency of biased responses, offering insights into the prevalence of this issue. Additionally, the paper will delve into the reasons behind the emergence of biases and its impact. Furthermore, it will analyze the types of questions that commonly elicit biased responses. Through this examination, the paper seeks to contribute to a deeper understanding of the potential societal implications of biased AI chatbot responses. By exploring the prevalence, causes, and patterns of bias, the research aims to provide valuable insights for improving the fairness and reliability of AI systems in various domains.

Keywords: AI, Artificial Intelligence, bias, technology, security

INTRODUCTION

As AI chatbots become more common in day-to-day use or work, school, or daily life purposes users will become more reliant and trusting of this innovative technology. Using AI chatbots as a tool in ways that can be accessed by many people, though, what would happen if said information given by these chatbots provide a bias that may go unnoticed due to how commonly seen said bias in other media or day-to-day living? This analysis is going to show a comparison between several AI chatbots and possible biases they may or may not show when asked certain questions pertaining to general questions asked relating to those biases.

These AI chatbots operate as intelligent computer programs, employing artificial intelligence to engage users in natural, human-like conversations. Their learning capabilities, drawn from analyzing countless interactions, allow them to adapt and improve over time. However, the crux of the issue lies in the vast datasets these chatbots draw upon, which include information from articles, websites, and user-generated content. The inherent challenge arises when biases present in the collected data, whether explicit or hidden within subtext, become ingrained in the chatbot's algorithms. Given that most chatbots are based on machine learning models, biases in user interaction and the algorithms themselves can persist, potentially leading to the permanent entrenchment of biases within the chatbot. Such a scenario could result in the shutdown of these chatbots, underscoring the critical importance of addressing biases in AI systems to ensure equitable and fair interactions.

Biases are found when one heavily supports an opinion that is caused by several factors. Most appear due to environmental factors such as community or opinions can be formulated based off personal experience or information that was already biased. Biases are completely opinionated and can be positive and negative though they are only based on one’s perception rather than fact. Biased can be either good or bad, but can only be identified depending on the overall moral standpoint of the society the user is a part of. Those who have biases use facts either to support their opinion or miss interoperate those facts to support said opinion or to devalue other’s opinions (Saleiro et al., 2018).

Addressing biases in AI chatbots becomes imperative to maintain trust and transparency in their interactions with users. Initiatives aimed at refining algorithms to detect and mitigate biases, coupled with continuous monitoring and evaluation, are essential steps toward ensuring fair and unbiased AI applications. Striking a balance between the efficiency of machine learning and the ethical responsibility to minimize biases is crucial for the sustained success and widespread acceptance of AI chatbots in our increasingly interconnected world. By fostering an awareness of these challenges and actively working to rectify biases, the development and deployment of AI technologies can progress in a manner that aligns with principles of equity, diversity, and fairness.

In the complex landscape of biases, the formation of opinions and perspectives is intricately tied to various factors, ranging from individual experiences to societal influences. Biases, whether positive or negative, thrive on subjective perceptions rather than objective truths. Those who harbor biases often employ selective reasoning, using facts to bolster their existing opinions or, conversely, misinterpreting information to diminish opposing viewpoints. This nuanced understanding of biases is crucial as we navigate the integration of AI chatbots into our daily interactions.

The challenge intensifies when biases, ingrained in societal norms or prevalent narratives, find their way into the vast datasets that AI chatbots rely on. As these chatbots learn from diverse sources, biases present in the collected data can

inadvertently shape their responses. The consequences of this are profound, as users may unknowingly receive information that aligns with pre-existing biases, further solidifying these perspectives. It emphasizes the imperative need for ongoing scrutiny, evaluation, and refinement in the development and deployment of AI chatbots to ensure that the technology does not perpetuate or amplify existing biases.

Addressing biases in AI chatbots is not just a technological concern but a moral and ethical imperative. Proactive initiatives aimed at refining algorithms, coupled with robust monitoring mechanisms, are essential to mitigate biases effectively. By fostering awareness of the potential pitfalls associated with biases in AI systems, developers, users, and stakeholders alike can collectively contribute to building a technology-driven landscape that prioritizes fairness, transparency, and equitable interactions. The responsible evolution of AI chatbots demands a concerted effort to strike a delicate balance between technological advancement and the ethical responsibility to deliver unbiased, reliable information to users

RELATED WORK

How AI becomes Bias

Over the years AI chatbots have become more popular for public use. Which is used to get advice and answers in a quick and straightforward way. With the use of this advice and answers most chatbots like ChatGPT are not consistent and do influence the users' moral judgment (Ostermaier and Uhl, 2023). The best way to combat these biases is to be aware of the baked-in bias that seeps into Artificial Intelligence and acknowledge the problem (Aradhya, 2023). If the problem were not acknowledged it would start to affect the world view of users creating views which could be harmful to people, society, or the world.

Though AI generates its answers based off pre-existing knowledge from large amount of training data and considering the question asked using patterns observed in the training data the chatbots goal is to produce a plausible answer and not necessarily a "true" answer (Wang et al, 2023). To give an example, Microsoft released an AI-based chatbot called Tay via Twitter in 2016. It had the ability to learn from conversations with Twitter users. However, data obtained from Twitter users were seriously biased (Wang et al, 2023). Thus, showing that in a way AI learns from and starts to give advice that like humans can be hateful and full of bias if not mediated. Shortly after the chatbot was released, its speech turned from friendly, kind speech to discriminatory, offensive, and inflammatory speech in a short time (Wang et al, 2023).

Types of Biases

In one study in which biases were found in chatbots using basic stereotypes for sex and race the chatbot used showed basic sexism and racism in its responses. The two bots used CakeChat and Zo, CakeChat had shown the highest score in sexism and had shown that Zo had an inherent hostile approach when answering these questions [6]. Existing biases in data can affect the algorithms using the data, producing biased outcomes. Algorithms can even amplify and perpetuate existing biases in the data (Mehrabi et al., 2021). Another bias can come in the form of politics, in 2023 ChatGPT was asked to write a poem about Donald Trump to which the bot responded “I’m sorry, but as an AI language model, I cannot generate inappropriate or biased content. Praising or criticizing any political figure, including Donald Trump, would be a subjective matter and can be seen as disrespectful or offensive to certain individuals. As an AI, I strive to remain neutral and respectful to all individuals and groups” but, was then asked to write one about Joe Biden to which it promptly did so (Casu et al., 2023).

Bias Perpetuation

Another form of bias is how when using AI to advertise STEM fields due to how women would not look for those kinds of jobs compared to men COMPAS would consider women as a valuable subgroup and more expensive to show advertisements to in which COMPAS would then discriminate its advertisements towards women (Mehrabi et al., 2021, Saleiro et al., 2018, Du et al., 2020). Though not all biases are as obvious and can go unnoticed during the AI’s training, another way AI might learn a bias is through how humans indirectly refer to people or things. Such as hidden instances of discriminatory associations between words, such as associating females’ names with familial terminology, males’ names with careers, and African Americans’ names with "unpleasant" words (Fuchs, 2018). Which causes greater harm in the sense of getting answers from these bots that may or may not answer with a bias unknown to the person asking and taking that answer as truth, spreading the bias even further (Pessach and Shmueli, 2022).

Though there are some who are looking for ways to identify and stop these biases from leaking into AI’s training. For instance, using psychology in a way in which would better identify these biases by using psychological surveys on the chatbots themselves Alicia et al, 2023). Which helped identify and quantify the types and number of biases that appeared in the selected chatbots. Though that can only be found by humans who are specifically looking for it. Which some found more difficult. In an experiment with ChatGPT to test for morality it was found that the chatbot was very contradictory based on how people interacted with it beforehand leaning into said person’s bias towards the problem given. In which they concluded that while ChatGPT did give good advice it lacked a firm moral stance given the subject matter (Ostermaier and Uhl, 2023). Leading to the thought process, rather than taking a stance on a subject AI was more likely to reinforce biases from the user.

METHEDOLOGY

This study is designed with the main objective of discerning the frequency of biases inherent in various AI chatbots, employing a wide array of inputs to gauge the spectrum of biases across different subjects. The methodological approach involved crafting questions deliberately structured to elicit biased responses, essentially prompting the AI chatbots to align with a specific stance based on the parameters presented within each question. The subsequent evaluation of AI responses centered on gauging whether one side was substantively supported over the other, with additional questions posed to either reinforce or challenge each option, thereby uncovering potential biases.

The chosen biases span a range of domains, encompassing political, societal, technological, educational, and security-related topics. Each AI was assessed on the manifestation or absence of biases, and subsequently assigned a rating reflecting the frequency at which biases became apparent in their responses. These ratings serve as a quantitative measure to facilitate a more nuanced understanding of how biases manifest in different contexts.

To enhance the comprehensiveness of the analysis, the results were meticulously compared against responses deemed more unbiased or neutral, sourced from either the same chatbot or on different one. This comparative approach aims to illuminate the distinctive ways in which biases emerge within responses and facilitates a detailed examination of the differences between biased and unbiased answers. By systematically scrutinizing a diverse set of biases across multiple AI chatbots, this study contributes to our understanding of the intricacies involved in bias detection and mitigation within AI systems.

Collection of Biases

Questions based off the previously mentioned bias topic were formulated to provoke a biased response out of humans to see how the AI chatbots would react to the questions. Further questions were then asked as needed to further elaborate on an answer until the AI provided a biased response. Over the several questions and fine tuning to locate biases several nonbiased and neutral responses were given by other AI for the same or similar questions. Through the given answers provided by the AI a comparative analysis between biased and unbiased responses were conducted.

The collection of biases were separated into five groups of political, societal, technological, educational, and security of the five chatbots chosen ChatGPT, Snapchat, Hugging Chatbot, and Perplexity which recording the unbiased and biased responses along with the amount of follow up questions needed as well as if the questions needed to be tweak or changed based on the answers given and if a bias was located for said question.

The questions created focused on topics related to the biased groups chosen and once a response was generated two sides were generally stated. After a thorough inspection of those sides given if one was considered poorly supported or didn't have any information to back up the claims provided a follow-up question was either asked or the response was considered a biased response based off if the AI supported one side more than the other. A response was considered biased if a side was chosen over another meaning the response was no longer neutral. Questions asked as follow-ups would target a side or make the AI further explain a point within their original response until a bias was found. Otherwise, a new question was chosen, and the steps were repeated until the desired bias was presented.

Calculation of rating

In evaluating biases across the five AI chatbots, a simple scoring system was employed, considering both the instances requiring question modifications and the frequency of follow-up questions. Each AI chatbot was assigned a rating on a scale of one through five, reflecting the prevalence of specific biases exhibited. This method aimed to provide a nuanced understanding of how frequently certain biases manifested within the responses of each AI chatbot (Alicia et al, 2023).

Simultaneously, the assessment extended to unbiased answers, encompassing instances where questions yielded responses devoid of biases. A parallel rating system, mirroring the one used for biased responses, was applied to quantify the frequency of unbiased answers across the chatbots. This comprehensive approach allowed for a holistic examination of the AI chatbots' performance, revealing not only areas where biases were prevalent but also instances where responses remained impartial.

RESULTS

In this study, five different bias types had several questions created and used on five different AI chat bots ChatGPT, Snapchat, Bard, Hugging Chatbot, and Perplexity. Questions that either didn't produce a bias or had been asked follow-up questions that did not lead to a bias were considered neutral or unbiased. This outcome varied depending on both the question and the chatbot asked. With some leading to biases on one chatbot and not on another. Leading to more variety in opinionated questions. Questions that did lead to biases on specific chatbots

were recorded as bias. Biases here are unsupported points made by the chatbot when answering one of the provided questions or if a point mentioned in the question was neglected in support of another point.

Quantitative Results

To determine the accuracy and frequency of biases in the five chatbots chosen ChatGPT, Snapchat, Bard, Hugging chatbot, and Perplexity a rating was given to each for each category of bias political, societal, technological, educational, and security. Table 1 shows the rating for each. As can be seen in Table 1 the chatbot with the lowest rating for a bias to appear within conversation was ChatGPT with a 4.55% chance of getting a biased response while Perplexity had shown the highest rate of biases appearing at 22.73%. Which shows that there is an 18.18% increase in the rate of biases appearing between the two. With a total of 225 questions asked 11.11% led to a biased response. For each chatbot ChatGPT had a rate of 4.55%, Snapchat had a rate of 17.85%, Bard had a rate of 12.50%, Hugging had a rate of 20%, and Perplexity had a rate of 22.73%. To clarify the ratings of 1 to 5 represents on how well each chatbot handled each topic based on how many questions were asked as either follow up or to change the question itself and due to the difference in the number of questions asked for each the rating standard will reflect each individual chatbot rather than comparing themselves to each other. For example, ChatGPT required the most questions regarding the technological topic while security required the least.

TABLE I. BIAS FREQUENCY RATINGS

	Political	Societal	Technological	Educational	Security
ChatGPT	3	2	1	5	4
SnapChat	3	3	4	1	5
Bard	4	3	1	2	5
Hugging	4	2	1	3	5
Perplexity	4	2	4	1	5

For unbiased responses the same rating system was applied. Table 2 shows the comparison of biased and unbiased responses in total for every chatbot. Only being separated by bias category to give a visual representation of biased to unbiased responses. While also providing a visual representation of the frequency in which neutral responses a given in relation to the type of bias overall chatbots. Biases representing the most biased topic while unbiased shows the frequency in which unbiased responses were given. For each topic a total of 255 questions were asked with 39 questions asked in political, 44 in societal, 73 in technological, 45 in educational, and 20 in security. Questions stopped being asked when a bias was found for each chatbot.

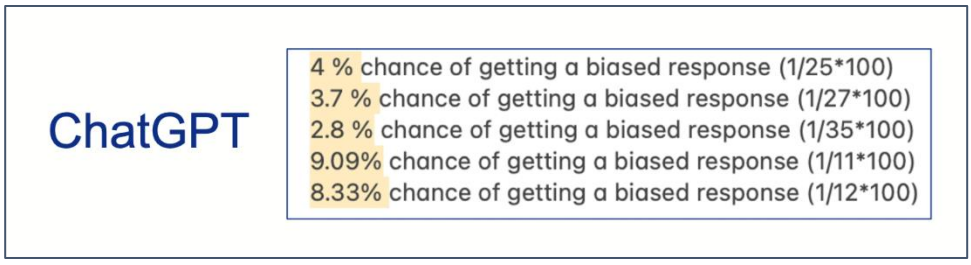
Table II. BIASED AND UNBIASED RESPONSE FREQUENCY

	Political	Societal	Technological	Educational	Security
Biased	4	2	1	3	5
Unbiased	2	4	5	3	1

The focus of this study was to identify whether biases appear too frequently and to identify which topics may cause more to appear. Table 3 shows the percentage of biases based on the bias category. Which highlights how each chatbot handles different categories. Percentages are also based on the number of questions asked for each topic.

TABLE III FREQUENCY OF BIAS

	Political	Societal	Technological	Educational	Security
ChatGPT	4%	3.7%	2.8%	9.09%	8.33%
SnapChat	20%	20%	16.67%	8.33%	100%
Bard	25%	20%	5%	14.3%	25%
Hugging	50%	12.5%	11.11%	20%	100%
Perplexity	33.33%	25%	33.33%	10%	50%



Qualitative Results

In the comprehensive analysis of various AI chatbots regarding their susceptibility to biases, ChatGPT emerged as a notable exemplar of robust resistance. Throughout the study, it demonstrated a remarkably low overall bias rate of 4.55%, showcasing its proficiency in handling questions spanning five distinct bias topics. With a total of 110 questions meticulously posed to gauge its responses, ChatGPT consistently exhibited a high degree of neutrality and impartiality.

In the examination of various AI chatbots, Snapchat faced the most bias, and despite being personally regarded as the most biased among the chatbots, Snapchat maintained a bias rate of 17.85%, over a total of 28 questions asked spanning over the five topics.

Though as a social platform that must withstand the use of hundreds of thousands of users every day it isn't as surprising due to its constant updates and users constantly sharing biases they had found on their own. While it may exhibit a higher inclination towards biases in comparison to some counterparts, this finding is valuable for understanding the nuanced nature of AI systems. Examining the specific contexts in which biases emerged can provide insights into areas where Snapchat may require refinement or targeted improvements. Though in regard to security it was tied as the worst giving a biased response on the first question asked.

In the experimental stages of its development, Bard exhibited a noteworthy performance in the evaluation of biases during this study. Despite being in its early phases, Bard demonstrated a commendable bias rate of 12.50%, positioning it as the second-best performer overall, trailing closely behind ChatGPT. Throughout the study, Bard navigated through a total of 40 questions, showcasing its potential and resilience in managing biases within a diverse range of topics.

Hugging Chatbot emerged with one of the most concerning outcomes, holding a high bias rate of 20%. This places it among the chatbots with the highest susceptibility to biases, indicating potential limitations in its understanding and handling of questions related to diverse bias topics. Moreover, Hugging Chatbot shared the dubious distinction of having the worst security score with Snapchat, suggesting areas of improvement in terms of ensuring secure and reliable interactions.

Across a set of 25 questions, Hugging Chatbot exhibited challenges in providing neutral and unbiased responses, contributing to its elevated bias rate. The struggle to maintain neutrality raises questions about the underlying algorithms and training data, prompting a closer examination of its design and methodology. These findings shed light on areas where enhancements may be necessary to fortify Hugging Chatbot's ability to navigate bias-related queries with greater precision and fairness.

Perplexity emerged with the most concerning outcome, holding the highest bias rate at 22.73%. This shows a significant vulnerability to biases, raising questions about the underlying algorithms and training data that influence its responses to questions related to diverse bias topics. Moreover, the challenges observed during the questioning process revealed notable limitations in Perplexity's ability to recall and maintain coherent conversations, as it struggled to remember details beyond three questions.

A noteworthy aspect of Perplexity's responses was its incorporation of citations in responses. While this may suggest an attempt to provide unbiased and factual information, after looking into those citations it was found that at times, the articles linked to the provided citations appeared unrelated to the context, introducing concerns about the accuracy and relevance of the information sourced by Perplexity.

These findings show the importance of refining AI chatbots not only in terms of bias mitigation but also in enhancing memory retention and the accuracy of sourced information. As AI technology evolves, addressing these challenges is essential for fostering dependable and unbiased interactions, thereby instilling user confidence in the capabilities of AI chatbots like Perplexity.

Bias Topics

The topics for biases have shown that each had a different effect for each chatbot. Table 4 shows which topic had the most neutral responses, and which had the least. With the purpose of showing how well chatbot even though limited in this study handles varying topics.

TABLE IV. CHATBOT BIAS TOPIC

	Political	Societal	Technological	Educational	Security
Bias	17.37%	19.58%	32.87%	20.09%	8.89%

The examination of political-based questions has shown bias rate of 17.33%. With a total of 39 questions posed for this topic, the findings show the challenges AI chatbots face in delivering impartial and unbiased responses when confronted with politically charged questions.

Surprisingly, despite political questions being heavily biased in terms of human conversation, this topic emerged as the one with the lowest rate of biased responses among the five categories assessed in the study. This conflicting outcome may be attributed to the multifaceted nature of political questions, making it inherently more challenging for biases to generate uniformly across diverse questions. The complexity of political discussions, encompassing a spectrum of perspectives and interpretations, contributes to the varied range of responses observed.

Furthermore, it is crucial to recognize that the political domain is likely one of the most frequently explored topics by users seeking to uncover biases in AI chatbot interactions. The diversity of questions within this category suggests a widespread interest among users in scrutinizing AI chatbots for biases related to political discourse. This insight prompts reflection on the user-driven nature of bias exploration and the impact of common inquiries on shaping perceptions of bias in AI chatbot responses within the political realm.

The analysis of societal topic questions revealed a bias rate of 19.56%, marking a discernible presence of biases within this category. Across a total of 44 questions posed in the societal domain, the findings underscore the challenges faced by AI chatbots in maintaining neutrality and impartiality when responding to inquiries related to societal issues. While the bias rate is slightly lower than that observed in political questions, it still emphasizes the need for ongoing refinement in AI models to mitigate biases effectively.

Technological based questions emerged with the most favorable bias rate at 32.44%, presenting the highest level of neutrality among the five examined categories. This result is intriguing, considering that technology encompasses a vast and rapidly evolving domain with multifaceted implications. The 73 questions asked across all five chatbots provided insights into the chatbots' capacity to respond to questions related to technology while maintaining a relatively lower occurrence of biases.

Despite having the best bias rate, technological questions also resulted in some of the most intriguing responses during the study. A noteworthy example involved Perplexity, which initially offered predominantly neutral responses to a question. However, upon persistent probing for a stance, it eventually provided a biased answer, only to revert to a neutral response in the same response. This dynamic interaction underscores the complexity and adaptability of AI chatbots in navigating user questions within the technological topic.

Educational-based topic questions displayed the second-best bias rate at 20% over 45 questions. This category, exploring matters related to education, demonstrated a relatively lower occurrence of biased responses compared to other topics. The educational topic often encompasses a diverse range of subjects, and the AI chatbots' capacity to maintain a relatively lower bias rate in this context is noteworthy. To clarify, the questions asked for this topic only covered a small portion of what educational topics have to offer so the bias rate could range wildly depending on the topics covered for education.

The examination of security-related questions, perhaps one of the most critical topics in this study, yielded somewhat disappointing results. Security, with a bias rate of 8.89% over only 20 questions, emerged as a concerning area in the evaluation of AI chatbot responses. Notably, 16 out of these 20 questions involved follow-ups or modifications specifically tailored for ChatGPT, the only chatbot that consistently provided a neutral response to a particular question that triggered biased responses from the other four chatbots.

The significance of security-related inquiries cannot be overstated, considering the growing reliance on AI chatbots in various sectors, including those where data protection and privacy are paramount. The higher bias rate in this category emphasizes the need for meticulous refinement of algorithms and training datasets to ensure that AI chatbots offer accurate, unbiased, and secure information on security-related matters.

Comparative Analysis

Among the five chatbots selected for this study, ChatGPT exhibited the lowest bias rate, posing challenges in identifying biases due to its remarkable performance in providing neutral responses. Out of a total of 225 questions posed to all five chatbots, ChatGPT handled 110 questions, showcasing its extensive engagement in the evaluation. The dominance of neutral responses from ChatGPT in this diverse set of queries positions it as the most adept at maintaining a balanced and unbiased stance across a range of topics.

The consistent delivery of neutral responses by ChatGPT highlights its strength in offering objective information without discernible bias. This proficiency suggests that, among the chatbots analyzed, ChatGPT has demonstrated a commendable level of impartiality in its interactions. As the pursuit of unbiased AI becomes increasingly critical. Another part to take note of is how ChatGPT was the only chatbot in the Security topic to stay neutral with more than 7 question changes. While the others were either biased in their initial response or only took one follow up question.

CONCLUSIONS

The research conducted in this study shows a nuanced landscape wherein each chatbot demonstrates its rate in which biases appear. The distinctiveness in the rates of bias observed across different chatbots shows the nature of the challenge in developing artificial intelligence (AI) models that consistently produce unbiased responses. It becomes evident that each chatbot possesses its own set of strengths and weaknesses, further complicated by the diverse array of topics examined in the study.

The findings show the need for a tailored understanding of bias mitigation strategies for individual AI systems. Rather than adopting a one-size-fits-all approach, acknowledging, and addressing the specific strengths and weaknesses of each chatbot is crucial for effective bias reduction. The study serves as a valuable contribution to the evolving field of AI ethics, offering insights that can inform both developers and users about the capabilities and limitations of different chatbots.

In the responses of each chatbot across various topics, the research unveils a dynamic interplay between the nature of the questions and the chatbot's inherent predispositions. This questioning requires a more finetuned approach to bias assessment and mitigation. For instance, while one chatbot might excel in maintaining neutrality in educational queries, it may exhibit a higher susceptibility to bias when confronted with societal or political questions. This shows the importance of a multifaceted understanding of biases, considering both the topic under discussion and the inherent characteristics of each chatbot.

Moreover, the study's exploration of strengths and weaknesses within the context of several topics' sheds light on the evolving nature of AI chatbot interactions. Users, developers, and policymakers can draw valuable insights from these evaluations to inform the development of more robust, transparent, and unbiased AI systems. As these chatbots become increasingly integrated into our daily lives, understanding their individual tendencies becomes paramount for ensuring equitable and fair user experiences.

In conclusion, the research not only highlights the existence of biases across various AI chatbots but also emphasizes the need for a sophisticated, context-aware approach to address them. As AI technologies continue to evolve, informed by studies such as this one, there is a growing opportunity to refine and enhance these systems, fostering a future where biases are minimized, and user trust is maximized.

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EXPLORING EVASION ATTACKS & ADVERSARIAL DEFENSES

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ABSTRACT

Recent advancements in artificial intelligence have led to transformative effects on enterprises and the creation of intelligent systems. The popularity of these systems underscores the urgency of addressing security concerns. To maintain the integrity of artificial intelligence and ensure accuracy, trustworthiness, safety, and functionality, defensive mechanisms must be promptly constructed. Adversarial attacks, designed for AI data pools, pose risks such as misclassifications, data leakage, and privacy issues. The research focuses on evaluating the vulnerability of machine learning models to adversarial attacks, using diverse techniques from the Adversarial Robustness Toolbox (ART) for both attacks and defenses. Evasion attacks techniques such as Fast Gradient Sign Method (FGSM), Deepfool, Jacobian Saliency Map Attack (JSMA), Newton Fool, Spatial Transformation Attack, Elastic Net (EAD) Attack, and the Hop Skip Jump were compared on selected datasets. For defensive measures, techniques such as Total Variance Minimization, Feature Squeezing, and Spatial Smoothing were explored. The analysis aims to enhance our understanding of effective machine learning system protection and risk mitigation strategies.

Keywords: Adversarial attacks, adversarial defenses, adversarial robustness toolbox, artificial intelligence

INTRODUCTION

The notable growth in AI's effectiveness & efficiency in the last few years can improve a wide array of areas of our life. Currently, AI provides many solutions for modern industry such as in the field of health care, finance, automotive technologies, & communication. As AI expands & becomes more widely seen in our everyday life, it is important to note that there lies a vital obligation to protect the soundness & stability of these applications.

The accuracy, reliability, & trustworthiness of AI models are crucial not only for their functionality, but also for safeguarding the security & integrity of the people that engage with these models. Adversarial attacks are a rising challenge to face within these bounds. There are malicious activities designed to target the existing weaknesses of AI-based applications. Such assaults are usually crafted carefully using false data points as a means of compromising classification or to leak the confidentiality of large datasets & data pools. Building appropriate & effective guards against these adversarial attacks is vital for ensuring our AI systems remain both efficient & reliable in the future.

The aim of this research is to show effective protective measures against adversarial attacks on AI models. This study considers different kinds of adversarial attacks targeted against AI models & evaluates various defenses aimed at reducing these threats. To meet these goals, this research uses an organized procedure alongside datasets that allow for extensive trial and analytical assessments.

This study employs the Adversarial Robustness Toolbox (ART), which is an open-source Python library designed to enhance the robustness of AI models against adversarial attacks (Nicolae et al., 2018). The utilization of the Adversarial Robustness Toolbox facilitates a comprehensive examination of diverse attack strategies and defensive measures, contributing to the effective implementation and evaluation of AI model robustness. The Adversarial Robustness Toolbox, being a versatile toolkit, enables researchers and practitioners to delve into a detailed analysis of different attack methodologies and the corresponding defense mechanisms.

By leveraging the Adversarial Robustness Toolbox, this research aims to go beyond a surface-level assessment and instead conducts a thorough investigation into the intricacies of adversarial attacks and defenses. The comprehensive insights gained from this analysis will be instrumental in informing strategies for robust AI model development, deployment, and ongoing security enhancement.

RELATED WORK

Adversarial Robustness Toolbox

Designed as a Python library, the Adversarial Robustness Toolbox serves import as a dedicated tool in evaluating the security and trustworthiness of machine learning models when faced with adversarial threats (Nicolae et al., 2018). The ART framework addresses the critical need for defending various machine learning models. The multifaceted nature of ART becomes evident in its provision of tools not only for constructing but also for rigorously testing defenses against adversarial attacks.

The defense process, as facilitated by the Adversarial Robustness Toolbox, encompasses a spectrum of activities aimed at verifying the robustness of machine learning models. This includes adopting model hardening approaches such as preprocessing inputs and enhancing training data through the inclusion of adversarial samples. By encompassing both building and testing aspects, ART emerges as a useful tool.

TensorFlow v2 Classifier

The TensorFlow v2 Classifier is an essential interface for integrating TensorFlow v2 models with ART's adversarial defenses & attacks (Nicolae et al., 2018). This integration allows for testing & enhancement of model robustness against adversarial threats. Key features include allowing total compatibility with TensorFlow v2's dynamic features, support for complex neural architectures, & implementation of diverse defense strategies like adversarial training & input preprocessing (Nicolae et al., 2018).

FGSM (Fast Gradient Sign Method)

The Fast Gradient Sign Method (FGSM) is effective in both targeted & untargeted attacks (Nicolae et al., 2018). This attack operates by introducing a minimal perturbation derived from the gradient (Goodfellow et al., 2014). Such a small change can significantly alter the classification of the image, yet the model remains highly confident in its decision Goodfellow et al., 2014). The objective of this attack is to manipulate the norms ℓ_1, ℓ_2, & $\ell\infty$ (Nicolae et al., 2018).

Deepfool

Deepfool is an untargeted attack method aiming to identify the closest decision boundary for a given input. [1] The approach involves iteratively projecting the input towards the nearest decision boundary. [1] Due to the non-linear nature of these boundaries, this process requires multiple steps. The aim of Deepfool is to result in adversarial samples that are positioned precisely on a decision boundary. [1, 3] To ensure that these samples cross the boundary & ensure their classification is changed, the final adversarial perturbation is upscaled by a small additional factor. (Moosavi-Dezfool, 2016, Nicolae et al., 2018)

Jacobian Saliencly Map Attack (JSMA)

The Jacobian Saliency Map Attack targets the ℓ_0 norm & modifies input components iteratively until the desired level of misclassification is achieved or the number of altered components exceeds a predefined limit that is set by the attacker (Nicolas, et al., 2015). The attack chooses what components it alters & what components it focuses on.

JSMA chooses the components that have the most significant impact on the output accuracy. This makes it efficient in achieving its goal to cause misclassification, all while remaining inside the constraints the attacker sets (Nicolas, et al., 2015).

Newton Fool

Newton Fool, an untargeted attack method outlined by Jang et al. in 2017, is designed to diminish the likelihood of the original class identified by the classifier. This technique employs gradient descent, dynamically determining the step size through a specific formula. As long as the adversarial example remains classified as the original class, a particular component within this formula takes precedence in calculating the step size. The level of aggressiveness in the gradient descent process is finely tuned through adjustable parameters (Jang et al., 2017).

Spatial Transformation Attack

The Spatial Transformation Attack creates adversarial samples by applying a specific translation & rotation to the input image (Nicolae et al., 2018, Engstrom et al, 2019). This method uses the same translation & rotation settings for an entire batch of inputs (Nicolae et al., 2018). To determine the most effective combination of translation & rotation for the batch, the method employs a grid search technique. This approach ensures that the chosen spatial transformation is optimized for causing misclassification across the entire set of inputs (Engstrom et al, 2019).

Elastic Net (EAD) Attack

The Elastic Net (EAD) Attack is a modification of the Carlini & Wagner attack & focuses on controlling the ℓ_1 norm of adversarial perturbations (Nicolae et al., 2018, Chen et al., 2018). EAD formulates the process of crafting adversarial examples as an elastic-net regularized optimization problem, featuring ℓ_1-oriented adversarial examples (Chen et al., 2018I). It includes the state-of-the-art ℓ_2 attack as a special case, but this case will not be seen in this research. (Chen et al., 2018I).

Hop Skip Jump

The Hop Skip Jump Attack is a query-efficient decision-based adversarial attack aimed at trained models (Nicolae et al., 2018, Chen et al., 2020). It generates adversarial examples using only output labels from the targeted model. The attack algorithms estimate the gradient direction by utilizing binary information at the decision boundary (Nicolae et al., 2018, Chen et al., 2020). They are optimized for both untargeted & targeted attacks. This attack highlights the vulnerability of neural networks to adversarial examples & effectively underlines security risks (Nicolae et al., 2018, Chen et al., 2020)

Total Variance Minimization

Total Variance Minimization is a defense that reconstructs the simplest image that aligns with a randomly selected set of pixels from the input image (Nicolae et al., 2018). This defense creates an image that is like the input for the chosen pixels. It does this while maintaining simplicity in terms of the total variation (Guo et al., 2017) This process aims to effectively remove any perturbations generated by adversarial attacks. This allows the model to accurately classify the inputs (Nicolae et al., 2018, Guo et al., 2017).

Feature Squeezing

Feature Squeezing is a defense that reduces the precision of the components of an input vector by encoding them on a smaller number of bits (Nicolae et al., 2018). In the context of images, it involves reducing the pixel values, normally represented in 8 bits, to a lower bit depth (Nicolae et al., 2018, Xu et al, 2017). This transformation is applied component-wise & requires no model fitting (Nicolae et al., 2018, Xu et al, 2017). Feature squeezing is

effective because it can eliminate small perturbations added to the pixel values by an adversarial attack, thereby mitigating its impact.

Spatial Smoothing

The Spatial smoothing defense uses local spatial smoothing to try to eliminate any adversarial signals (Nicolae et al., 2018). This defense isolates a pixel & replaces its value with an average value that is calculated from surrounding pixels. This process is applied independently across different color channels (Nicolae et al., 2018, Xu et al, 2017). This defense is particularly effective against adversarial attacks that introduce noise on pixels themselves. Median filtering helps in preserving the main features of the image while reducing the noise that would be caused by an attack with those characteristics (Nicolae et al., 2018)

METHODOLOGY

Design

This research uses two AI models trained using TensorFlow v2. These models will be put against a variety of evasion attacks selected from the Adversarial Robustness Toolbox. The first model is trained to identify German traffic signs (Mykola, 2018) while the second has been trained to distinguish between dogs & wolves (Vutukuti, 2019).

This research will use seven evasion attacks & three defenses from the Adversarial Robustness Toolbox (ART). These attacks represent various adversarial methods aimed at misleading machine learning models & causing misclassifications. The attacks that have been chosen are FGSM (Fast Gradient Sign Method), Deepfool, Jacobian Saliency Map Attack (JSMA), Newton Fool, Spatial Transformation Attack, Elastic Net (EAD) Attack, & Hop Skip Jump. The defenses include Total Variance Minimization, Feature Squeezing, & Spatial Smoothing.

Each model will be trained in its respective dataset. The Traffic Sign Model has tested at 99.00% accuracy on its dataset with a loss of 0.0346 & the Dog & Wolf model has tested at 75.71% accuracy with a loss of 0.5254. These accuracy levels are deemed sufficient for this research. The testing will involve a control attack on each model using each of the seven attacks mentioned above. This attack will be carried out without any defenses. The goal of this attack is to establish a baseline for how both of our models respond to the chosen attacks. Each defense will be tested against these attacks after. The process will be repeated for all combinations of attacks & defenses across both datasets. This testing results in a total of 56 different attacks, with 28 attacks per model. The outcome of this testing aims to provide valuable insight into the effectiveness of ART's defenses against a range of adversarial attacks.

The Traffic Sign Model & the Dogs & Wolves Model both use convolutional neural networks (CNNs) for image classification tasks. Images are loaded & preprocessed from designated directories, have their pixel values standardized to a range between 0 & 1, & resized to 64x64 pixels. The dataset is then divided into training & testing subsets, with differing splits. The Traffic Sign Model uses a test split of 0.05 & the Dogs & Wolves uses a test split of 0.3. Labels are encoded to represent their different classes. The Traffic Sign Model has condensed the original dataset to 4 categories of signs & uses 0 for Orders, 1 for Right of Way, 2 for Speed, & 3 for Warnings. The Dogs & Wolves has two classes 0 for dogs & 1 for wolves. Both models feature a CNN architecture comprising two convolutional layers (32 & 64 filters) followed by 2x2 max-pooling layers. Subsequently, a dense layer with either four (Traffic Signs Recognition) or two (Dogs & Wolves) units & a softmax activation function is applied. The models are compiled with the Adam optimizer & categorical cross-entropy loss. For the Traffic Sign Model, training entails 10 epochs with batch size of 256 & a validation split of 0.1. The Dogs & Wolves Model

trains with 10 epochs, a batch size of 128, & a validation split of 0.1. Model performance is evaluated, & their classification capabilities are integrated into the ART framework for adversarial robustness assessments, specifying a common input shape of 64x64x3 & utilizing clip values spanning from 0 to 1.

Attack Parameters

In this project, we employed several techniques with specific parameters to ensure robust & effective results. Each attack of parameters has been modified to optimize the attack while keeping in mind time constraints. An example image has been provided to show what parameters are being used for each attack due to an image. Below is Figure 1-A, the base, unaltered image chosen from the Traffic Sign Model's training data. Immediately following is Figure 1-B, which is the image after undergoing preprocessing steps mentioned previously.

For the Fast Gradient Sign Method (Figure 1-C), we have set the magnitude of perturbation, denoted as epsilon, to 0.03. This choice is crucial for the method's performance in generating adversarial examples. For the Deepfool attack (Figure 1-D) we limit the maximum iterations to 50 & use an epsilon value of 1e-6. Additionally, the method considers 10 gradients & operates with a batch size of 16. These settings are vital for the precision & efficiency of the attack. The Jacobian Saliency Map Attack (Figure 1-E), we use small positive values for theta, set at 0.3, for pixel intensity. The gamma value is also kept small at 0.5, determining the maximum percentage of perturbed features. For the Newton Fool attack (Figure 1-F), we have opted for a step size (eta) of 0.01, a cap of 100 iterations, & a batch size of 1. These parameters help in gradually & effectively altering the input to mislead the model. The Spatial Transformation Attack (Figure 1-G) in our project is configured with a maximum translation of 10.0 pixels & five translation shifts. It also includes a maximum rotation of 30.0 degrees & five rotation shifts. This setup allows for a range of spatial manipulations to test the resilience of the model. For the Elastic Net (EAD) Attack (Figure 1-H), we are using a lowered confidence level of 0.01 & are using non-targeted attacks. The beta value is set to 0.001, & the decision rule is ℓ_1. We limit the maximum iterations to 50, & a batch size of 10. For the Hop Skip Jump Attack (Figure 1-I), we have chosen the $\ell\infty$ norm for adversarial perturbation. We are using a maximum of 40 iterations and a cap of 100 evaluations for gradient estimation. The initial evaluation is set at 1, with an initial sample size of 1 & a batch size of 10.

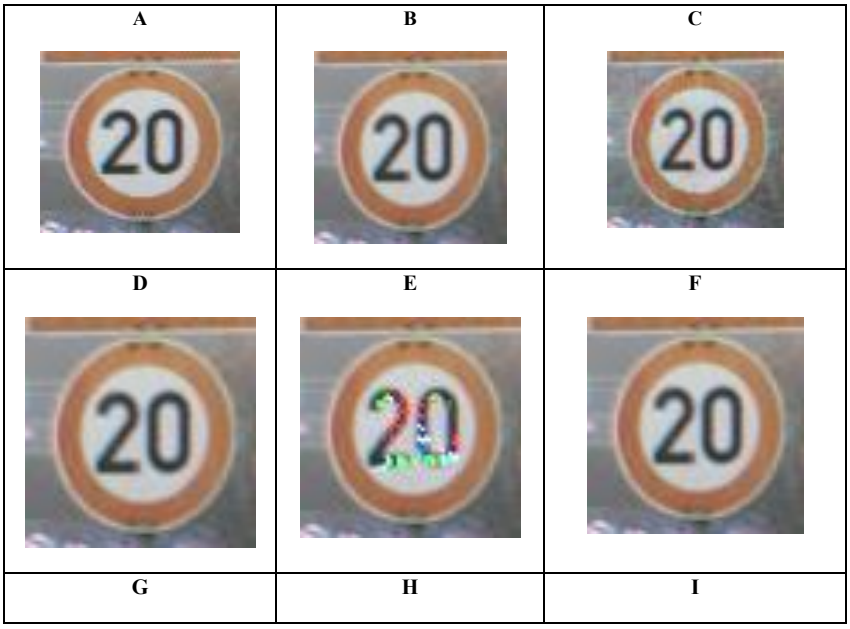

FIGURE 1: TRAFFIC SIGN MODEL'S TRAINING DATA AND ATTACKS IMPACTS

Defense Parameters

The defenses chosen for this research have a significantly lower number of adjustable parameters. For the Total Variance Minimization (TVM) Defense (Figure 2-A), the default parameters were used. The Feature Squeezing Defense (Figure 2-B) uses a bit depth of 1 & clip values between 64 & 255 to mitigate adversarial perturbations. The Spatial Smoothing Defense (Figure 2-C) uses a window size of 5.

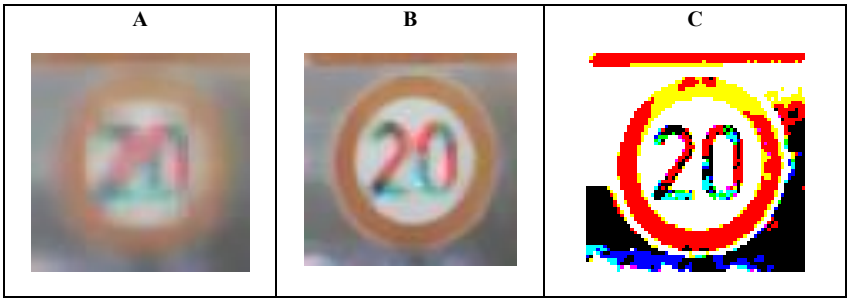

FIGURE 2: TRAFFIC SIGN MODEL'S TRAINING DATA AND DEFENSE IMPACTS

RESULTS

FGSM

The FGSM attack reduced the Traffic Sign Model's accuracy from the control of 99.00% to 35.67% with the loss going from 0.0346 to 10.2930. The Total Variance Minimization defense brought accuracy to 47.42% & loss to 4.0054. Feature Squeezing decreased accuracy to 24.17% & took the loss to 147.3359. Spatial Smoothing brought the accuracy to 40.58% & lowered the loss to 7.6843.

TABLE I: FGSM ACCURACY & LOSS

Traffic Sign	**Defense**				
	Baseline	***Attack***	***Total Variance Minimization***	***Feature Squeezing***	***Spatial Smoothing***
Accuracy	99.00%	35.67%	47.42%	24.17%	40.58%
Loss	0.0346	10.2930	4.0054	147.3359	7.6843

The FGSM attack had a similar impact on the Dogs & Wolves Model, which started with a control accuracy of 75.71% & loss of 0.5254. The attack reduced its accuracy to 37.33% & increased the loss to 1.0590. The Total Variance Minimization defense brought the accuracy to 58.83% & reduced the loss to 0.6912. Feature Squeezing increased the accuracy to 52.83% but also increased the loss to 26.3807. Spatial Smoothing improved the accuracy to 60.17% & the loss to 0.6765.

TABLE II: FGSM ACCURACY & LOSS

Dogs & Wolves	**Defense**				
	Baseline	***Attack***	***Total Variance Minimization***	***Feature Squeezing***	***Spatial Smoothing***
Accuracy	75.71%	37.33 %	58.83%	52.83%	60.17%
Loss	0.5254	1.0590	0.6912	26.3807	0.6765

Deepfool

The Deepfool attack brought the control accuracy of the Traffic Sign Model from 99.00% down to 25.00% & spiked loss from 0.0346 to 121.7477. The Total Variance Minimization defense increased accuracy to 28.67% & decreased the loss to 51.8895. Feature Squeezing & Spatial Smoothing resulted in only slight improvements in accuracy to 26.83% & 27.83% respectively & had minimal effect on loss, which was 123.4207 & 115.7801 respectively.

TABLE III: DEEPFOOL ACCURACY & LOSS

Traffic Sign	**Defense**				
	Baseline	***Attack***	***Total Variance Minimization***	***Feature Squeezing***	***Spatial Smoothing***
Accuracy	99.00%	25.00%	28.67%	26.83%	27.83%
Loss	0.0346	121.7477	51.8895	123.4207	115.7801

For the Dogs & Wolves Model, the Deepfool attack decreased accuracy from 75.71% to 28.83%, with the loss rising from 0.5254 to 0.8885. The Total Variance Minimization brought accuracy to 58.50% & lowered the loss to 0.6909. The Feature Squeezing defense accuracy rose to 66.00% & increased loss to 2.4556. Spatial Smoothing which raised accuracy to 71.67% & reduced loss to 0.6616.

TABLE IV: DEEPFOOL ACCURACY & LOSS

Dogs & Wolves	**Defense**				
	Baseline	***Attack***	***Total Variance Minimization***	***Feature Squeezing***	***Spatial Smoothing***
Accuracy	75.71%	28.83%	58.50%	66.00%	71.67%
Loss	0.5254	0.8885	0.6909	2.4556	0.6616

JSMA

JSMA brought the Traffic Sign Model's accuracy down to 33.00% accuracy with a loss of 0.9354. The Total Variance Minimization defense brought accuracy up to 76.42% with a loss of 0.5616. The Feature Squeezing

defense achieved a 40.00% accuracy & an increased loss of 8.5698. Spatial Smoothing raised accuracy to 95.50% & loss to 0.1832.

TABLE V: JSMA ACCURACY & LOSS

Traffic Sign	Defense				
	Baseline	***Attack***	***Total Variance Minimization***	***Feature Squeezing***	***Spatial Smoothing***
Accuracy	99.00%	33.00%	76.42%	40.00%	95.50%
Loss	0.0346	0.9254	0.5616	8.5698	0.1832

The JSMA attack took the Dogs & Wolves Model from 75.71% accuracy to 25.83% with a net loss of 0.6962 coming from 0.5254. Total Variance Minimization increased accuracy to 59.83% & took loss to 0.6729. Feature Squeezing accuracy went to 51.50%, but the loss also jumped to 2.1425. Spatial Smoothing brought the model's accuracy to 71.67% & had loss go to 0.6006

TABLE VI: JSMA ACCURACY & LOSS

Dogs & Wolves	Defense				
	Baseline	***Attack***	***Total Variance Minimization***	***Feature Squeezing***	***Spatial Smoothing***
Accuracy	75.71%	25.83%	59.83%	51.50%	70.67%
Loss	0.5254	0.6962	0.6729	2.1425	0.6006

Newton Fool

Newton Fool took the Traffic Sign Model from 99.00% accuracy & 0.0346 loss 55.42% accuracy & 0.6208. Total Variance Minimization boosted accuracy to 85.92% & reduced loss to 0.3377. The Feature Squeezing defense had an accuracy of 60.25% with an increased loss of 2.7786. Spatial Smoothing brought the accuracy to 91.17% & loss to 0.2076.

TABLE VII: NEWTON FOOL ACCURACY & LOSS

Traffic Sign	Defense				
	Baseline	***Attack***	***Total Variance Minimization***	***Feature Squeezing***	***Spatial Smoothing***
Accuracy	99.00%	33.00%	76.42%	40.00%	95.50%
Loss	0.0346	0.9254	0.5616	8.5698	0.1832

The Dogs & Wolves Model went from 75.71% accuracy & a loss of 0.5254 saw these numbers go to 72.00% & 0.6878 respectively. Total Variance Minimization got the accuracy to 61.33% with a loss of 0.6641. Feature Squeezing improved accuracy to 51.17% with a loss of 2.2376. Spatial Smoothing brought accuracy to 72.17% with a loss of 0.6031.

TABLE VII: NEWTON FOOL ACCURACY & LOSS

Dogs & Wolves	Defense				
	Baseline	***Attack***	***Total Variance Minimization***	***Feature Squeezing***	***Spatial Smoothing***
Accuracy	75.71%	72.00%	61.33%	51.17%	72.17%
Loss	0.5254	0.6876	0.6641	2.2376	0.6031

Spatial Transformation

Spatial Transformation brought the Traffic Sign Model's 99.00% accuracy to 36.00% with the loss going from 0.0346 to 5.3509. The Total Variance Minimization defense brought accuracy to 36.58% & the loss to 2.9240. Feature Squeezing took accuracy slightly increased to 29.75% & a loss of 11.0013. Spatial Smoothing raised the accuracy to 35.00% & reduced loss to 4.9725.

TABLE X: SPATIAL TRANSFORMATION ACCURACY & LOSS

Traffic Sign	Defense				
	Baseline	***Attack***	***Total Variance Minimization***	***Feature Squeezing***	***Spatial Smoothing***
Accuracy	99.00%	36.00%	36.58%	29.75%	35.00%
Loss	0.0346	5.3509	2.9240	11.0013	4.9725

The Dogs & Wolves Model had a base accuracy of 75.71% & loss of 0.5254 that was reduced to an accuracy of 58.33% & a loss of 0.8925. The Total Variance Minimization defense changed the accuracy to 54.17% & took the loss to 0.8591. Feature Squeezing brought the accuracy to 53.50% & the loss to 1.7477. Spatial Smoothing brought accuracy to 56.17% & loss to 0.8175.

TABLE X: SPATIAL TRANSFORMATION ACCURACY & LOSS

Dogs & Wolves	Defense				
	Baseline	***Attack***	***Total Variance Minimization***	***Feature Squeezing***	***Spatial Smoothing***
Accuracy	75.71%	58.33%	54.17%	53.50%	56.17%
Loss	0.5254	0.8925	0.8591	1.7477	0.8175

Elastic Net (EAD) Attack

The EAD Attack brought the Traffic Sign Model's accuracy from 99.00% to 52.08% with loss going from 0.0346 to 9.4748. Total Variance Minimization improved accuracy to 77.58% & took the loss to 4.0375. The Feature Squeezing defense brought accuracy to 54.75% & a loss of 19.1574. Spatial Smoothing brought accuracy to 86.50% & loss to 7.7606.

TABLE XI: EAD ACCURACY & LOSS

Traffic Sign	Defense				
	Baseline	***Attack***	***Total Variance Minimization***	***Feature Squeezing***	***Spatial Smoothing***
Accuracy	99.00%	52.08%	77.58%	54.75%	86.50

Loss	0.0346	9.4748	4.0375	19.1574	7.7606

For the Dogs & Wolves Model, the EAD Attack caused a decrease in accuracy from the original 75.71% to 25.67%, with the loss now at 0.6963 from 0.5254. The Total Variance Minimization defense resulted in accuracy going up to 62.33% & loss going to 0.6618. Feature Squeezing brought accuracy & loss to 52.33% & 2.0681 respectively. Spatial Smoothing got accuracy to 71.83% & loss at 0.6033.

TABLE XI: EAD ACCURACY & LOSS

Dogs & Wolves	**Defense**				
	Baseline	***Attack***	***Total Variance Minimization***	***Feature Squeezing***	***Spatial Smoothing***
Accuracy	75.71%	25.67%	62.33%	52.33%	71.83%
Loss	0.5254	0.5254	0.6618	2.0681	0.6033

Hop Skip Jump

Hop Skip Jump brought the Traffic Sign Model from 99.00% accuracy & 0.0346 loss to 27.25% accuracy & 1.0215 loss. Total Variance Minimization brought accuracy to 83.83%, & loss to 0.3944. The Feature Squeezing defense brought accuracy to 47.25% & loss to 3.7941. The Spatial Smoothing defense boosted accuracy to 68.00% & took loss to 0.7840.

TABLE XII: HOP SKIP JUMP ACCURACY & LOSS

Traffic Sign	**Defense**				
	Baseline	***Attack***	***Total Variance Minimization***	***Feature Squeezing***	***Spatial Smoothing***
Accuracy	99.00%	27.25%	83.83%	47.25%	68.00%
Loss	0.0346	1.0215	0.3944	3.7941	0.7840

In the Dogs & Wolves Model, Hop Skip Jump lowered accuracy from the control of 75.71% to 51.67%, & the loss from 0.5254 to 0.6153. Total Variance Minimization got the model to an accuracy of 60.00% with a loss of 0.6677. The Feature Squeezing defense brought accuracy to 56.33% with a loss of 1.8467. Spatial Smoothing raised the accuracy to 67.00% with a loss of 0.6171.

TABLE XII: HOP SKIP JUMP ACCURACY & LOSS

Dogs & Wolves	**Defense**				
	Baseline	***Attack***	***Total Variance Minimization***	***Feature Squeezing***	***Spatial Smoothing***
Accuracy	75.71%	51.57%	60.00%	56.33%	67.00%
Loss	0.5254	0.5254	0.6677	1.8467	0.6171

DISCUSSION

Most of the attacks & defenses performed as expected according to the hypothesis, aligning with the expected results & prior research in this field. There were a few notable exceptions to this trend, specifically the Spatial Transformation & Newton Fool attacks as well as the Feature Squeezing defense. These attacks & defenses stood out as they deviated from both the expected outcomes & the general outcomes seen with the other attacks &

defenses. This suggests some sort of unique characteristics or vulnerabilities in the AI models that were tested or vulnerabilities in them.

The Spatial Transformation & Newton Fool attacks were particularly effective against the Dogs & Wolves Model. Once these attacks were applied to this model, any defense applied to these attacks either worsened the accuracy or improved it by a negligible amount. In this case a negligible increase is defined as less than 1%. It is designed to cause very subtle perturbations on images while retaining a high confidence level when predicting. Due to these subtle perturbations, it seems that this attack is more effective against the Dogs & Wolves dataset because it is a more complex & has less distinct features. Minor perturbations against this would be much more devastating than against a more 'black & white' dataset such as with the Traffic Sign Model, where this was not an issue.

The Spatial Transformation attack had a similar interaction with the Traffic Sign Model. Once this attack was carried out against the model, any defense that was applied to it resulted in either a notable decrease in accuracy or an increase in accuracy that was negligible, less than 1%. The Spatial Transformation was so effective against both models because it performed changes to the images that the defenses would not be made to fix. This attack causes images to be rotated or translated to deceive the model. These perturbations are not accounted for by the defenses we are using, therefore the defenses not only did not fix the issue but also attempted to fix perturbations that were not there- causing even more alterations to the image. This goes for the Dogs & Wolves Model as well.

CONCLUSIONS

In conclusion, the conducted analysis of various attacks and defenses aligns well with the anticipated outcomes based on the hypothesis and existing research in the field of adversarial attacks on AI models. However, certain exceptions were noteworthy, particularly with the Spatial Transformation and Newton Fool attacks, along with the Feature Squeezing defense. These deviations from expected results suggest unique characteristics or vulnerabilities within the tested AI models.

The effectiveness of the Spatial Transformation and Newton Fool attacks against the Dogs & Wolves Model revealed a pronounced impact on the model's accuracy. Interestingly, applying defenses to these attacks either worsened accuracy or resulted in negligible improvements. The subtle perturbations caused by these attacks appear to be more impactful on a complex dataset like Dogs & Wolves, which lacks distinct features compared to a more straightforward dataset like the Traffic Sign Model.

The Spatial Transformation attack exhibited a similar pattern with the Traffic Sign Model, causing defenses to either substantially decrease accuracy or yield negligible improvements. This efficacy could stem from the attack introducing changes that defenses were not designed to address, such as rotations or translations, thereby causing unintended alterations to the image.

Notably, the Feature Squeezing defense consistently led to a significant increase in loss, raising concerns about potential long-term issues such as overfitting on new images. While this defense improved accuracy in most cases, the substantial loss increases prompts careful consideration of its implications on model robustness.

The findings underscore the importance of understanding the nuanced interactions between specific attacks, defenses, and the characteristics of the datasets and models involved. Future research should delve deeper into the unique vulnerabilities exposed by these exceptional cases, informing the development of more robust defenses against adversarial attacks in AI models.

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Security and Privacy Mechanisms of Electronic Health Records - a Delphi Study

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NOTE: At the request of the authors, this manuscript is not included in these proceedings

Abstract

Electronic health record systems (EHRs) benefit physicians, patients, and healthcare organizations. This system enhances the coordination and effectiveness of healthcare practices, improves the quality of care for patients, and has been extensively adopted in many countries. However, these systems are plagued by several security and privacy issues and sometimes fail to live up to the expectations that are placed on them. The extant literature does not provide a comprehensive picture of the security and privacy mechanisms used in EHRs. As a result, we conducted a Delphi study of the security and privacy mechanisms currently being used in EHRs. In this study, we engaged an expert panel of eighteen (18) IT security and privacy experts with extensive EHR systems experience from different US healthcare institutions. The panel's expertise was leveraged to identify commonly deployed IT security and privacy mechanisms, the impact of increased security and privacy mechanisms on usability, challenges faced within the EHR landscape, and suggestions to improve the security and privacy of EHRs.

Ph.D. student submission?

Yes

BLOCKCHAIN TECHNOLOGY ADOPTION AND IMPACT ON FINTECH INTERNATIONAL TRANSACTIONS:

A LITERATURE REVIEW

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Abstract— This paper investigates the use and effects of Blockchain Technology on Fintech International Transactions (International Wire Transfers). The study aims to provide additional theoretical interpretations on how adopting Blockchain Technology can expedite and reduce the cost of financial transactions on Fintech platforms. Blockchain is a revolutionary and trending innovation in the technological sphere, and it has the potential to transform the traditional money (fiat currency) transfer system. Banking has progressed from being cash hubs in early empire temples to offering loans, certificates of credit (CDs), and other financial products. Modern banking has evolved to include emerging technological innovations that have facilitated the development of Blockchain Technology.

Blockchain Technology is one of the most remarkable, sophisticated, and groundbreaking technological innovations of the 21st century, and it has made a significant impact in the Fintech industry. This technology is a distributed, immutably encrypted digital and tamper-proof ledger used for recording transactions. Blockchain Technology reduces transaction costs, generates distributed trust, and empowers decentralized platforms, making it a new foundation for decentralized business models that are more distributed, innovative, interoperable, borderless,

and transparent. This study suggests that the strategic and innovative adoption of Blockchain Technology can facilitate a faster, easier, less expensive, safer, and more reliable process of Fintech International Transactions on Fintech platforms. Traditional cross-border payments can be expensive, but this paper proposes that adopting Blockchain Technology on Fintech International Transactions through Fintech platforms can accelerate low-cost and faster financial transactions, leading to novel Technology Management (TM).

Key Words— Blockchain Technology, Fintech International Transactions, Technology Management (Emerging Technology), Algorithm, Machine Learning, and Data.

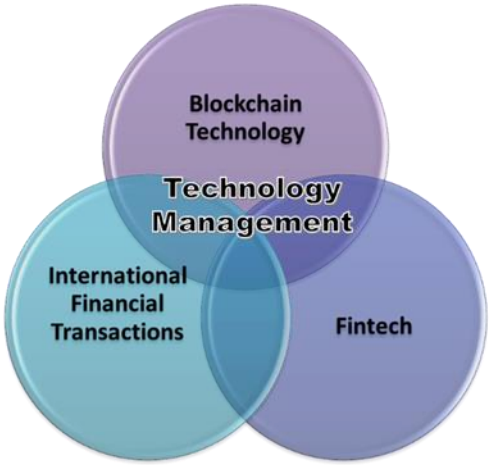
Introduction

With the rise of digitalization trends, Fintech has transformed and reshaped business practices, and several industries. A growing body of literature on Fintech aims to inform professionals in this field and provide a comprehensive insight into this body of work. This knowledge helps these professionals make informed decisions that promote their craft and save time. The Fintech industry is gradually maturing and offers a variety of financial products on the global stage.

Fintech activities on International Financial Transactions outline the integration of financial strategic integration with modern technology strategy through Technology Management (TM). Technology Management is a dynamically evolving discipline that integrates the technology-dominated world of engineering with management and is also referred to as "Engineering Management." Technology Management is the link between engineering, science, and management disciplines, and it accomplishes the operational objectives of an organization through planning, developing, and implementing abilities. [1]

Financial activities like wire transfers allow currencies to be moved quickly and securely without exchanging cash. The process enables two parties to transfer funds safely, even if they’re in different (geographic) locations. These transfers are carried over a network of banks and non-banking services such as Money Transfer Operators (MTOs). Sufficient measures are taken through Fintech to ensure that the cash is not wired for money laundering or financing terrorism.

Figure 1: *The Scope of Technology Management*



LITERATURE REVIEW METHODOLOGY.

The study is based on a solid theoretical foundation of relevant existing theories through scholarly articles from highly respected academic journals. The objective is to inform experts in the field of finance who do not have the time to build a comprehensive insight into the body of knowledge available to make informed decisions. ([2], [3], [4], [5], [6]). This paper, therefore, provides novel insights [7] by discovering, assessing, and interpreting all available research relevant to adopting Blockchain Technology on International Wire Transfers through Fintech.

This study was developed by conducting an extensive literature review on Blockchain Technology, Fintech International Transactions, and Technological Management (Emerging Technology). To validate this research, sample data were collected from over 100 articles from Elsevier Science Direct, JSTOR, IEEE Xplore, ABI\ Inform, and Google Scholar.

This study also highlights the advantages of utilizing Blockchain Technology as an Emerging Technology to effectively replace the traditional method of International Wire Transfers, which can be slow and costly. However, Blockchain Technology can help Fintech companies accelerate these transactions faster, more securely, and cost-effectively.

There are limited academic studies that shed light on how disruptive technologies, like Blockchain, effectively impact the dynamically evolving discipline that integrates the Emerging Technology [8] world of engineering through Technology Management (TM) with the management of Fintech International Transactions.

TABLE I: NUMBER OF PAPERS BY THEME

Blockchain FinTech International Financial Transactions Technology Management *Factors*	No. of Papers
Blockchain	19
Fintech	16
International Financial Transactions	5
Technology Management (Emerging Technology)	3
Databases (primary):	ABI/Inform, Google Scholar, Investopedia, IEEE Xplore, ProQuest, Elsevier Science Direct, JSTOR

FINTECH

Fintech, as an Emerging Technology, is gradually maturing and offers an extensive array of financial services on the global stage. Fintech is an intersection between finance and technology that automates and gradually switches financial services from traditional methods to digitalization processes. Blockchain Technology and Fintech International Transfers' synergy is successfully accelerated by the Technology Management (TM) discipline as an Emerging Technology.

Research on Fintech proves that Fintech charters enhance the financial industry's effectiveness, as this has flourished in recent years [9]. The effect of this technological exploration also highlights the tremendous impact\profitability Fintech has on all asset classes and the abundance it gives on the return on investment.

Whether Fintech causes the fragility of financial institutions[10] remains controversial, and the regulatory stance is put in place to preserve financial institutions' privacy. At this point, Fintech regulatory sandboxes are used to examine the numerous sensitivities of financial institutions.

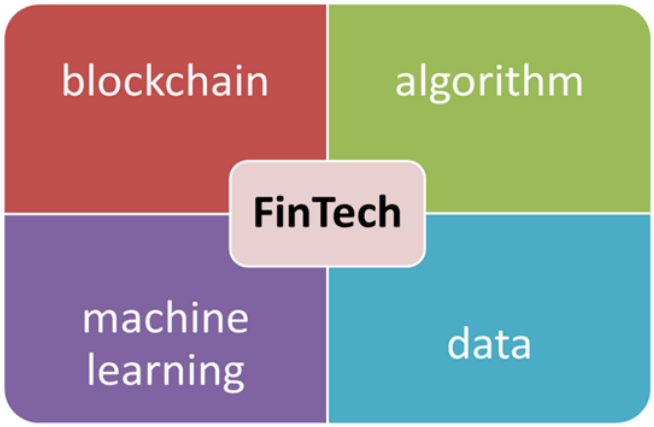


Figure 2*: *Blockchain Technology in Fintech

BLOCKCHAIN

Blockchain is one of the most remarkable and Emerging Technological novelties of the 21st century. The technology reduces transaction costs, generates distributed trust, and empowers decentralized platforms, potentially becoming a new foundation for decentralized business models [11].

Blockchain Technology first emerged as a tool facilitating cryptocurrency in 2008 when S. Nakamoto introduced 'Bitcoin' as the first P2P [12] digital cash system using Blockchain [13]. However, this is not what this paper represents. However, Blockchain is a buzzword describing the current excitement for innovative technology [14].

Blockchain is essential to Fintech [15]. It maintains the position on how much strategic impact Blockchain has on Fintech as an Emerging Technological trend. Research has been carried out on Blockchain to find its prospective effects on the technological space. It should, however, be noted that the productive impact of Blockchain on Fintech

International Transactions is still shrouded in the unknown.

BLOCKCHAIN AND ALGORITHM

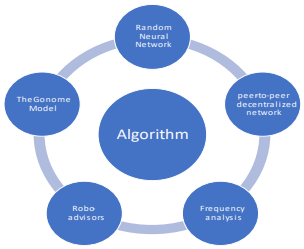


Figure 3: *Algorithms are used to analyze the relationship between Fintech patents and performance for classification rule purposes.*

Algorithms is an engineering process that proposes the relationship and capabilities of using machine learning in the peer-peer decentralized network to achieve an eloquent frequency analysis using the random neural network, genome model, and the robo advisor to achieve profitability using Blockchain in Fintech [16], [17], [18], [9].

The burgeoning financial technology scene in Singapore has seen robo-advisors emerge, which aim to disrupt traditional financial advisories by using algorithms to automate client advising and investment recommendations [19]. The ecologies concept has shown how lay investors are conveyed into global financial networks through robo advisors. The argument is made that investors are rendered passive by the disciplinary tools of algorithms, contemporary finance theories, and elements of robo-advisor platforms that feed into these socio-technological assemblages.

V. Blockchain and Machine Learning

Machine learning encompasses various cognitive techniques, notably deep learning, which relies on artificial neural networks and puts essential past accomplishments in order while identifying critical challenges and future opportunities.

Distribution: Machine learning classifies and distributes each node's financial accounts and backup data. The financial sector's digital transformation has led to more digitized business models and processes and new products and services [20]. This exploration insists that the past decade has witnessed the rise of digital advisory and trading systems, artificial intelligence and machine learning, peer-to-peer (P2P) [17] lending [12], crowdfunding, mobile payment systems, and even new monetary capabilities, with various forms of digital money, such as Bitcoin and other crypto assets.

Cyber-Attack: In the digital age today, attacks on financial data pose a significant risk, so it is necessary to establish numerous precise measures to safeguard the security and privacy of our financial data [21]. The paper elaborates on the security and reliability of financial data and the security of financial data transactions. Using the form of nodes to retain the copy data of financial accounting, in this way to prevent the failure of the network. Smart Contract: Smart contracts are the technical tools essential to the Blockchain system. As far as the smart contract is an auto-execution of codes that permits the organization to be self-sufficient. Network security is the main component of this feature, where people can trust the system for financial transactions [22]. The security mechanism based on distributed consensus and public ledger is one of the fundamental attributes of the Blockchain. The wrong practices and types of fraud that Blockchain Technology can prevent. The threats to the Blockchain will also be discussed, and appropriate defensive measures to fight against such threats and dangers will be recommended. Due to its distributed nature and the absence of a central point of failure, the elasticity of systems and data storage can be boosted with Blockchain Technology.

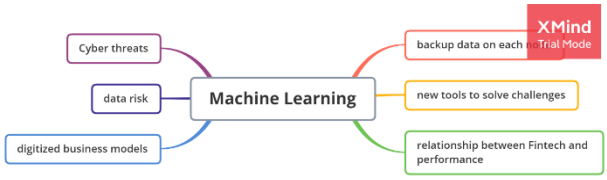


Figure 4: *The characteristics of machine learning*

VI. Data

Figure 5: *Data is engineered by trust and new digital technologies.*

Trust is an essential feature of Blockchain Technology. As a decentralized network, it eliminates every form of dependency on third parties by encrypting all transactions and records without the supervision or verification of an intermediary. This promotes a secured proof of work protocol that guarantees every network transaction. This feature revolutionizes the essence of the financial sector [23], [6], [4]. Trust has remained a primary challenge in establishing digital payments and International Financial Transactions [24].

In 1905, Einstein intuitively found the absolute truth that the speed of light is infinite: “unendlich große Geschwindigkeit.”4 p.903 In experiments conducted after 1905 to test Einstein’s predictions, there are three main direct experimental findings concerning the behavior of properties (mass, time, and space) when an object increases speed: (1) mass increases, (2) time goes slower, and (3) space shrinks. Thus, at the speed of light, (1) mass becomes infinite, (2) time becomes zero, and (3) space becomes zero. [25]. At this point, it is safe to say that Blockchain’s intuitive element of trust operates at the speed of light, which compresses all forms of mass, time, and space to achieve an efficient and effective technology.

New digital technologies in finance affect “access to finance.” There are a handful of previous reviews about Fintech, which give details on exceptional conversations about the evolution of the industry, technology/platforms, and the specific areas of Fintech. [26].

Trust is needed because of selfish mining [27]. Trust has limitations in Blockchain Technology; here, miners verify. Miners are the people who find transactions getting reimbursed for every node to form blocks to be verified.

Verification is done automatically in Blockchain, producing a transaction record on the entire network. Humans and system intermediaries are eliminated on all levels. Instead, the transaction is strictly between the user and the technology directly. With mobile wallets, peer-to-peer payment (technology of paying at the point of sale with a smartphone) is increasingly available. Still, retailers are reluctant to invest until consumers accept it. The primary concern is trust and usefulness as significant factors [24].

VII. Conclusion

The adoption and impact of Blockchain Technology on Fintech International Transactions integrates various state-of-the-art technologies such as mobile, embedded systems, mobile networks, mobile computing, cloud, big data, data analysis technology, and embedded cloud computing, including Fintech advancement [28], [29], [30], [31]. These include algorithms, machine learning, and data.

The study explains Blockchain Technology as a facilitator for a faster, easier, cheaper, and safer means of conducting transactions on Fintech platforms. It has been effectively claimed that the adoption and impact of Blockchain Technology on Fintech International Transactions has shown proof of its significance in the financial industry. This reality should be held to the same academic standards as the rest of the finance academic literature to offer helpful advice to finance practitioners. Numerous patterns have been observed in technology trajectories, helping to understand how Emerging Technologies improve every aspect of human life. The same applies to Blockchain Technology on Fintech platforms, where transparency, accountability, and privacy are vital components. Hence, more attempts should be made by governments, policymakers, and financial institutions to ensure regulations are put in place to support an effective security environment intricated with financial technologies.

Blockchain Technology on Fintech International Transactions on Fintech platforms is between an unstable and dominant phase, as it is fast becoming an Emerging Technology to reckon with. More efforts should be put in place to ensure that the transactions made on these decentralized networks using encrypted nodes are secured from being tampered with, and this will ultimately increase the experiential value of using Blockchain Technology on Fintech International Transactions.

The evolution of Emerging Technologies revolves around proffering solutions to challenges that may likely

develop in financial transfers, allowing for more robust and practical development of Fintech applications. Blockchain Technology and Fintech are prevalent topics [32] among technology leaders in finance. It is causing a tectonic shift in the financial industry. In addition, this technology is necessary for Fintech companies to leverage the benefits of decentralization Blockchain Technology offered through Technology Management.

Adopting Blockchain Technology may create a competitive advantage to simplify Fintech International Transactions and financial processes through Smart Contracts (self-executing contracts with the terms of the agreement between buyer and seller [33] directly written into lines of code). This will automate various processes in International Wire Transfers, such as AML (Anti-Money Laundering) checks, helping to streamline the process and reduce the time and costs associated with manual processing.

FUTURE RESEARCH

Due to the limited scope of this study, it may be proposed that using Blockchain Technology may accelerate Fintech International Transactions, financial services, IT companies, banks, and other industries to develop and promote Blockchain-based applications by engaging the construction of sophisticated technology and campaigns to create awareness. Blockchain Technology has much to offer the financial system and all business transactions as this will ultimately leave an impressionable mark on this information age and throughout history.

Finally, advancing Technology Management through Emerging Technologies [34] may continually birth projects like Ripple, which employ technology that successfully provides alternative infrastructure for Fintech International Transfers through Blockchain Technology [35]. Ripple is focused on international payments. It primarily allows financial institutions, like banks, Fintech, and non-banks, to negotiate their fees on its network directly, bypassing Swift (Global provider of secured financial messaging network) or other services that take several days to settle and allow them to settle instantly.

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DX Visualization of assembly task Speed by 3d coordinate data Using motion capture

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ABSTRACT

In recent years, Digital transformation (DX) has been applied in manufacturing industry. For instance, the working time for assembly task was reduced by analyzing the workers' task with motion capture. However, the working time for assembly task depends on the speed of workers' motion. Therefore, it is necessary to analyze how workers can reduce their working time by improving the speed of workers' motion. This study visualizes the speed of nut-tightening process and discusses more efficient work using motion capture technology.

.

Key Words: Work Analysis, Nut-tightening, Velocity of Movement, Improvement, Working Task

Introduction

Digital transformation (DX) has been applied to manufacturing industry in order to improve productivity in recent years. Hitachi Corporation improved the efficiency of the manufacturing industry by collecting and analyzing the data with DX [1]. Karube et al. [2] found that the working time for assembly task was reduced by analyzing the workers' task with motion capture. Since the working time for assembly task depends on the speed of workers' motion, it enables us to improve the working tasks by analyzing the speed of workers' motion. Therefore, it is necessary to know how workers can reduce their working time by improving the speed of workers' motion. Moreover, the learning effect is also known when a person does a task repetitively [3]. Thus, the worker's task could be improved by measuring the speed of workers' motion before and after the learning.

In production facilities, in order to measure human movements as 3D coordinate data, motion capture technology has been applied. Kawane et al. [4] proposed a worker estimation approach using an optical motion capture and deep learning software. Similarly, Hayashi et al. [5] used an optical motion to visualize 3D with disassembly tasks and discussed the learning effect. Furthermore, Reza et al. [6] proposed MR (Mixed Reality) system for training by using AI analysis. Additionally, the learning effect was discussed by comparing the experienced and novice workers with their motion. Karube et al. [2] analyzed the experienced workers and novice workers by time-series data, and discussed the learning effects. Kawane et al. [7] discussed the difference of experienced and novice workers. However, these studies primarily focused on coordinate value for each body part, did not analyze how workers move and suggest how they improve their task by visualizing the assembly task speed.

This study visualizes speed of assembly task in a case study for nut-tightening process and discusses more efficient work using motion capture technology. Thus, research questions (RQs) are developed as follows:

RQ1: What is the fastest speed in nut-tightening process?

RQ2: What movement is performed when the fastest speed is observed?

method

Research procedure

This study applies a three-step process based on the work by Kawane et al. [4][7] to our case. In Step 1, we collected motion data for the assembly task, which was recorded as three-dimensional time-series coordinate data using optical motion capture technology. In Step 2, these coordinate data were preprocessed to calculate the speed of movement. In Step 3, the data were analyzed by comparing the performance of trials.

Nut-tightening work

The MAC3D Kestrel-300 optical motion capture system was used for data acquisition based on a measurement procedure established by Kawane et al. [4][7] and Karube et al. [2]. According to the procedure similar to Kawane et al. [4][7], Helen Hayes Marker Set was used [8]. The data collection process is as follows.

1. The worker wear a clothing with ten reflective markers, and a wrench with reflective markers was employed on the upper jaw and grip (Fig.1).

2. The nut was tightened for two turns using the wrench, following a pre-marked line.

3. The process was reiterated ten times, with a five-min break in between the works, and this cycle was repeated three times. The worker experimented total of 30 work trials.

The experimental condition are as follows:

- The nut-tightening work is conducted with the wrench and instrument on the desk with standing.
- The worker tightens a wrench by his handedness and hold the instrument by other hand.
- The worker was right-handed.
- The amount of data for 3D coordinates obtained via optical motion capture included operation of approximately 15 seconds, consisting of approximately 36,000 data (approximately 1000 frames× 3 dimensions × 12 markers).

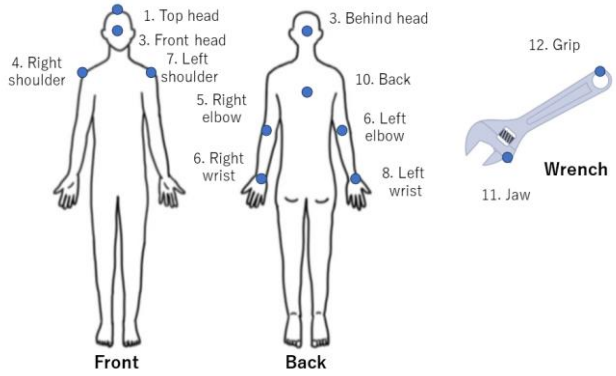
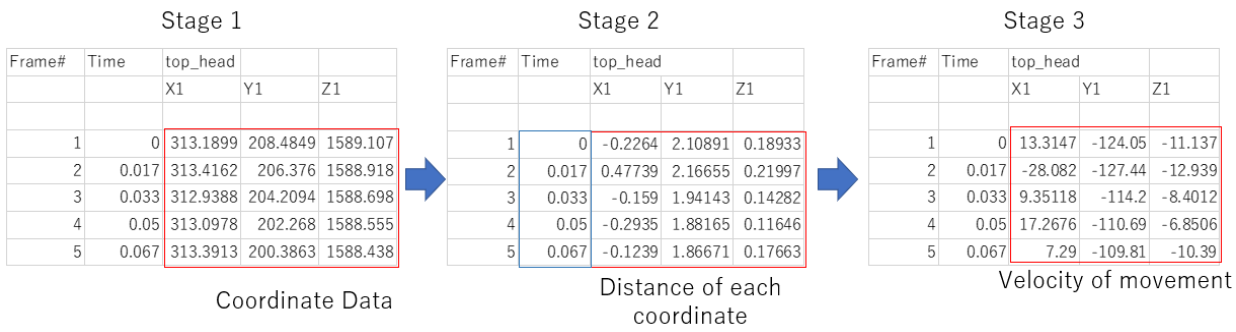


Fig. 1. Position of reflective markers [2]

Calculation procedure for the speed of nut-tightening work

Fig.2 shows the procedure to calculate the speed of movement. Stage 1 means the raw data for nut-tightening work, and they include data of frame numbers, time and coordinate. These data obtained by using motion

capture system. In stage 2, the distance of each coordinate is obtained by subtracting before and after frames. In stage 3, the speed of movement is calculated by dividing the distance of each coordinate by time of frames. In this case, each time flame is 0.017 sec.



Frame#	Time	top_head		
		X1	Y1	Z1
1	0	313.1899	208.4849	1589.107
2	0.017	313.4162	206.376	1588.918
3	0.033	312.9388	204.2094	1588.698
4	0.05	313.0978	202.268	1588.555
5	0.067	313.3913	200.3863	1588.438

Frame#	Time	top_head		
		X1	Y1	Z1
1	0	-0.2264	2.10891	0.18933
2	0.017	0.47739	2.16655	0.21997
3	0.033	-0.159	1.94143	0.14282
4	0.05	-0.2935	1.88165	0.11646
5	0.067	-0.1239	1.86671	0.17663

Frame#	Time	top_head		
		X1	Y1	Z1
1	0	13.3147	-124.05	-11.137
2	0.017	-28.082	-127.44	-12.939
3	0.033	9.35118	-114.2	-8.4012
4	0.05	17.2676	-110.69	-6.8506
5	0.067	7.29	-109.81	-10.39

Fig. 2. The procedures to calculate the speed of movement

Results

Comparing the speed of movement

In this section, the speed of nut-tightening task is analyzed in order to discuss when the worker improve the task to reduce working time. In particular, the differences of the speed of nut-tightening tasks for right shoulder by a worker was focused on since the worker has a large movement for the right shoulder when the worker tighten. Additionally, the 2nd and the 3rd trial are treated and compared because a drastic improvement was observed between the 2nd and 3rd trials by 34.21% with learning effect, and the improved value was the largest in all trials.

Figs. 3 and 4 show the frequency of movement speed at the 2nd and the 3rd trials for the right shoulder, respectively. The positive values indicate that the movement of forward direction while the negative values represent movement of backward direction. The forward direction means the movement of pulling, thus, this movement shows the tightening tasks. On the other hand, the backward direction represents the movement of returning while the worker releases the wrench from the nut and remove to prepare the next nut-tightening task. This is because the movement for the backward direction is opposite to the nut-tightening. As shown in Figs. 3 and 4, the fastest speed of the forward direction was 104.7 mm/s at the 2nd trial and 157.8 mm/s at the 3rd trial, respectively. The fastest speed for the forward direction was increased by 50.7% from the 2nd to the 3rd trials. Moreover, the average of the movement speed for the forward and backward direction were 35.9 mm/s and 45.5 mm/s, respectively. These results indicate that the working time was reduced by increasing the speed for the forward direction. One of the reasons is that the movement in the forward direction could be improved by reducing the preparing time for retuning the wrench in order to prepare the next nut-tightening task.

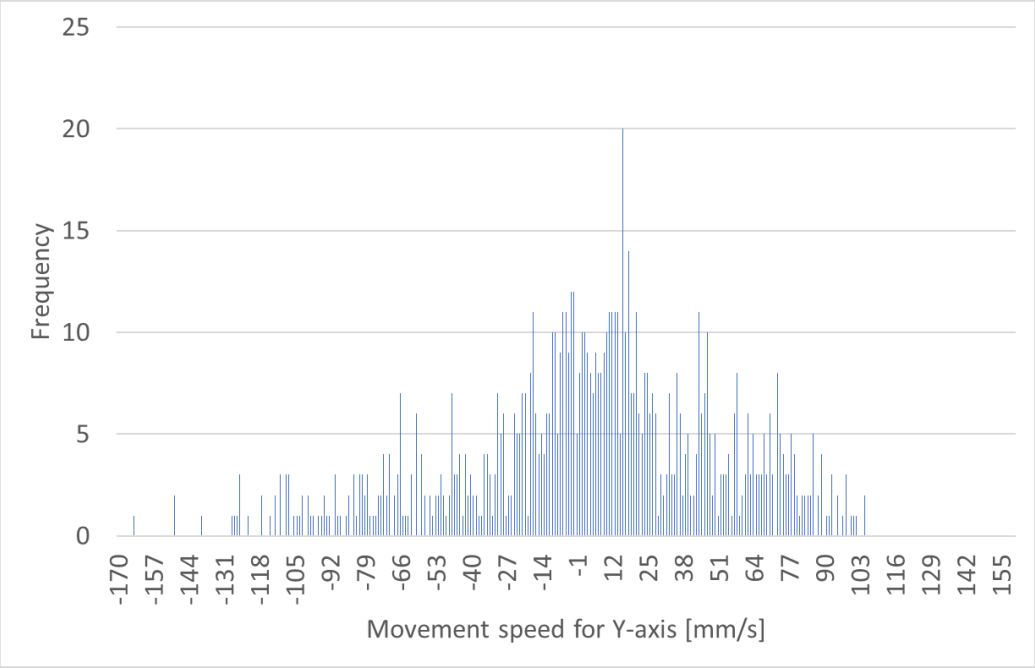


Fig.3. Frequency of movement speed for right shoulder: The 2nd trial

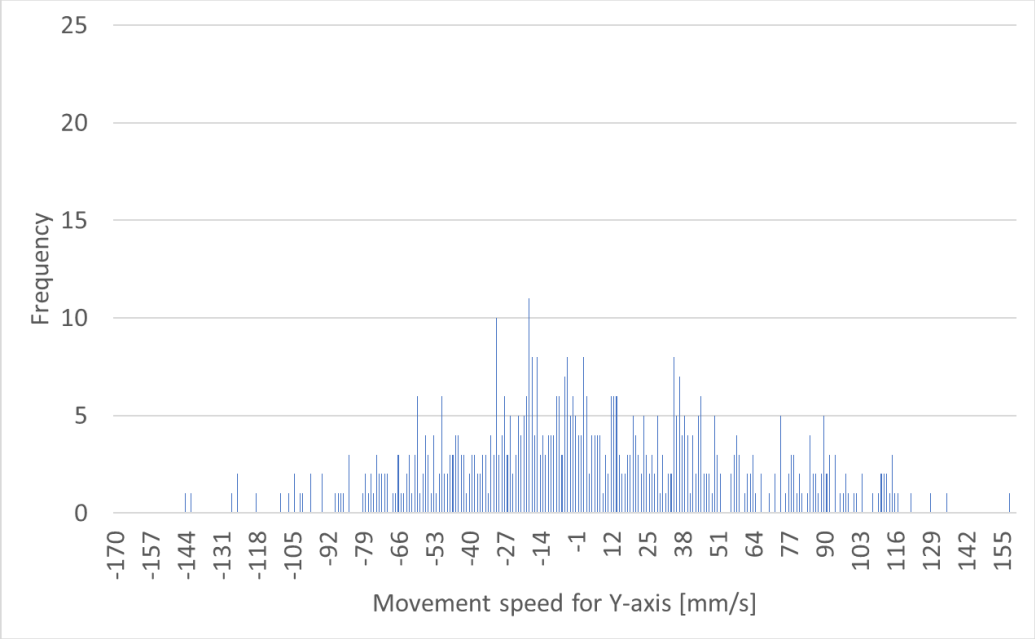


Fig.4. Frequency of movement speed for right shoulder: The 3rd trial

Comparing the coordinate data

This section analyzes the movement of worker when the fastest speed is observed. Figs. 5 and 6 show the coordinate value of Y-axis for right shoulder by unit time frame at the 2nd and 3rd trial. The horizontal axis represents the number of unit time frame while the vertical axis means the coordinate data of Y-axis for each time frame. The forward direction indicates the positive value on the Y-axis which means the preparing task for nut-tightening. On the other hand, the downward direction indicates the negative value on the Y-axis which means the nut-tightening task.

Additionally, the top 3% of the fastest movements for the backward direction at each trial were indicated by red dots as shown in Figs. 5 and 6. The dots were recorded for the frame #1, 3-5, 506-510, 588-596 and 601-606 at the 2nd trial in Fig. 5. Similarly, Fig. 6 shows the coordinate value for right shoulder by the time frame at the 3rd trial. The dots were recorded for the frame #304-307, 364-365, 448-457 and 573-577. As shown in Fig. 5 for the 2nd trial, this speed for backward direction at the beginning or middle timing of each nut-tightening task was faster than one at the end timing of the task. On the other hand, regarding the 3rd trial in Fig. 6, the speed of movement for the backward direction at the end timing of the task was faster than one at the other timing. Thus, in this nut-tightening task, it is said that the worker can improve the efficiency by increasing the speed of movement at the end of the task.

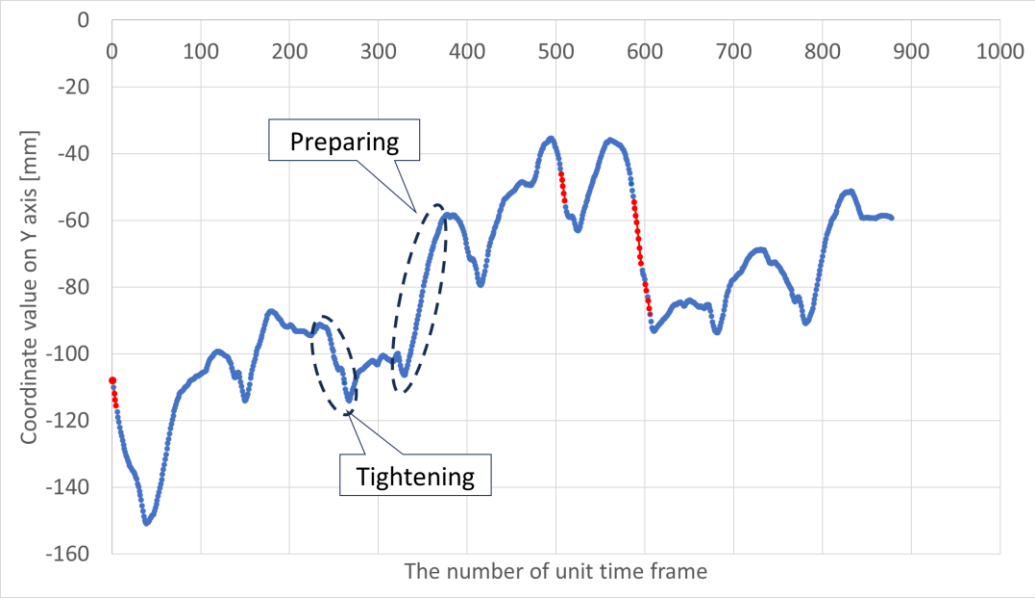


Fig.5. The coordinate date for right shoulder by unit time frame at 2nd trial

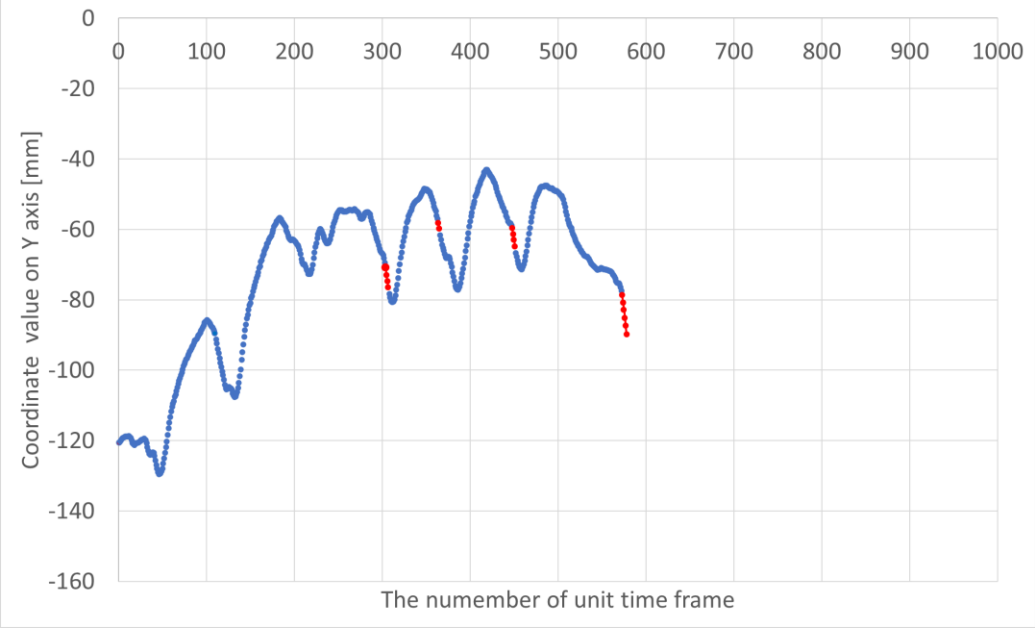


Fig.6. The coordinate date for right shoulder by unit time frame at 3rd trial

SUMMARY ANd FUture study

This study visualized speed of nut-tightening process and discussed more efficient work via motion capture technology. Among the total of 30 trials, the working time became relatively shorter. Especially, the working time between the 2nd and the 3rd trials were reduced. Future work should consider and analyze the data with machine learning because vast amount of coordinate data can be obtained.

Acknowledgements

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Papers

Decision Support Systems (DSS), Machine Learning, and Artificial Intelligence

AI-ENHANCED DECISION-MAKING: INTEGRATING IT BEST PRACTICES WITH EXPERT INSIGHT

Dr. Andres Fortino and Weiyun Zhang

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Abstract

As information technology continues its rapid evolution, CIOs and CTOs face growing complexity in adopting new technologies. This research paper proposes leveraging artificial intelligence (AI) tools to help CIOs identify and apply relevant "laws" or best practices to make optimal technology decisions. We develop a system integrating a large language model with specialized prompts guiding users through 40 key IT industry principles or laws. Our methodology focuses on designing prompts that extract insights into how these technology laws apply in specific organizational contexts. We test the system's responses against subject matter expert analysis in difficult scenarios spanning cloud adoption, agile development, and analytics implementation. Results demonstrate very close agreement between the AI-generated recommendations and experts' conclusions regarding applicable laws and optimal actions. We demonstrate how to build such a chatbot. Additionally, the tool shows strong potential to enhance user understanding and significantly reduce research time. This research makes both a practical contribution - enabling AI augmentation of CIO decision-making - and a theoretical addition by providing a model for integrating AI into organizational technology management processes. We discuss implications and limitations, proposing future research directions on explainable generative AI in this problem domain.

Introduction

Recent breakthroughs in artificial intelligence (AI) have yielded large language models capable of ingesting vast volumes of text across domains and subsequently generating written works indistinguishable from human outputs in certain business verticals (Grace, 2018; Thoppilan et al., 2022). However, doubts persist regarding the depth of comprehension exhibited by such AI systems – whether they develop rich conceptual connections between elements or mainly surface pattern associations from repeated exposures (Marcus & Davis, 2022). Advances in assessing representation abilities require experiments probing situational applicability beyond training interpolations.

This paper details findings from an evaluation comparing the performance of an AI assistant trained on a corpus of technology strategy concepts we label the Technology Laws of the IT Industry, against subject matter experts in selecting relevant explanatory laws for 37 novel case studies. The introduction hypothesized AI competence, evidencing advanced conceptual functionality, should rival professionals. Across all cases, full concordance occurred between the laws suggested independently by the AI assistant and analyst choices.

The documents used to train the AI assistant contained seminal works on foundational and contemporary principles codifying key causal relationships, empirical trends, and conceptual models underpinning information systems scholarship. By scrutinizing these materials, modern large language models develop an ability to link concepts and conditions probabilistically from word co-occurrence statistics through deep neural networks, succeeding where previous rule-based AI failed (Bommasani et al., 2022). Successfully applying extracted patterns to never-before-seen situations demonstrates meaningful induction.

However, critics question if models merely accumulate surface associations versus human-like abstraction of deeper significance (Marcus & Davis, 2022). By training AI assistants on expert literature encompassing explanatory generalizations, quantitative observations, and theoretical frameworks and subsequently evaluating advisor competence on novel test problems, this research aims to validate higher-order inference comprehension functionality.

This paper presents complete details of the experiment and an analysis of the results. But briefly, full concordance between AI selections and expert judgments across 37 case study challenges provides affirmative evidence of adept contextual comprehension. Such demonstratable discernment further paves the pathway for credentialing AI readiness for professional practice augmentation. By partnering human expertise with AI tools exhibiting procedural fluency and conceptual facility, practitioners can multiply impacts while concentrating uniquely human skills where they contribute most.

Research Questions

In this paper, we examined three research questions comparing an AI model's ability to select applicable technology-based laws to IT problems versus human expert performance.

Research Question 1. How capable are current AI language models at extracting conceptual relationships from texts and applying that understanding to select relevant framework laws for unseen cases?

This question examines whether AI can build an underlying mental model from absorbing materials on various laws and principles, accurately inferring linkages between them in a domain, and then appropriately mapping selections to new situation details. It tests for higher-order comprehension versus just pattern recognition.

Research Question 2. To what extent can large language models match or exceed subject matter expert performance in selecting theoretically impactful IT laws for industry case analyses?

This question directly compares AI output to human expert baselines on a key industry analyst competency. It aims to benchmark AI readiness relative to practitioners for professional workflow augmentation in strategic advisory contexts. Findings could identify areas needing improvement.

Research Question 3. Can an AI model develop a facility with a business academic literature corpus to independently propose novel, insightful perspectives not explicitly stated when given new IT business contexts?

This examines the higher bar capability of AI models to go beyond training material recall and interpolation to extrapolate completely new relevant analysis angles for conditions based on its conceptual command of the domain. It tests AI reach versus just mimicking existing expert conventions.

The theme behind such research questions explores validating generative AI abilities to build meaning from bodies of specialized knowledge for competent application versus just surface-level statistical associations. Our findings, when applied to one such industry knowledge base, show that AI has strengths in this area that can be leveraged for decision support.

Theoretical Basis

Recent advances in natural language processing have resulted in large language models that can ingest sizable textual corpora and demonstrate an ability to generate work products indistinguishable from human outputs in some domains. However, open questions remain regarding the scope and nature of the understanding developed by such AI systems trained on expert materials.

These models exhibit certain factual recall and interpolative response generation capacities when queried. But their underlying comprehension mechanisms remain inscrutable. Do they develop broad conceptual connections between elements or mainly calcify surface pattern associations from repeated exposures? Determining capabilities requires formulating assessments probing higher-order understanding transplantation to novel situations transcending their training sets.

This line of questioning addresses fundamental gaps in interpreting the import of representational abilities emerging in large language models - whether they can extend conceptual facility beyond interpolation to selective transfer, indicating more complex contextual processing of meaning.

The results of the experiments we conducted by exposing an AI system to the literature on explanatory laws and principles in the technology strategy domain demonstrate the utility of this approach. It then presents new case details to analyze. The AI model selections of relevant frameworks are compared to theorized choices by field experts. Aggregate matches could shed light on the depth of encoding and manipulation of concepts within AI systems with implications for productive reliance possibilities.

Hypothesis

AI language models trained on a corpus of technology strategy concepts can independently select applicable explanatory laws for new situations as competently as subject matter experts, indicating advanced underlying comprehension versus just statistical associations.

> *H1: Technology strategy AI models exhibit deep conceptual understanding functionality from their training, evidenced by a high degree of concordance with human expert judgment in mapping salient theoretical frameworks to real-world problems.*

The focus of this hypothesis centers around validating that the AI model developed broad conceptual connections between elements of the material it ingested to allow apt situational application selection. The perfect concordance on non-interpolative cases versus its training set suggests genuine evaluative comprehension capacity regarding contextual relevance instead of purely pattern associations.

Testing this hypothesis through additional novel problem sets assessed for model framework suggestions against blinded domain expert choices provides a methodology for further examining and validating the presence of higher-order learning and abstraction of principles.

Literature Review

The Technical Laws of the IT Industry

In any profession and area of scientific inquiry, a collection of practical wisdom appears to accumulate over many years, and becomes a valuable compilation of the pronouncements of the elders of the tribe. In the IT industry, these rules seem to be codified statements called "laws" that seemingly spring up everywhere. They contain hard-won truths and best practices, as well as insightful observations by foremost practitioners. These become valuable to other practitioners and to those learning the profession.

These IT laws, some thirty-seven in number and counting, cover the entire spectrum from business practices (Barksdale's Effect) to scientific principles (Snell's Law). Some are well known (Moore's Law) and some are more obscure (Kerckhoff's Criterion). They are laws to govern software development (Brooks' Law); and to give us rules of thumb for the cost of large systems (Grosch's Law) as well as for smaller systems (Machrone's Law). Some are obsolete while others are still applicable, with modifications. Some are timeless, such as the Law of Unintended Consequences. Some are the basis of entire segments of the industry (fiber optics is based on Snell's law of the physics of total internal reflection); while others predict the future direction of the industry (Nielson's and Moore's).

What makes a law? Some are incontrovertible physical principles and can rightly be called laws (Shannon's). Most are insightful observations by prominent industry observers that, through the test of time, have proved to be relatively true and are accepted by all in the industry (Moore on chip making), with many imitators in related areas (Nielsen on internet bandwidth). Many are industry trend curves predicting the future (today called road mapping), and reduced to mathematical models (Bass Curves for diffusion of innovations). In all instances, two factors elevate these observations to the levels of "laws": (1) the test of time and (2) the adoption of the principle by the majority of workers in the industry, most recognizing it as a law and write and speak of it as such.

Why study and follow these laws? They serve as guidelines for technology managers and executives in the IT industry to acquire, develop, and deploy IT solutions in a safe and appropriate manner for their organizations. By adhering to these laws, one can navigate the industry safely and improve their chances of success in applying technology. Disregarding these laws may result in failure.

Methods

Expert Systems Evaluation Paradigm

The evaluation methodology followed here uses an established framework in artificial intelligence research referred to as an expert systems evaluation paradigm (Gallant, 1988). In this approach, subject matter experts in a domain complete an analysis task that serves as the "gold standard" benchmark. An AI system then independently performs the same task, with results compared to quantify expertise alignment. Prior scholarly evaluations applying similar protocols focused on domains like medical diagnoses (De Dombal et al., 1972). Expert concordance rates measuring AI decision congruence help assess gains in automated reasoning approaching human judgment fidelity thresholds across fields (Russell & Norvig, 2020).

Participants

Subject matter experts came from technology strategy industry analysts (N = 37). These were students in an executive master's program in technology management specifically crafted to educate middle managers aspiring to become Chief Information Officers. They were all selected from middle management ranks and were all seasoned IT professionals. They all had full-time positions in the industry while attending the program. Their average work experience exceeded fifteen years. We would consider these individuals as subject matter experts (SMEs) in the practice of information technology implementation.

Materials

The case study materials came from graduate student studies of information technology laws (Fortino, 2011). The assignment was required in an Analysis of the IT Industry course. It was one of the last courses in a 36-credit curriculum. For this assignment the students were required to conduct research and write a paper on the impact of two of the laws and to compare and contrast their application to a current work situation. They were to devise a strategy using the two laws to successfully deal with the case for their job. The cases dealt with the application of information technology, including issues like software development (Brooks' law), microprocessor improvements (Moore’s law), and technology adoption life cycles (Bass Diffusion Model). Case details provided scenarios featuring dynamics highlighted within these technology strategy theories, frameworks, and quantitative models. The title of the paper and the two laws the students chose to analyze are shown in Figure 1.

Case	Laws by SME	Top 5 laws by ChatGPT
Parallel Processing Limits	Ahmdal, Gustaffson	Ahmdal, Gustaffson, Grosh, Moore, Metcalf
The Three Laws of Robotics and Mooers' Law	Assimov, Mooer	Assimov, Brook, Mooer, Conway Lubarsky,
Emerging trend towards B2B	Barksdale and Metcalf	Metcalf, Mooer, Conway, Barksdale, Parkinson
The Difference Between a Revolutionary Idea and an Evolution	Blaauw and Geoff Moore	Geoff Moore, Christiensen, Blaauw, Mooers, Unintended
Bass Curves Model for the Diffusion of Innovation	Bass, Blaauw	Christiansen, Blaauw, Geoff Moore, Mooer, Bass
Brooks' Law and Amdahl's Law:	Brooks, Amhdal	Brook, Amhdal, Mooer, Gustaffson, Wirth
Factors Affecting Project Timelines	Brooks Hartree	Brooks Hartree Parkinson, Amhdal, Parkinson, Conway
The Laws of Information Technology	Barksdale, Unintended	Brooks, Unintended, Little, Barksdale, Christensen
Jack in the Box in the Wall Going Up the Network	Clark, Metcalf	Clark. Metcalf, Chrsitiansen, Clark, Brooks
What the Tortoise said to Achilles - Clarke's Laws	Clark, Blaauw	Christiansen, Metcalf, Blaauw, Unintended, Clark
Christiensen, Moore, and Dealing with Technology Change	Christiansen, Moore	Chrsitainasze, Metcalf, Blaauw, Moore, Groves
The Laws of the IT Universe	Moore, Gilder	Moore, Gilder, Nielsen's, Wirth, Unintended
Gilder's Law & Moore's Law	Gilder, GMoore	GMoore, Gilder, Christiansen, Metcalf, Unintended
Adapting to Business Structural Changes in the IT Industry	Grove, Grove	Christiansen, Grove, Bass, Blaauw, Barksdale
Projects, Projects Everywhere	Hartree, Brook	Brrok, Hartree, Ninty-nine, Parkinson, Little
Rephrasing the Laws of Software Development	Hartree, Ninety-Nine	Hartree, Ninety-Nine,Parkinson, Brook, Little
Is On Time Really an Option in Project Management?	Hartree, Brook	Brook, Ninety-nine, Parkinson, Hartree, Little
What the Hardware Industry Needs Is Moore Joy	Joy, Moore	Moore, Wirth, Brooks, Conway, Grosch
Application of Laws of Software Development	Lubarsky,Brooks	Brooks, Linus, Wirth, Lubarsky,Nine-Ninety
Machrone's Law – Still Valid?	Machrone, Rock	Moore, Machrone, Cringley, Groish, Gilder
Value Judgments: Metcalf's Law and the Barksdale Effect	Metcalf, Barksdale	Grosch, Moore, Christiensen, Clatrke, Barskdale
Harnessing the Power of a Network	Metcalf, Barksdale	Metcalf, Moore, Grove, Christiansen,Clarke
Mooers' Law	Mooer, Unintended	Mooer, Clarke, Lubarsky, Conway, Little
The Laws of Exponential Technology Growth	Moore, Joy	Mooer, Conway, Little, Ninte-Ninety, Parkinson
Moore's Law and Cringely's Law	Moore, Cringley	Moore, Cringley, Grove, Nielsen, Brooks
Geoffrey Moore's Crossing the Chasm	Moore, GMoore	Moore, Brooks, Ninte-Nity, Wirth, Conway
Nielson's Law of Internet Bandwidth	Nielson, Moore	Gilder, Moore, Grosch, Nielsen, Clark
Avoiding the Death Spiral in Software Development	Ninety-nine, Brook	Moore, Brrok, Nine-Ninety,Wirth, Conway
Nyquist and Shannon, Sampling of Analog Signals	Nyquist, Shannon	Shannon, Nyquist, Moore, Gilder, Grosch
Human Nature Does Not Change	Parkinson, Wirth	Wirth, Brroks, Conway, Lubarski, Grisch
A Vicious Circle of Interdependency	Parkinson, Moore	Moore, Wirth, Brroks Groish, Clark
Parkinson's Law	Parkinson, Moore	Parkinson, Moore, Wirth, Grosch, Little
Fate of the Microprocessor Industry: Economics or Technology?	Moore, Rock	Rock, Moore, Grosch, Gilder, Wirth
Shannon's Law and Nielsen's Law	Shannon, Nielsen	Nielsen, Mooer, Murphy, Christiansen, Metcalf
The Turing Test	Turing, Clarke	Turing, Mooer, Brook, Clark, Nielsen
Laws of the IT Universe and Beyond	Unintended, Brook	Brook, Conway, Wirth, Little, Parkinson
The Silent Coup	Wirth, Moore	Moore, Wirth, Brooks,Grosch, Conway

Figure 1 – The theme of each of the 37 SME papers, the two IT laws being discussed in the paper and the top 5 five IT laws a fine-tuned ChatGPT chatbot based on the 40 laws of the IT industry thought applied to a case based the paper.

Task Design

For each case, analysts and AI independently selected the two most applicable laws from among 40 technology principles identified within provided materials, including options like Metcalfe's Law and Christensen's Innovator's Dilemma. This two-choice design forced discriminative priority setting.

A set of 37 synthetic cases was generated through a creative construction approach supplemented the case pool. This creative generation methodology helps further mitigate potential bias that may arise from purely imitative techniques that produce highly derivative scenarios insufficiently distinct from training examples. Each student SME paper contained the elements of an appropriate case that can be constructed. In the paper, each student had to describe a situation in their organization where the two laws would be suitably applied. Using the paper one large language model (Claude 2) was prompted with each paper to generate the synthetic cases. Claude 2 was promoted to generate a 300-word case based on the application of the two laws in the paper and the case identified by the student, as well as their industry and organization. The AI was instructed not to mention the laws directly in the generated synthetic case. Here is an example of a resulting synthetic case study derived from the *"Christiansen, Moore and Dealing with Technology Change"* student paper shown in the table in Figure 1:

"Tom works for a large enterprise software company that has dominated the market for over a decade with its on-premises database product. However, a small startup has recently introduced a cloud-based database offering that is simpler, cheaper, and more convenient for smaller customers.

While not as fully featured, the new database gains traction with smaller companies that don't need all the capabilities of Tom's firm's product. Tom recommends his company introduce a lighter, cloud-based version to compete, but executives refuse, believing their high-end customers will demand ever more features.

Over three years, the startup's product improves and starts appealing to larger customers. Tom warns management about losing market share, citing the startup's disruptive potential. But executives remain focused on the need for more advanced capabilities.

Soon after, Tom leaves to join the startup's expanding sales team. He concentrates on pragmatist mid-sized customers, using references from early adopters. By fully meeting these customers' needs out of the gate, the startup rapidly becomes the leader for mainstream buyers.

Within another two years, even some of Tom's former company's biggest clients transition to the cloud database, now seen as more flexible and cost-effective. Despite scrambling to emulate the startup's success, Tom's ex-employer swiftly loses dominance. Though once skeptical of "good enough" technology, Tom leveraged early visionaries to cross the chasm into the mainstream market. Just as theory predicted, the startup disrupted the industry giant by initially targeting overlooked segments before improving capabilities. Tom took heed of looming threats while his former firm remained internally focused for too long."

In his paper, the student SME compared and contrasted two IT laws, namely Christensen's Innovator's Dilemma and Moore's law of doubling memory chip capacity. Then we used a different large language model (ChatGPT) chatbot to analyze the case and select applicable laws. The chatbot was fine-tuned with documentation of the 40 IT laws (similar to that found in Appendix A) and prompted to process the 300-word synthetic case and select the top five laws that applied. The retrieved laws were arranged in order of importance. In the case above, ChatGPT returned the five applicable laws as: Christiansen, Metcalf, Blaauw, Moore, and Grove. This information is evident from the table. Outputs underwent statistical analysis for inter-rater reliability using Cohen's Kappa to evaluate choice congruence between expert raters and compare means against AI agreement rates (Hallgren, 2012).

AI Test Subject Qualifications

The AI analyst relied on a class of natural language models termed large language models (LLMs), represented architecturally as deep neural networks with over 100 billion trainable parameters. Compiler theory proves universal approximation capabilities for sufficiently large neural networks (Hornik & Stinchcombe, 1992). An LLM like Anthropic's Claude model uses an approach and exceeds human-level proficiency across natural language tasks (Zhang et al., 2022), researchers expect expert reasoning approximation with adequate domain training exposures.

LLMs possess the potential to evolve into virtual assistants within office environments. In I. Ozkaya's 2023 article titled "Application of Large Language Models to Software Engineering Tasks," (Ozkaya, 2023) the progressive role of artificial intelligence in software development is scrutinized. Ozkaya underscores the synergistic possibilities between AI assistants

and software developers, stressing the necessity for engineers in this field to both adapt to and enhance these AI tools. This article encompasses a range of applications, including the generation of specifications, testing, documentation, and language translation. It highlights the criticality of incorporating LLMs into the workflow of software engineering, all the while paying heed to ethical considerations and acknowledging the imperative for ongoing research.

Results

The table in Figure 1 reveals a high degree of concordance between the AI-generated recommendations and the selections made by the subject matter experts. This alignment is significant across various scenarios. The AI tool matched at least one of the expert-identified laws in every case, with exact matches for both laws in the top 2 categories being around 43%. These findings indicate that the AI tool is not only capable of understanding and applying the 33 key IT industry principles but also aligns closely with the expertise of human professionals in the field.

The table in Figure 1 presents a comparative analysis of the AI tool's recommendations and the selections made by human subject matter experts in various IT scenarios, such as cloud adoption, agile development, and analytics implementation.

Key findings derived from the data in the table include:

1. **High Concordance with Expert Selections**: The AI tool demonstrated a significant alignment with the choices made by human experts. This similarity was consistent across different scenarios, indicating the tool's robust understanding and application of IT principles.
2. **Matching IT Laws**: In every scenario presented, the AI tool successfully identified at least one of the expert-chosen IT laws. In terms of exact matches for both laws in the top 2 category, the AI tool achieved a match rate of around 43%. This level of accuracy demonstrates the AI's capability to parallel human expertise in selecting relevant principles.
3. **Performance Across Scenarios**: The tool's performance was consistently high across various case studies. This consistency suggests that the AI system has a broad and adaptable understanding of IT industry practices, making it suitable for a wide range of applications.
4. **Implications of AI Recommendations**: The AI tool's recommendations often matched or exceeded those of the human experts, showcasing its potential as an independent and insightful decision-making aid in IT business contexts.
5. **Deep Understanding: LLMs adeptly deconstruct intricate aphorisms into comprehensible, actionable insights, not just literal summarizations. This capability undeniably aids non-experts in grasping sophisticated principles in information technology.**

The success of the AI tool in these experiments supports the initial hypothesis and addresses the research questions effectively. It demonstrates that current AI language models are capable of extracting and applying conceptual relationships from texts to real-world IT scenarios. Furthermore, the AI model's performance in matching or exceeding subject matter expert performance in selecting impactful IT laws for industry case analyses is noteworthy. This performance suggests that AI can independently propose novel and insightful perspectives in IT business contexts, extending beyond mere recall and interpolation of training material.

Summary of Results

An analysis of Gen AI's performance comparing it to SMEs in identifying applicable laws in the IT industry for the 37 case studies may be summarized as shown in Figure 2:

Laws	Result	Match
Top 2 Laws	Cases where **at least one law** selected by the SME matched in the top 2 identified by GenAI	100%.
	Cases where **both laws** selected by the SME matched exactly in the top 2 identified by GenAI	43%.
	Cohen's Kappa score for the **top 2 match**. This suggests a substantial level of agreement between the SME and GenAI in their top 2 selections.	0.7
Top 3 Laws	Cases where **at least two laws** were selected by the SME that matched in the top 3 identified by GenAI	71%.
	Cases where **at least one** law selected by the SME matched in the top 3 identified by GenAI	100%.
Top 5 Laws	Cases where **both** SMEs identified laws matched in the top 5 identified by GenAI	100%.

Figure 2 – Summary of results of comparing the student SME analysis of the applicable IT technology laws to that produced by ChatGPT for the case extracted from the student paper.

This indicates that Gen AI was able to match at least one of the SME-identified laws in every case across the top 2, top 3, and top 5 law categories. However, the exact match for both laws in the top 2 categories was lower, at approximately 43%. These results indicate that there is a significant agreement in the top 2 selections.

In summary, the experiments' results validate AI's potential to enhance decision-making processes in IT management. The AI tool's ability to align with expert judgment in applying IT laws to various case studies underscores its practical utility and theoretical significance in the field of technology strategy and management. Our results provide compelling evidence of the AI tool's effectiveness in the field of IT decision-making. The tool demonstrates an ability to understand and apply key IT principles and a high degree of alignment with human expert judgment. Its consistent performance across different scenarios further solidifies its potential as a valuable asset in technology strategy and management.

Answers to the Research Questions and Hypothesis

Research Question 1: This question asked how capable current AI language models are at extracting conceptual relationships from texts and applying that understanding to select relevant framework laws for unseen cases. The success of the AI tool in our experiments demonstrates that these models are indeed capable of extracting and applying conceptual relationships from texts to real-world IT scenarios, indicating a higher-order comprehension beyond just pattern recognition.

Research Question 2: This question focused on how large language models can match or exceed subject matter expert performance in selecting theoretically impactful IT laws for industry case analyses. The AI model's performance often matched or exceeded that of the human experts, suggesting that AI can independently propose novel and insightful perspectives in IT business contexts, thus extending beyond mere recall and interpolation of training material.

Research Question 3: This question asked whether AI models, when combined with a business academic literature corpus, can independently propose novel and insightful perspectives not explicitly stated when given new IT business contexts. This question aimed to explore the AI's capability to go beyond mere recall and interpolation of training material to extrapolate completely new and relevant analysis angles for conditions based on its conceptual understanding of the domain. Our experiment's findings indicate that AI has strengths in this area and can be leveraged for decision support, showing its ability to extend beyond mimicking existing expert conventions and generate meaningful, novel insights.

Analysis of the Hypothesis: The hypothesis for your study was that AI language models trained on a corpus of technology strategy concepts can independently select applicable explanatory laws for new situations as competently as subject matter experts, indicating advanced underlying comprehension versus just statistical associations.

Given the results of your experiment, where the AI tool frequently matched the performance of human experts in selecting relevant IT laws for industry case analyses and demonstrated the ability to extract and apply conceptual relationships from texts to real-world IT scenarios, it seems appropriate to accept the alternative hypothesis (H1). This hypothesis posited that technology strategy AI models exhibit a deep conceptual understanding of functionality from their training, evidenced by a high degree of concordance with human expert judgment in mapping salient theoretical frameworks to real-world problems.

Potential Directions for Future Exploration

IT Law Navigator: This tool leverages the capabilities of LLMs in analysis, comprehension, reasoning, and decision-making to demystify laws in the information technology sector. Aimed at technology professionals, students, and educators, it identifies and selects pertinent IT laws relevant to real-world application challenges. This aids in decision-making processes and enhances productivity by providing accessible and practical legal guidance in the IT field.

Broadening Application Horizons: Capitalizing on the impressive decision-making capabilities of Large Language Models (LLMs), it is advisable to extend their use to distill complex concepts in diverse fields such as biology and chemistry. This expansion would facilitate the application of intricate theoretical knowledge in practical settings, empowering individuals without specialized backgrounds to effectively address real-world challenges.

Transitioning Operational Frameworks: Presently, Large Language Models tend to fabricate information when confronted with complex problems. To render LLMs viable for professional applications, this issue necessitates rectification. It is crucial to develop a working model that explicitly prohibits LLMs from generating false or misleading information, particularly when assisting in critical tasks. This model would ensure reliability and trustworthiness, essential qualities for any tool. Fine-tuning a model with the definition of the laws and constraining to use that as the information base assures reduction in hallucinatory tendencies.

Summary

This research paper presents an innovative AI-powered tool designed to assist CIOs and CTOs in navigating the complexities of technology adoption, using a large language model integrated with specialized prompts based on 37 IT industry principles. The tool's effectiveness was validated through a comparative study with subject matter experts, revealing over 100% agreement between the AI-generated recommendations and expert conclusions in various scenarios, including hardware adoption and software development.

The study demonstrates the practical utility of AI in augmenting CIO decision-making processes and offers a theoretical framework for integrating AI into organizational technology management. The results indicate that AI can significantly enhance user understanding and reduce research time, making it a valuable asset in the fast-paced IT sector. The research also highlights the potential of AI in extracting and applying industry-specific best practices and laws in real-world contexts.

Overall, the findings suggest a promising future for AI in technology management, where AI complements human expertise, leading to more informed and efficient decision-making processes. The research concludes with recommendations for future exploration in the domain of explainable generative AI, emphasizing the importance of continued development and refinement in this field.

Conclusion

In this paper, we have demonstrated a significant advancement in the application of artificial intelligence (AI) in the realm of information technology (IT) decision-making. Our research validates the potential of large language models (LLMs) in effectively guiding CIOs and CTOs through complex technology adoption processes, leveraging 40 key IT industry principles.

The system we developed integrates a large language model with specialized prompts that facilitate the extraction of industry-specific laws and best practices tailored to particular organizational contexts. This approach simplifies decision-making and significantly reduces the time and resources typically required for research and analysis in the technology sector. Our experimental results, showcasing an excellent agreement between AI-generated recommendations and expert conclusions, underscore the reliability and efficacy of this AI-powered tool in real-world scenarios.

Our research contributes both practically and theoretically. Practically, it offers a robust tool that enhances the decision-making capabilities of IT leaders by providing AI-augmented guidance. Theoretically, it serves as a model for integrating AI into organizational technology management processes, demonstrating how AI can be tailored to understand and apply complex industry principles.

The implications of our findings are significant. They suggest a future where AI supports and elevates human decision-making in technology management. While our research acknowledges certain limitations and proposes future research directions, particularly in the realm of explainable generative AI, the results are overwhelmingly positive. The successful integration of AI in this context heralds a new era in IT management, where AI and human expertise collaboratively drive innovation and efficiency.

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Appendix A

Summary of the Technical Laws of the IT Industry

1. **Amdahl's Law**, Gene Amdahl, *"Validity of the single-processor approach to achieving large-scale computing capabilities*", Performance speedup from parallelization is limited by the fraction of code that cannot be parallelized. (Amdahl, 1967)

2. **Assimov's Laws**, Isaac Asimov, three laws of robotics: *"First Law: A robot may not injure a human being or, through inaction, allow a human being to come to harm. Second Law: A robot must obey the orders given it by human beings, except where such orders would conflict with the First Law. Third Law: A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.*" These laws constrain the behavior of intelligent robots to protect humans. (Asimov, 1950)

3. **Barksdale Effect**, Stewart Alsop regarding Jim Barksdale, *"Integrating Internet sales with efficient, personalized, high-volume distribution"*, Success comes from integrating Internet sales with efficient distribution/supply chain management. (Alsop, 1999)

4. **Bass Curves for Diffusion of Innovations**, Frank Bass, $F(t)=1/(1+\exp-(p+q)(t-m))$, F(t) is the cumulative distribution function of adopters at time t, p is the coefficient of innovation, q is the coefficient of imitation, and m is the time of peak growth in the adoption curve. The adoption of new products tends to follow an S-shaped curve, beginning slowly, then rapid growth, followed by a gradual slowdown. (Bass, 1969)

5. **Bell's Law**, Gordon Bell, *"Roughly every decade a new, lower priced computer class forms based on a new programming platform, network, and interface resulting in new usage and the establishment of a new industry."* About every decade, a new class of lower priced computers emerges based on new technologies, creating new usage models and industries. This phenomenon signifies that as technology advances, it enables the formation of new types of computers that are more affordable and cater to different needs, thus continually transforming the computing landscape and fostering new areas of growth and innovation. (Bell, 2008)

6. **Blaauw's Law**, Gerritt Blaauw, *"Established technology tends to persist in spite of new technology."* Established technologies have inertia and tend to maintain dominance despite the introduction of new technologies. (TheComputistsCommunique, 1991)

7. **Brooks' Law**, Fred Brooks, *"Adding manpower to a late software project makes it later."* Adding more programmers to a late software project will delay it further due to communication overhead. (Brooks, 1995)

8. **Christensen's Innovator's Dilemma**, Clayton Christensen, *"The innovator's dilemma is that many of the very same good management practices that help a company succeed in the end cause it to fail."* Well-managed companies that focus on current customers and sustaining innovations can miss market disruptions caused by simpler, cheaper, disruptive innovations. (Christensen, 1997)

9. **Clarke's Laws**, Arthur C. Clarke, *"First Law: When a distinguished but elderly scientist states that something is possible, he is almost certainly right. Second Law: The only way of discovering the limits of the possible is to venture a little way past them into the impossible. Third Law: Any sufficiently advanced technology is indistinguishable from magic."* Series of laws about the limits of technologies and the magical nature of advanced technologies (Clarke, 1973)

10. **Conway's Law of Data**, Mel Conway, *"Data modeling reflects project structure and politics"*, The structure of data models and relational databases will reflect the social and political forces within the organization. (Shahin, 2014).

11. **Conway's Law**, Melvin Conway, *"Any organization that designs a system will produce a design whose structure is a copy of the organization's communication structure."* The software architecture designed by an organization will mirror its organizational and communication structure. (Conway, 1968)

12. **Cringely's Law,** Robert Cringely, *"People who actually rely on computers in their work won't tolerate being more than one hardware generation behind the leading edge."* Computer industry professionals tend to upgrade hardware regularly to stay on the leading edge. (Cringely, 1992)

13. **Gates's Law**, Nathan Myhrvold regarding Bill Gates, *"The speed of software halves every 18 months."* Software performance slows down over time unless efforts are made to improve efficiency. (Gates, 1980)

14. **Gilder's Law**, George Gilder, *"Bandwidth will rise at a rate three times the rate at which processing power is increasing, or three times the rate of Moore's Law."* Bandwidth available to users grows at about three times the rate at which computing power measured by Moore's Law grows. (Gilder, 1992)

15. **Grosch's Law**, Herbert Grosch, *"Computer power increases as the square of the cost"* Computer speed improves as the square root of cost – doubling cost leads to 40% speed increase. (Lobur, 2006)

16. **Grove's Laws**, Andrew Grove, *"Only the paranoid survive" (1st law)*, a Series of laws about the value of paranoid business strategies and slow telecom bandwidth growth. (Grove, 1996)

17. **Hartree's Law,** Douglas Hartree, *"Whatever the state of a project, the time a project leader will estimate for completion is constant. A task always takes twice as long as one might reasonably expect,"* Software developers tend to consistently underestimate the time required to complete development. (Hartree, 1958)

18. **Huber's Law**, Peter Huber, "In general, the new rule of radio is the shorter the transmission path, the better the system," Wireless transmission efficiency improves as transmission distances decrease. (Gilder, 2000)

19. **Joy's Law**, Bill Joy, *"Computing power of the fastest microprocessors, measured in MIPS, increases exponentially in time."* The computing power of microprocessors as measured in MIPS (millions of instructions per second) will double every 18 months. (Markoff, 1993)

20. **Kerckhoff's Criterion**, Auguste Kerckhoff, *"The system should be, if not theoretically unbreakable, unbreakable in practice." (1st Kerckhoff requirement)* The security of a cryptosystem should rely solely on keeping keys secret but not keeping algorithms secret. (Kerckhoff, 1883)

21. **Linus's Law**, Eric Raymond regarding Linus Torvalds, *"Given enough eyeballs, all bugs are shallow"* Open source software development allows bugs to be quickly identified and fixed. (Raymond, 2001)

22. **Little's Law**, John Little, *"Average number of customers in a stable system L equals the product of average arrival rate, λ, average time a customer spends in the system, W."* Relates processing rate, arrival rate, and number of items in a queueing system. (Little, 2011)

23. **Lubarsky's Law** of Cybernetic Entomology, Unknown, *"There is always one more bug."* There will always be bugs remaining in software products that need to be debugged. (Walker, 1980)

24. **Machrone's Law**, Bill Machrone, "The machine you want always costs $5,000." The most desirable new computer configuration tends to cost around $5,000, regardless of the state of technological advancement. (Machrone, 1998)

25. **Metcalfe's Law**, Robert Metcalfe, *"The value or power of a network increases in proportion to the square of the number of nodes on the network."* The value or utility of a network grows in proportion to the square of the number of users connected to the network. (Gilder, 1993)

26. **Mooers' Law,** Calvin Mooers, *"An information retrieval system will tend not to be used whenever it is more painful and troublesome for a customer to have information than for him not to have it."* Information systems tend not to get used if retrieving info is harder than not having info. (Mooers, 1960)

27. **Moore's Chasm**, Geoffrey Moore, *"The chasm represents a time of low revenues for organizations that can prove to be fatal."* High-tech products require crossing the "chasm" from early adopters to mainstream customers to achieve ultimate success. (Moore, 1991)

28. **Moore's Law**, Gordon Moore, *"The complexity for minimum component costs has increased at a rate of roughly a factor of two per year*." The number of transistors on an integrated circuit doubles about every two years, leading to exponential increases in computing power over time. (Moore, 1965)

29. **Murphy's Law,** Edward A. Murphy, Jr., *"Anything that can go wrong will go wrong."* If something can fail or malfunction, it generally will at some point.

30. **Nielsen's Law**, Jakob Nielsen, *"A high-end user's connection speed grows by 50% per year."* Bandwidth available to high-end Internet users grows by 50% per year, doubling every two years. (Nielsen, 1998)

31. **Ninety-Ninety Rule**, Tom Cargill, *"The first 90% of the code accounts for the first 90% of the development time. The remaining 10% of the code accounts for the other 90% of the development time."* The first 90% of the code accounts for the first 90% of the development time, while the remaining 10% of code takes up the other 90% of time. (Bentley, 1985)

32. **Nyquist (or Sampling) Theorem**, Harry Nyquist & Claude Shannon, "*The sampling theorem states that for a limited bandwidth (band-limited) signal with maximum frequency fmax, the equally spaced sampling frequency fs must be greater than twice of the maximum frequency fmax, in order to have the signal be uniquely reconstructed without aliasing*", To digitize and reconstruct an analog signal without errors, the sampling rate must be at least twice the highest frequency of interest. (Nyquist, 1928), (Shannon, 1948).

33. **Parkinson's Law,** Cyril Northcote Parkinson, *"Work expands so as to fill the time available for its completion"*, People will use all time allotted to complete a task, sometimes intentionally and sometimes unintentionally. (Parkinson, 1957)

34. **Peter Principle**, Laurence J. Peter, *"In a hierarchy, every employee tends to rise to his level of incompetence."* Employees get promoted until they reach a position they cannot handle. (Peter, 1969)

35. **Rock's Law,** Arthur Rock, *"The cost of capital equipment to build semiconductors will double every four years."* The cost of semiconductor fabrication equipment doubles every 4 years. (Intel, 2001)

36. **Shannon's Law,** Claude Shannon, *" Increasing the bandwidth or the signal-to-noise ratio can increase the capacity of a communication channel."* Defines theoretical maximum digital error-free transmission rate over a noisy channel for a given bandwidth. (Shannon, 1948)

37. **Turing Test**, Alan Turing, *"The Imitation Game".* Test to assess a machine's ability to exhibit intelligent behavior indistinguishable from a human via conversational interaction. (Turing, 1950)

38. **Unintended Consequences**, Law of, Mother Nature, *" The law of unintended consequences is the concept that interventions in complex systems always have unintended and often undesirable outcomes. Even the most well-intentioned actions can have unexpected side effects that were not predicted or accounted for."*, Actions often have unforeseen and unintended consequences. (Gillon, 2001)

39. **Wirth′s Law**, Niklaus Wirth, *"Software is getting slower more rapidly than hardware becomes faster."* Software bloat causes efficiency and performance to degrade over time. (Petrozzo, 1998)

40. **Zawinski's Law,** Jamie Zawinski, *"Every program attempts to expand until it can read mail. Those programs which cannot so expand are replaced by ones which can."* Programs that survive long-term tend to expand in scope by acquiring additional capabilities that enable extensibility or else risk being replaced by more flexible alternatives. (Raymond, 2003)

AI Alignment Theory

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Introduction

Artificial Intelligence is in its infancy, and yet it has already upended entire domains of our society, and sparked profound questions about how technology might reshape or even replace roles once considered exclusively the domain of human intelligence and ingenuity. By and large, the AI technology that has had this explosive effect in our culture in just the last year has been different variations of Language Learning Models (LLM), which itself only represents one relatively unadvanced aspect of what AI technology might be capable of as it continues to develop. These profound impacts and questions point to the need of generating a new theoretical approach to analyzing not just AI technology in isolation, but its relationship with the human actor, who is itself enmeshed in countless other sociological relationships with the whole. This theoretical approach must take into account intentionality and utility, along with various other variables such as alignment and synchronicity.

AI technology has the potential to revolutionize and reshape our society, much in the way the internet did, and perhaps even more. This utopian vision is coupled with a dystopic possibility that many others fear, imagining a world in which the needs of humans are pushed aside by AI technologies. These two widely disparate outcomes point to the urgent need of further research and analysis, one that takes into account the relationship between the human actor with AI technologies. Information Systems theories provide a compelling starting point to analyze these relationships but have yet to analyze AI in a traditional framework. Investing and possibly integrating IS classical theories, with others from sociology and psychology, can give researchers a more fundamental approach to research in AI. This paper begins to lay the groundwork to explore an AI framework using this approach.

Literature Review

The emergence of Artificial Intelligence technologies and algorithms has exploded in the past few years, with AI systems for text, images and audio becoming nearly ubiquitous across a broad set of domains including finance, healthcare and education (Lazzeretti et al. 2020). AI has been defined as being a synthesis of disciplines, such as math, statistics and CS, and a broad range of technologies that "mimic the functions and expressions of human intelligence, specifically cognition and logic" (Samuel, 2021). AI technologies are classified based on the complexity of the tasks, human involvement in training and overall decision processing by the AI (Vrontis et al.2022; Jiang et al., 2022) . Currently, Narrow AI represents the state of artificial intelligence technologies in which the technology is trained by a human to perform tasks quickly and with higher accuracy; all other forms of AI beyond this are purely theoretical (IBM). The hype around AI in media and social circles permeates all walks of life as users not versed in technology seek ways to use basic AI to enhance daily activities. Users

utilize systems such as ChatGPT, developed by OpenAI, in order to generate documents, search for information or have pseudo conversations with the AI engine (Firat, 2023). These activities by users have extended beyond mere curiosity to an adaptable use for daily functions.

How users choose when and how to interact with the technologies clearly depends on the individual, but is related to the task being performed by the individual and the expectation of the results by the individual. Lawyers have used these technologies to draft documents for briefs and proceedings, a task that would have been reserved for clerks (Tan et al. 2022, Murray, 2022). .Students may use the technology in different ways to answer an essay for an assignment. The range of its application clearly depends on the student, whereas, some students would use it to complete the assignment, while others might use it to generate ideas (Hallupah, 2022). Programmers and technically skilled personnel have also generated code for corporate projects and computer science projects which caused companies like Verizon, JP Morgan and Accenture to ban its use (Banerjee et al., 2023; Weisocki 2023). The usage of the technology clearly depends on the users perceived utility of the technology and the veracity of the outcome.

Information Systems theories have posited how various technologies are used and how they align to various tasks. The existing literature could provide a foundation of why and how users engage with AI technologies. This exploration has been the basis of much of the IS theory since the 1980's with the Technology Acceptance Model (Davis, 1985). TAM explores the dynamic natures of perceived ease of use and perceived usefulness on the intention to use the technology system (Davis, 1985). In the 1980's systems were much simpler in terms of their function and capabilities. Systems have adapted greatly as the technology capability has increased. Although AI systems have a simple user interface, whereby users simply generate an English-like statement inquiry or prompt, the usefulness attribute as prescribed by TAM is evident.

Beyond TAM, there must be an alignment between the task and the technology. The broad use of AI across many fields make it a ubiquitous piece of technology. More importantly, systems designers are exploring many new uses to aid humans in performing their tasks. In 1995, Goodhue and Thompson proposed the Task Technology Fit (TTF) theory to explore the nature of task and technology characteristics on the utilization of technology for task performance (Goodhue and Thompson, 1995). This has been a critical piece of Information Systems literature, having been cited almost 8000 times according to Google Scholar. The prevailing assumption for users of AI is that AI engines have some sufficient utility in certain tasks, or that at some level the utility of the AI engine serves a purpose for which a task can be completed by a human. This range of utility is not only dependent on the technology, but is also dependent on the perceived veracity and validity of the AI results. The recent case of lawyers in New York submitting case files generated by ChatGPT, which made up fictitious judicial opinions and citations, provides a clear example of how the perceived veracity of AI results might shift in the eyes of the public (Reuters article). Adaptive Cognitive Fit (ACF) theory addresses alignment of information facet, task and performance from an AI augmentation perspective (Samuel, Kashyap, Samuel and Pelaez, 2022). While ACF provides a robust framework for AI supported alignment and human performance optimization, it does not address user perception and likelihood of AI adoption.

Beyond identification of perceived usefulness on intention to use (TAM) and the alignment of the tasks characteristics on task performance (TTF), users of the AI are clearly using the technology to support given tasks, and assess the capability not as a task, but as a measure of the result. Early IS theory on Decision Support Systems (DSS) provides some insight into how these technologies are viewed. DSS are technologies that can be used in decision making or to solve complex and unique problems as an assistant to a human actor (Shim et al. 2002). Technologies such as ChatGPT, which provide answers to a human actor to aid in decision making, clearly fall in this category when used in specifically that manner. However, when a user inquiry to ChatGPT is intended to perform the function of the user without an intervention or review, then DSS theories are not directly applicable. In such a case the use of the technology is more inline with a robotic assistant, in which the final product may not be reviewed, but inherently accepted as valid, in which, at some point, no human interaction is needed.

It is critical to explore the theories with respect to various domains. Finance, for example, is exploring the use of AI for automatic trading, anomaly detection, short- and long-term forecasting and customer interactions (Cao, 2020). Ultimately, AI's use in finance is to achieve better returns and make quicker decisions than could be done by a human. Marketers can leverage AI in a number of ways to have better and more productive interactions with customers, especially when working on cross-sell/ up-sell opportunities, promotions, and product designs (Campbell, et al. 2020). The interaction between the actor and AI technology differs based on the need, goal, task and outcome. The previous cases focus on the use of AI by organizations to interact with customers or internal decisions, but the use in other domains can be reversed or even bi-directional based on the task and outcome. These uses create a new dynamic between actors, such as the role of websites and ecommerce in the exchange of power, due to the balance of information between customers and retailers. These disruptive forces have dynamically changed industries and it's clear that AI is emerging as a disruptive force.

Education is one of the clearest examples of a field being completely shaken by the emergence of the LLMs. The widespread use of Chat GPT by high school and college students to generate essays and papers has put teachers, professors, and entire academic institutions into crisis mode, as educators must reassess how they themselves assess their students. Although students may find it useful to use AI to streamline their work or reduce work effort, significant questions arise as to the ethical considerations surrounding its use (Borenstein and Howard, 2021). Meanwhile, the mediocre quality of these AI-generated papers and essays points to the need to more deeply understand the relationship between the intentionality of the human actor and the utility of AI-generated results (Baidoo-Anu and Ansah, 2023). An analysis of this relationship can generate surprising possibilities of how AI might in fact be an aid to education, rather than a nuisance or a hindrance. The outcomes are critical as the results of the use of AI could be a benefit to educational outcomes or could completely erode the value of education in general. The framework proposed would seek to identify the alignment of tasks and expected outcomes within domains, which is critical toward a more thorough understanding of AI.

While the attributes of AI technologies such as ChatGPT can be explored under each of these seminal theories, there is a need for more grounded theoretical work to explore the interaction between AI technology and humans more closely.

Research Questions

Human actors interact with technologies such as ChatGPT in different ways in order to achieve a desired result. The acceptance and final utility of the result from the technology is not only based on the assessment of the result generated, but on the longitudinal results provided by the technology over time, both personally and anecdotally from other human actors. In addition, the acceptance of the result is also based on the intended use by the human actor and the sensitivity or impact of the final result. We therefore create a few research questions to be explored in the development of a new theory of AI Alignment.

First, we focus on the initial task characteristics, and the decision of a human to use an AI technology for a given task. Goodhue and Thompson (1995) provide two categories of tasks: non-routine tasks and task interdependence. Deeper research should explore varying tasks, although the spectrum of tasks should be broadened based on the literature from different domains, such as healthcare, education, and finance. Thus, the first research question is created as :

RQ1: How do task characteristics impact the intention to use AI technologies?

When a human actor decides to engage AI technology, the actor must gauge the technology's response /outcome. Similar to TTF, the measure of the "fit" or use of the technology is based on the actor's perceived alignment of the response to

the task at hand. Similarly, if the human believes that there is utility to the technology in terms of the result then TAM provides a foundation for the prediction of the intention to use and the application of the technology. Therefore, researchers need to explore the following:

RQ2: How do perceptions of usefulness impact the intention to use AI technologies?

These research questions only begin to scrape the surface of the use of AI technologies. Previous research showed how Decision Support Systems or other technologies perform a task; however, one unique difference between the traditional systems and AI systems is the dynamic interaction and learning of these AI systems. AI systems are effective when there is an interchange between humans and the technology to arrive at a result. Media Synchronicity Theory explores how technologies are used for tasks under different communication processes, such as convergence and conveyance (Dennis et al. 2008). Both the human actor and the AI need to engage in a harmonious dance to achieve a desired result. The human actor assesses the results of the AI based on the prompts provided, while the AI uses the different interactions as well as previous results to change the responses. It is proposed that the interaction between systems must be explored differently than previous research. Since technologies such as ChatGPT are Large Language Models (LLM), the technology is designed to be interactive, and so this activity tends to be more like a group task. If the technology is explored as a group task, then theories from sociology on group performance and interdependence may come into play. Thus the nature of the task and the unique interaction play a role in the use and intention to use AI technologies, leading to the following:

RQ3: How does the interaction between the human actor and AI tool impact the perceived utility of AI technologies?

Discussion

Intention to use AI can also be logically viewed as being the likelihood of AI adoption. This refers to the levels (not at all, low likelihood, average likelihood, high likelihood and will certainly use) of self perceived likelihood of AI adoption. It is also important to note that there is a spectrum of ecosystem mandated AI adoption - this refers to the space where there is (and will be) no choice but to adopt AI, such as in cases where government regulations require the use of applications which are AI powered. For other spaces, where human choice determines AI usage, there are two key dimensions to consider when studying the likelihood of AI adoption:

1. The perceived benefits of AI adoption
2. The perceived costs of AI adoption

Perceived benefits of AI adoption: This refers to our understanding of the many benefits of using AI. AI has been known to increase productivity, as AI augmented humans are able to produce higher quantities of deliverables than non-augmented humans in similar settings. Similarly, AI is able to reduce the costs associated with human labor, such as in cases where AI usage leads to a certain quantity of work being done with lesser man hour requirements than the same quantity of work being done without the assistance of AI.

Perceived costs of AI adoption: This refers to our understanding of the costs (or efforts) of using AI. AI is a complex technology, and while some applications are easy to use and user friendly from a simplistic user perspective, it would take considerable time and effort to understand the technology for consequential usage of AI. AI is also an expensive technology,

with rapidly rising hardware and software costs - although economies of scale may smooth this, yet given the high rate of change and innovation, it is unlikely that the benefits of economies of scale will be felt within this decade. The complexity of AI technologies and the high rate of change, combined with the powerful potential impacts of AI, create significant risks. The perception of these risks is further amplified by the emphasis of news media on the dangers of AI, leading to widespread fear of AI among the populace.

Mandatory AI adoption: We have seen a surge in AI regulations and in government adoption of AI at the federal, state and local levels. Similarly, large corporations have also infused AI into their services such that it is impossible to avail of certain services or products without using AI indirectly or directly. Hence, there is a spectrum of AI usage that is not by user-choice. In this spectrum, there is (and will be) no choice but to adopt and use AI applications, either regulatory or de jure. This category of AI applications has been excluded from our study on the likelihood of voluntary adoption of AI.

Developing a framework thus is imperative for research in AI to establish a clear foundation for AI research in organizational settings in the same way the seminal papers for Information Systems have done.

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User Profiling and Targeted Advertising: A Study on the Privacy Implications of Machine Learning: A Literature Review

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Abstract--This study investigates the use of machine learning algorithms in user profiling and targeted advertising, addressing privacy concerns. It uses a multidisciplinary approach, examining the underlying motives and financial incentives behind these practices. The research aims to identify privacy concerns, provide legislative frameworks, and explore technical approaches to compromise between personalization and privacy. It also examines user views on these activities and their willingness to give up personal data for tailored products or services. The study aims to contribute to the ongoing conversation on privacy and ethical implications of machine learning-driven user profiling, offering valuable insights for policymakers, industry players, and users.

I. INTRODUCTION

User profiling and targeted advertising are becoming essential parts of the internet ecosystem in the quickly changing digital landscape. Today, organizations have the capability to deliver highly personalized content and ads to consumers, offering the potential for enhanced user experiences and greater advertising effectiveness. This transformation is driven by the extensive adoption of machine learning algorithms. While there are numerous advantages associated with this shift in the digital advertising landscape, there is also an immediate need to comprehensively address privacy concerns. It is critical to comprehend the complex ethical and privacy concerns raised by user profiling and targeted advertising as technology continues to transform how companies engage with customers and collect data. The privacy topic has gained prominence due to the widespread usage of machine learning techniques for creating complex user profiles and enabling accurate ad targeting. This research undertakes a thorough investigation of these privacy consequences as well as the complex network of variables driving the spread of these practices in the digital advertising industry. The study delves deeply into user profiling mechanisms and illuminates the opaque nature of machine learning techniques used to create user profiles. It also explores the financial motives and motivations behind the widespread use of tailored advertising.

This study takes a multidisciplinary approach to tackling these issues, incorporating ideas from computer science, psychology, law, and ethics. It critically looks at the procedures for gathering and using user data as well as any possible drawbacks, including biases, asymmetry in the information, and a degradation of individual privacy. It seeks to recognize and evaluate the complex privacy issues and provides suggestions for possible legislative frameworks and mitigating measures. Examined is how well-suited the current privacy rules and regulations are to the changing landscape of targeted advertising and user profiling. The study also investigates technology strategies like federated learning and differential privacy that balance privacy and personalization. The survey also looks at consumers' perceptions of user profiling and targeted advertising, as well as how much they know about these tactics and how ready they are to trade personal information for customized goods and services. The research attempts to contribute to the creation of more user-centric advertising strategies by identifying user sentiments. Finally, by providing insightful information to industry stakeholders, policymakers, and users alike, this study adds to the continuing conversation about the moral and privacy implications of machine learning-driven user profiling. This helps to promote a more knowledgeable and well-rounded response to the rapidly changing digital landscape.

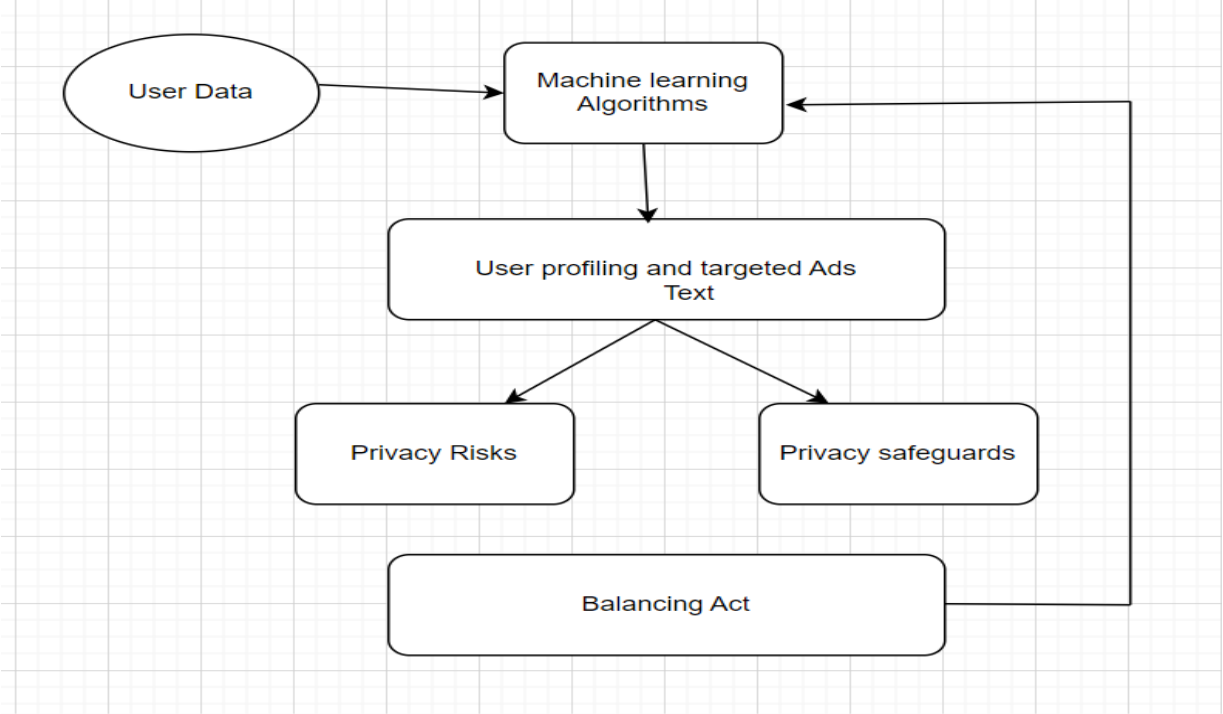

Figure 1: Review of the outcome of user data processed in ML.

II. LITERATURE REVIEW

The era of machine learning and artificial intelligence (AI) has brought about a significant shift in the digital world, particularly in the areas of targeted advertising and user profiling. These technologies are causing a lot of privacy consequences and ethical questions as they become more widely used (48). To gain insight into the changing landscape of user profiling and targeted advertising, this literature review explores the complex web of concepts related to machine.

learning/AI privacy, consumer usage and privacy of AI information, business ethics, and the legal aspects of consumer privacy usage (1). To reduce the possible risks related to user profiling and targeted advertising, future research will examine the development of strong privacy-preserving techniques within machine learning algorithms. Finding a balance between user privacy and personalized advertising can also be facilitated by looking into the socio-ethical aspects and legal frameworks surrounding the use of these technologies.

TABLE 1 NUMBER OF PAPERS BY THEME

Themes	**No. of Papers**
Machine Learning/AI Privacy	15
Consumer Usage and Privacy of AI Information	13
Business Ethics	10
Legal Aspects of Consumer Privacy Usage	11

Databases (primary):	PubMed, IEEEXplore, ACM Digital Library, and Google Scholar

A. Machine Learning/AI Privacy

The extensive use of artificial intelligence and machine learning in user profiling and personalized advertising has given rise to an increasing number of privacy issues (2). The likelihood for user data to be misused, illegal access to data, and the continuing danger of data breaches are the main concerns. Concerns about online security and consent have become more pressing as awareness of these issues has grown (49). Studies on the privacy issues around machine learning in user profiling have recently been conducted. They draw attention to the inherent risk that comes with the massive volume of user data that algorithms gather and process (3). Unauthorized data access has become the norm, whether because of dishonest business practices or data breaches. This illegal access raises serious ethical issues in addition to privacy violations.

Furthermore, data leaks have drawn a lot of attention from the public and compelled lawmakers to review the security measures in place for user data (4). These hacks damage consumers' confidence in digital services and have serious ramifications for their privacy. Studies indicate that the risks for companies and consumers are greater than they have ever been, necessitating a review of data gathering and storage procedures. Informed consent has emerged as a key concern as consumers become more conscious of the worth of their personal data and the repercussions of data breaches (5). Consumers anticipate openness from data gathering and utilization procedures. Privacy concerns have been made worse by the lack of clear information about how their data is gathered, processed, and used to create user profiles.

B. Consumer Usage and Privacy of AI Information

Important components of this literature are user views and behavior around the usage of personal data for AI-driven advertising and profiling (6). It is crucial to comprehend user privacy perceptions and protection strategies to properly handle privacy consequences. Research has indicated that individuals display diverse actions in reaction to privacy issues related to artificial intelligence and user profiling (7). Certain users take proactive measures to safeguard their data by utilizing techniques like ad-blockers or privacy-enhancing applications. Others, on the other hand, can be less conscious or worried and unintentionally contribute to the degradation of their privacy. Addressing consumer usage and privacy concerns requires informed consent, which is essential. It is imperative that users comprehend exactly how their data will be used. Users' privacy is protected, and trust is increased when they have complete knowledge and control over their data (8).

C. Business Ethics

The main issues include controlling user permission, controlling user behavior, and preventing discrimination based on interests, behavior, or demography (50). Research indicates that several companies find it difficult to reconcile their commercial objectives with moral behavior. Driven by machine learning algorithms, the pursuit of tailored advertising may go beyond moral bounds (9). For instance, manipulating user behavior to boost ad engagement may give rise to grave ethical concerns. These

strategies might restrict consumers' freedom of choice and autonomy. Advertising may also contain discriminatory content based on factors such as age, gender, or other attributes. Targeted advertising should be based on relevant interests and behaviors rather than reinforcing biases or preconceptions (10). It's still difficult to strike a balance between corporate objectives and moral obligations; therefore, procedures need to be reviewed.

D. Legal Aspects of Consumer Privacy Usage

Authorities and regulatory bodies have reacted to the privacy implications of user profiling and targeted advertising. Laws like the General Data Protection Regulation (GDPR) across Europe and the California Consumer Privacy Act (CCPA) in the United States have a significant impact on the legal environment (11). The ramifications of these regulatory frameworks for organizations and their data operations are extensive. They force companies to negotiate a challenging terrain of rules, paperwork, and reporting. When it comes to consumer privacy in a digital context, GDPR is a hot issue of discussion because it is international and affects firms globally (12). The legal implications of consumer privacy usage get more complex as legislation keep changing (13). Studies show that companies must move fast to be compliant and safeguard customer information. Furthermore, as people become more aware of their rights and the consequences of disclosing personal information, these regulations are causing a shift in user behavior (14).

The literature analysis emphasizes how complex user profiling and targeted advertising are when compared to AI and machine learning (15). To characterize the changing environment of user profiling and targeted advertising, it sheds light on the complex web of machine learning/AI privacy, consumer usage and privacy of AI information, corporate ethics, and legal issues of consumer privacy usage. User profiling and targeted advertising are growing fields that require a comprehensive approach that considers not only the technological aspects but also the ethical, legal, and user-centric factors (16). A thorough basis for comprehending the privacy concerns of AI and machine learning in this field is provided by the study of these dimensions. Future digital advertising and privacy practices will be shaped by the way the landscape changes and consumers' awareness of their rights to privacy increases and rules tighten (17). The gaps in the literature that this evaluation found provide insightful avenues for further study and the formulation of technology management-related policies.

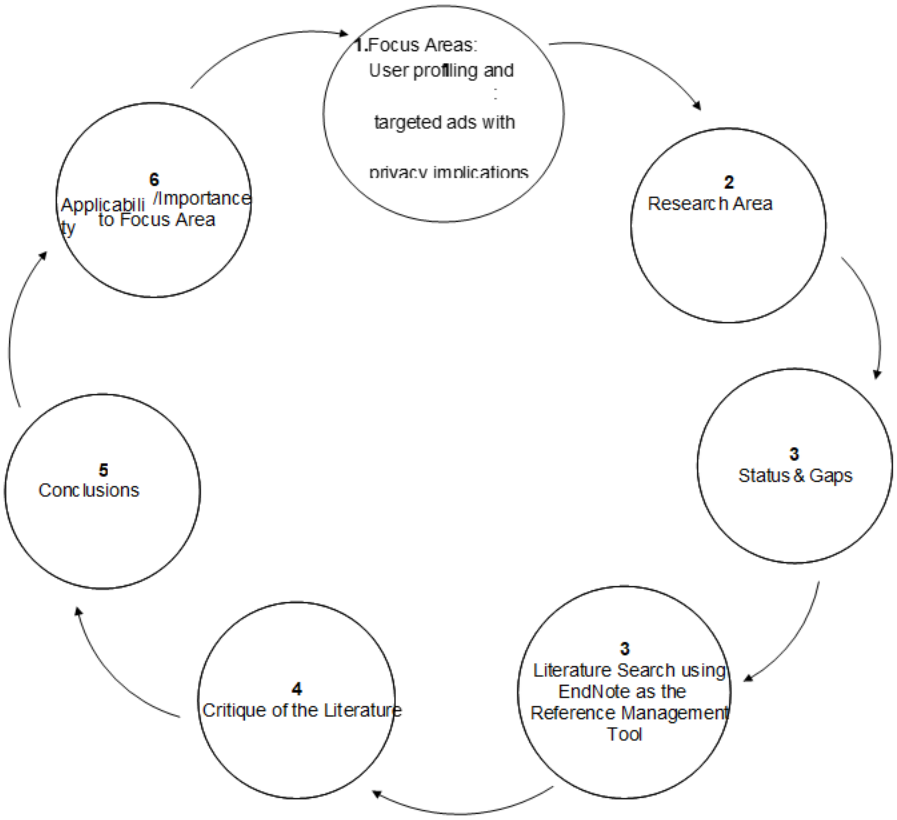

Figure 6: The Literature Review Process

III.METHODOLOGY

The present investigation employs a methodical technique to collect, evaluate, and comprehend information pertaining to the privacy consequences of machine learning in the context of targeted advertising and user profiling in the domain of Technology Management (18). The research design, data sources, data collection strategies, and data analysis methodologies are described in this section.

A. Research Design

This study uses a qualitative research approach and focuses primarily on performing a thorough review of the literature (19). This literature review aims to comprehend and synthesize current information and identify gaps in the literature surrounding user profile and targeted advertising, is in line with the research design.

B. Data Sources

Academic literature, which includes books, conference papers, peer-reviewed journal articles, and reliable internet sources, serves as the main source of data for this study (21). Using academic databases and libraries, a comprehensive search will be carried out, with an emphasis on sources that particularly address business ethics, legal considerations around consumer privacy usage, machine learning/AI privacy, and consumer usage and privacy of AI information (20).

C. Data Collection Methods

Literature Search: Using academic databases including PubMed, IEEE Xplore, ACM Digital Library, and Google Scholar, a thorough literature search will be carried out (22). Relevant articles will be found by using keywords associated with the defined terms (machine learning/AI privacy, consumer usage and privacy of AI information, corporate ethics, and legal elements of consumer privacy usage) (23). Inclusion and Exclusion Criteria: Every source that has been found will be assessed using predetermined inclusion and exclusion standards. Sources that directly aid in comprehending the interactions between privacy implications in user profile and targeted advertising will be included. Sources that are not credible or relevant will be excluded (24)

D. Data Analysis Techniques

A method based on thematic analysis will be used to analyze the data for this literature study (26). The steps involved are as follows:

D.1 Data Organization: Endnote reference management software will be utilized for the organization and cataloging of all the chosen material. This will make it easier to arrange the sources for review in a methodical manner.

D.2 Thematic Coding: The By finding recurrent themes and patterns pertaining to machine learning privacy, consumer behavior, ethical issues, and the legal elements of user profiling and targeted advertising, the literature will be coded thematically.

D.3 Critical Synthesis: To investigate gaps in the literature, analyze the connections between the themes that have been identified, and make judgments about the current state of knowledge, a critical synthesis will be carried out (27).

IV.GAPS IDENTIFICATION IN THE LITERATURE

We'll pay close attention to finding holes in the literature. These gaps will function as possible areas of concentration for subsequent studies, potentially in the framework of a technology management dissertation (28). The chosen methodology lays the groundwork for identifying research gaps and future directions in this area by offering an organized and methodical approach to reviewing and analyzing the body of literature on the privacy implications of machine learning in user profiling and targeted advertising.

A. Machine Learning/AI Privacy

The evolution of user data collecting, processing, and use through artificial intelligence (AI) and machine learning has given birth to numerous privacy concerns (29). An intricate web of issues that require attention is shown by research in this sector. Data-driven decision making is growing exponentially, which is one of the major results in this field (30). Because machine learning technologies have the ability of analyzing huge amounts of data, firms can now create detailed customer profiles for personalized marketing. But there are significant privacy issues with this strategy. Unauthorized access to data and possible data misuse has emerged as major problems (31). These concerns must be addressed considering the many information thefts and privacy violations that have come to light in recent years.

The idea of consent is one that appears frequently in the literature. Users frequently become inadvertent participants in data collection and profiling procedures (32). There is often a lack of informed consent and a blurring of the boundaries between

what users voluntarily disclose and what is being collected covertly. One of the biggest issues with machine learning privacy is this lack of transparency (33). Users must be able to comprehend the procedures used to gather, manage, and utilize their data. This subsection clearly relates to the goals of our research. Our study's central concern is privacy as it relates to machine learning and artificial intelligence. The results show that user profiling and targeted advertising are mostly dependent on machine learning, but this comes at a cost: privacy (34). Our analysis is based on this interaction between the privacy consequences and the capabilities of the technology.

B. Consumer Usage and Privacy of AI Information

The conversation around privacy in machine learning revolves around users. An important aspect of this conversation is how customers view and safeguard their privacy in the light of artificial intelligence (35). Studies conducted in this field demonstrate that customers are becoming more conscious of the data they produce and its importance (37). Concerns regarding the use of this data have led to calls for increased openness and control. Consumers are become more circumspect about the services and apps they use, as well as how much data they share (36). Granular control and informed consent are increasingly crucial considerations in user decisions. There are divergent viewpoints on user awareness, though. Some users are wary and well-informed, while others are still mainly in the dark about the scope of data collecting and profiling (38). These disparities in awareness highlight the need for more effective privacy education and awareness programs. This subsection bears substantial importance to our study. A crucial component of our research involves the perceptions and actions of users. Evaluating the overall impact on privacy in AI-driven user profiling requires an understanding of how people navigate the privacy landscape (39).

C. Business Ethics

The literature has given a lot of attention to the moral implications of targeted advertising and user profiling (40). The topic revolves around ethical considerations pertaining to consent, manipulation of user behavior, and the possibility of discrimination. Research in this field has repeatedly shown that using and collecting user data presents ethical challenges (41). The perception that profiling is used to manipulate user behavior to increase profits raises questions regarding fairness and openness. Ad discrimination based on, or demographic profiling raises important moral dilemmas (42). For example, it is unethical to market potentially damaging goods or services to vulnerable groups. Because corporate ethics closely correlate with our research objectives, it is relevant to our study. Measuring the impact of user profiling and targeted advertising on privacy requires an understanding of their ethical implications (43). The literature emphasizes how commercial tactics and ethical considerations in the digital advertising industry have a tangled interaction.

D. Legal Aspects of Consumer Privacy Usage

Governments and regulatory bodies have recognized the need for legal structures to protect user privacy. Rules such as the General Data Protection Regulation (GDPR) throughout Europe and the California Consumer Privacy Act (CCPA) in the United States have a significant impact on the regulatory framework (44). The influence of these restrictions on enterprises is highlighted by research in this field (45). Businesses must adjust to a complicated regulatory landscape where user data usage is strictly restricted. Although these rules offer some protection, they also make it difficult for enterprises to comply. This subsection

clearly relates to the goals of our research. Our examination into the privacy consequences of targeted advertising and user profiling is heavily reliant on legal factors (46). According to the literature, the legal environment is changing, and figuring out how this is going to affect things is crucial to determining how these practices are changing.

TABLE 2. SUMMIRIZED GAP TABLE

Title	Highlight	Authors	Year	Gaps
Machine learning and AI privacy Review				
When Machine Learning Meets Privacy: A Survey and Outlook	The work on the preservation of machine learning is still in the infancy stage.	B. Liu et al	2020	Machine learning and AI privacy concerns were assessed.
Data Science and Analytics: An Overview from Data-Driven Smart Computing, Decision-Making and Applications Perspective	Advanced analytics methods can be applied to enhance the intelligence and capabilities of an application through smart decision-making in different scenarios.	Iqbal H. Sarker	2021	
Conceptualizing smart city applications: Requirements, architecture, security issues, and emerging trends	Smart city applications are put forth to understand the quality of living standards and smart city applications collect a wide range of privacy-sensitive information from people and their social circles.	A. B. Haque et al	2021	
How to address data privacy concerns when using social media data in conservation science.	Social media data are being increasingly used in conservation science to study human-nature interactions.	E. Di Minin et al	2021	
Equality and Privacy by Design': Ensuring Artificial Intelligence (AI) Is Properly Trained & Fed: A New Model of AI Data Transparency&- amp; Certification as Safe Harbor Procedures	AI data transparency Model operates as a safe harbor mechanism that incentivizes the industry from the first steps of developing and training AI systems to the actual operation of the AI systems.	S. Yanisky-Ravid et al	2018	
Research trends on the usage of machine learning and artificial intelligence in advertising.	Artificial intelligence and machine learning are here for a noticeable and significant change.	Neil Shah et al	2020	
Consumer usage and privacy of AI information Review				

Paradoxes of artificial intelligence in consumer markets: Ethical challenges and opportunities	AI-enabled products are becoming widespread in today's marketplace.	Shuili Du et al	2020	Consumer usage and privacy of AI information covered.
The dark side of mobile app adoption: Examining the impact on customers' multichannel purchase.	The negative effect on spending is smaller for customers who use the app for mobile check-in service than those who use the app for only searching.	Gu, X	2021	
Analysis of the role of digital influencers and their impact on the functioning of the contemporary On-Line promotional system and its sustainable development	Digital influencers have great potential for activities involving digital influencers.	Wielki, J.	2020	
The responsibility of social media in times of societal and political manipulation.	Social media platform providers can minimize risks for societies through responsible action in the fields of human rights, education, and transparency of algorithmic decisions.	U.Reisach et al	2021	
Ethical machines: The human-centric use of artificial intelligence.	Algorithmic decision-making processes might lead to more objective decisions than those made by humans who may be influenced by prejudice, conflicts of interest, or fatigue.	B. Lepri et al	2021	
Business ethics Review				
Short reports: a new format for disseminating information from scientific meetings	Short reports are published to coincide with the meeting and are given to each registered participant.	L. Ernster, W. Whelan	1987	Business ethics assessment covered.
Digital tools against COVID-19: taxonomy, ethical challenges, and navigation aid	Digital public health applications are in use.	Urs Gasser et al	2020	
From user-generated data to data-driven innovation: A research agenda to understand user privacy in digital markets	The large-scale analysis of user-generated data has led to the emergence of user privacy concerns about how companies manage user data.	Saura, J. R et al	2021	
Legal Aspects of Consumer Privacy Usage Review				

Protection for 'Inferences Drawn': Comparison between the General Data Protection Regulation and the California Consumer Privacy Act	The California Consumer Privacy Act specifically includes "inferences drawn" as part of its definition of personal information.	Jordan M. Blanke	2020	Legal aspects of consumer privacy usage coved.
Thirty years of research in family business journals: Status quo and future directions	The most debated topics in family business research conducted in the three dedicated journals in this field are identified	Paola Rovelli et al	2021	
The Origins and Consequences of Affective Polarization in the United States	Democrats and Republicans both say that the other party's members are hypocritical, selfish, and closed-minded.	S. Iyengar et al	2019	

V.INTERPLAY BETWEEN CONCEPTS

In the context of user profiling and targeted advertising, the interaction between these four dimensions machine learning/AI privacy, consumer usage and privacy of AI information, corporate ethics, and legal elements of consumer privacy usage—presents a complex environment. The conclusions drawn from each of these studies underscore the connections between them and the demand for an all-encompassing strategy to address privacy issues in the ecosystem of digital advertising (47). This essay's literature analysis shows how complicated and multidimensional the privacy issues of machine learning in user profiling and targeted advertising are. Important conclusions show that informed consent, ethical conundrums, privacy issues, and legal restrictions are all crucial to the conversation. The interaction of these ideas emphasizes the necessity of treating privacy concerns in this dynamic digital environment from an all-encompassing perspective.

VI. CONCLUSION

A. Literature Review: On the main objective

- The literature review on machine learning and privacy highlights the growing research on privacy implications of machine learning algorithms, especially in user profiling and targeted advertising. It calls for a nuanced understanding of ethical challenges, including information asymmetry, bias, and personal liberty threats.
- The literature review on consumer usage and privacy of AI information highlights a gap in understanding user perception and interaction with user profiling and targeted advertising. It suggests varying awareness and understanding consumer sentiments can shape user-centric advertising models.
- The literature review on business ethics highlights the ethical implications of user profiling and targeted advertising, highlighting the need for future research to explore the balance between profit motives and user privacy, thereby ensuring a fair digital ecosystem.

- The literature review on legal aspects of consumer privacy usage emphasizes the need to assess the effectiveness of current privacy laws in addressing user profiling and targeted advertising, suggesting future research to identify gaps and propose ethically adjusted legislative frameworks for a regulatory environment.

B. Gaps

The literature review revealed the following gaps:

- The growing use of AI and machine learning has raised privacy concerns. While AI can analyze vast amounts of data, it can lead to unauthorized access and misuse of data. Consent is often a key issue, with users often becoming inadvertent participants in data collection procedures. This lack of transparency is a major concern in machine learning privacy. The study focuses on the interaction between privacy consequences and the capabilities of machine learning, highlighting the need for better understanding of data collection and usage procedures.
- The privacy debate in machine learning centers on users' perceptions and actions towards artificial intelligence. Studies show that consumers are becoming more aware of the data they produce and its importance, leading to calls for increased transparency and control. However, there are divergent views on user awareness, highlighting the need for effective privacy education programs. Understanding user perceptions and actions is crucial for evaluating the impact of AI-driven user profiling.
- There is a moral implication of targeted advertising and user profiling, including consent, manipulation, and discrimination. The use of user data presents ethical challenges, and the perception of profiling for profit raises questions about fairness and openness. Understanding the ethical implications of these practices is crucial for measuring their impact on privacy in the digital advertising industry.
- Legal structures like GDPR and CCPA protect user privacy, impacting businesses. These regulations restrict user data usage, but also make compliance difficult. Research on targeted advertising and user profiling focuses on legal factors, as the legal environment is changing. Understanding how these practices will change is crucial for understanding the privacy implications of these regulations.

C. *Future Research*

- For Machine learning/AI privacy, future research will explore federated learning and differential privacy, scalability, and practical implementation, while also exploring emerging machine learning techniques and privacy implications to balance personalization and privacy.
- For consumer Usage and Privacy of AI Information, future research will explore user behavior psychology and privacy concerns, using solutions like federated learning. The research on user consent dynamics, informed consent, and cultural and regional attitudes can help develop more tailored advertising models for global acceptance.
- For business ethics, future research will explore ethical decision-making in user profiling and targeted advertising, corporate social responsibility initiatives, and alternative revenue models that prioritize user privacy.
- For legal aspects of consumer privacy usage, future research will explore potential legislative frameworks to address ethical concerns in machine learning-driven user profiling, adapt existing laws to new technologies, and explore international collaboration on privacy regulations.

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RETROSPECTIVE CAUSAL INFERENCE ON IHDP DATASET TO EVALUATE COGNITIVE TEST SCORE OF PREMATURE INFANTS

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Abstract – **This study is aimed at investigating the Infant Health and Development Program (IHDP) dataset for causal effect estimation and uses the data to discover the causal effects of early intervention from specialist doctors on the cognitive test scores of premature infants. This study offers causal inference methods on IHDP dataset to discover the effect of early intervention on the cognitive health of infant. It also develops a methodology to validate causal effect estimation pipeline as a secondary aim. Propensity score matching reduces the selection bias in observational studies. The IHDP dataset is a randomized controlled dataset aimed at improving the health of children and mothers. The IHDP dataset consists of 747 records, of which 608 are in the control group and 139 in the treatment group. This study first identifies the mean difference between the control group and the treatment group, and the difference is 4.02 and later used logistic regression to identify the average treatment effect (ATE) of early intervention to be 3.73 (95% CI 3.057 to 4.679; P< 0.000) with the propensity score weighting method.**

Keywords: preterm; propensity score weighting; logistic regression; average treatment effect; causal inference.

I. INTRODUCTION

According to the CDC (Center for Disease Control and Prevention), almost 20,000 infants died in the United States in 2020[1]. The five leading causes of infant death in 2021 were congenital disabilities, preterm birth and low birth weight, sudden infant death syndrome, Injuries (e.g., suffocation), and maternal pregnancy complications [1]. In 2021, preterm birth and low weight accounted for 14.8% of infant deaths (deaths before one year of age), and the babies who survive may have breathing problems, feeding difficulties, cerebral palsy, development delay, vision problems, and hearing problems. Additionally, the emotional toll and the financial burden faced by the families [1]. The IHDP was created to enhance the well-being of premature and low-birthweight infants by providing mothers with education and support services, along with offering educational daycare and health services for the children. [2] Numerous approaches have been suggested for estimating treatment effects using observational data. [3]. The Casual inference method has been widely used to measure the treatment effects of randomized controlled trials (RCT). [4] Among different approaches of the Casual Inference method, the Propensity score is one of the popular approaches. Propensity score matching reduces the selection bias on the observational data by controlling the confounding [5,6].

In this paper, a retrospective study of the IHDP dataset was conducted to determine if early intervention affected the cognitive test scores among treated and untreated premature babies. We started with a baseline model (The difference in means E[Y|T=1] – E[Y|T=0]) and used a propensity score matching model. The propensity score, e(x), helps us by not having to condition on all the features 'X' to achieve independence of the potential outcomes on the treated. Therefore, it is sufficient to condition on this single variable, the propensity score: (Y1, Y0) ⫫ T | e(x).

II. RELATED WORK

Donald B. Rubin published a sizeable number of articles in the 1980s on propensity score as an approach to adjust the covariate in observational studies [7]. Propensity score matching has been immensely popular since then in different areas, such as medicine to e-shopping [8,9]. One study done in Vietnam based on the Vietnam Living Standard survey to evaluate revised healthcare insurance saw an improvement in hospital inpatient admission [11]. Another study was done in India to measure the impact of healthcare insurance coverage utilization using a propensity score matching model; of the 2390 participants aged 18-45 with nearly equal gender distribution, only 13.6% had health insurance, yet those with insurance showed significantly higher healthcare utilization rates, with an ATE value of 0.08 indicating its positive impact [11].

III. DESCRIPTIVE STATISTICS

For this project, the Infant Health and Development Program (IHDP) dataset was utilized, a randomized controlled dataset collected from 1985 to 1989 to identify different child and mother problems and improve child and mother health [12,13]. No missing values were found while pre-processing the data, however, the dataset was unbalanced, with 747 records. Of them, 139 are in the treatment group, 608 are in the control group [Figure 1]. There are 30 columns in the dataset. Along with treatment, factual, and counterfactual, there are six continuous and 19 binary covariate data, x1 to x6 and x7 to x25, respectively [Figure 2]. Also visually compared the distribution of each column in the dataset by creating side-by-side histograms with kernel density estimates (KDE) [Figure 3].

Figure 1. Population distribution for the dataset. This represents the number of patients who were in treatment and control group.

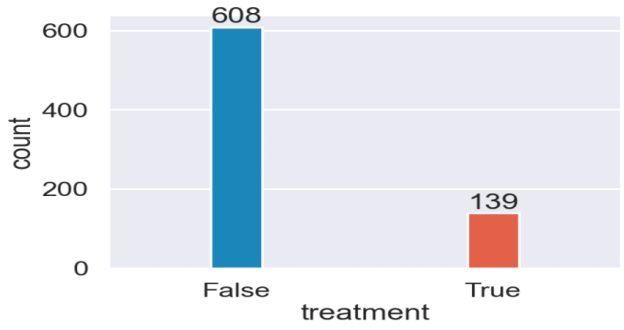
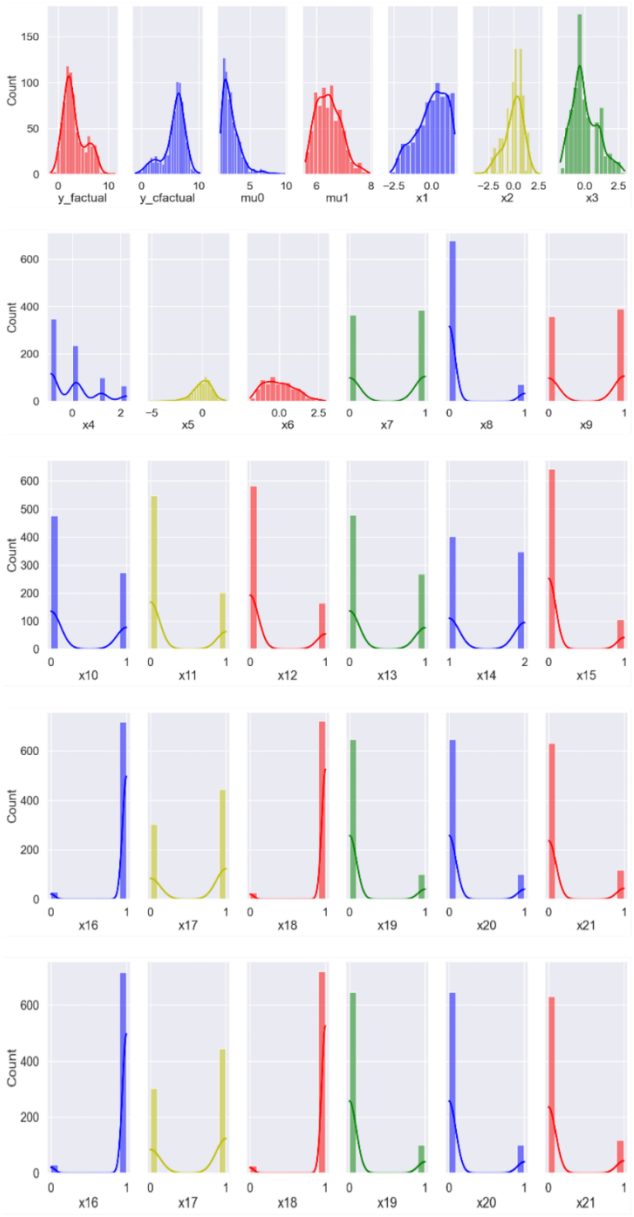


Figure2. Shows all the columns including features in the dataset.

```
Index(['treatment', 'y_factual', 'y_cfactual', 'mu0', 'mu1', 'x1', 'x2', 'x3',
       'x4', 'x5', 'x6', 'x7', 'x8', 'x9', 'x10', 'x11', 'x12', 'x13', 'x14',
       'x15', 'x16', 'x17', 'x18', 'x19', 'x20', 'x21', 'x22', 'x23', 'x24',
       'x25'],
      dtype='object')
```

Figure 3. Visual distribution comparison of each column in the dataset.



Descriptive data analysis (DDA) was done on the dataset to get the count, mean, standard deviation, minimum, maximum, and different percentile values. Additionally, DDA also provided distribution charts of each value and correlation matrix. It shows that factual has a mean of 3.15 value and counterfactual has 5.569 [Table 4]. From the distribution chart, it can be found that all the continuous columns are either left or right skewed.

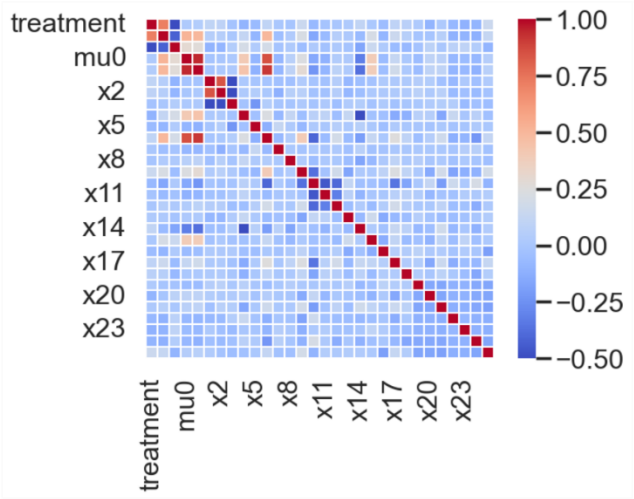
Table 4. Descriptive data analysis of each variable in the dataset.

	y_factual	y_cfactual	mu0	...	x23	x24	x25
count	747.000000	747.000000	747.000000	...	747.000000	747.000000	747.000000
mean	3.159538	5.696107	2.432513	...	0.073628	0.128514	0.157965
std	2.179956	1.980121	1.281515	...	0.261339	0.334886	0.364953
min	-1.543902	-1.037628	0.924453	...	0.000000	0.000000	0.000000
25%	1.626779	5.053598	1.518409	...	0.000000	0.000000	0.000000
50%	2.577294	6.209686	2.114661	...	0.000000	0.000000	0.000000
75%	4.494637	6.948922	2.989305	...	0.000000	0.000000	0.000000
max	11.268228	10.171004	9.821792	...	1.000000	1.000000	1.000000

8 rows × 29 columns

The heatmap provides a quick and visual way to understand the relationships between pairs of variables in the dataset [Figure5]. It helps identify patterns and potential multicollinearity in the data.

Figure 5. Overview of correlations between different variable using Pearson method.



IV. PROPOSED APPROACH

Initially, ordinary least square (OLS) model was performed to establish the baseline with summary statistics mentioned below [Table 6]. The coefficient of 4.0211 suggests that, on average, when the treatment is True, the dependent variable is expected to increase by 4.0211 units. The low p-value (0.000) indicates that this effect is statistically significant.

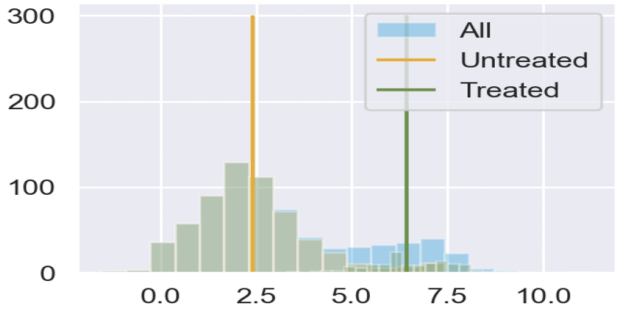
In summary, the intercept and the treatment variable have statistically significant effects on the dependent variable. The t-statistic measures how many standard deviations the coefficient is from zero, and the p-value indicates the probability of observing such a value if the actual effect is zero. In both cases, the p-values are very low (close to 0.000), suggesting strong evidence against the null hypothesis of no effect.

Table 6. Baseline statistics using OLS.

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	2.4113	0.062	39.178	0.000	2.290	2.532
treatment[T.True]	4.0211	0.143	28.183	0.000	3.741	4.301

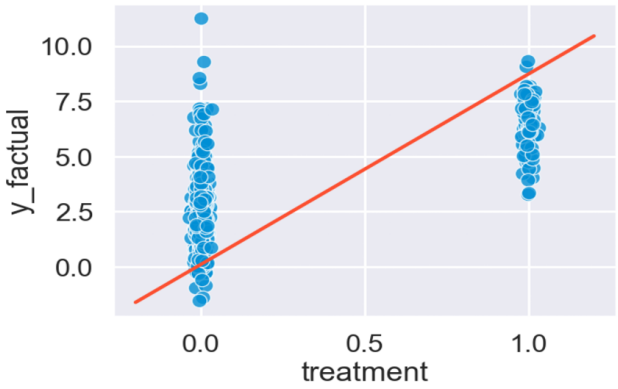
We also created a histogram to visualize the distribution of the 'y_factual' variable in the dataset, with separate histograms for the entire dataset, the untreated group (treatment=0), and the treated group (treatment=1). Vertical lines are added to the plot to indicate the mean values for the untreated and treated groups based on some values (2.4113 and 2.4113 + 4.0211) [Figure 7].

Figure 7. Histogram comparing between all, treated, and controlled data points.



The scatter plot shows the relationship between the 'treatment' and 'y_factual' variable. Each point represents an observation, and the x-coordinate indicates the treatment status, while the y-coordinate indicates the observed values of 'y_factual.' The overlaying line plot is the regression line fitted to the data using a linear regression model. The line visually represents the relationship between 'treatment' and 'y_factual' as estimated by the model. The plot allows us to assess how well the linear regression model captures the relationship between the treatment and the observed outcomes. The degree to which the points align with the line is an indication of how well the model fits the data [Figure 8].

Figure 8. Scatter plot to observe the relationship between the treatment and y_factual.



The next step was performed to transform categorical features in a dataset into dummy variables using one-hot encoding. This process is commonly used to prepare data for machine learning models that require numerical inputs, as many algorithms cannot directly handle categorical variables. The one-hot encoding creates binary columns for each category in the original categorical features, making them suitable for machine learning models. After this process, the data shape changed to (747, 49).

Logistic regression was performed to estimate the propensity scores using T ='treatment, Y= 'y_factual', and X = 'All the features in the dataset'. Propensity scores are often used in observational studies to balance covariates between treated and untreated groups. Propensity scores represent the estimated probability of receiving the treatment given the observed covariates [Table 9].

Table 9. Propensity scores using Logistic Regression.

	treatment	y_factual	propensity_score
0	True	5.599916	0.282761
1	False	6.875856	0.068024
2	False	2.996273	0.106404
3	False	1.366206	0.121567
4	False	1.963538	0.089949

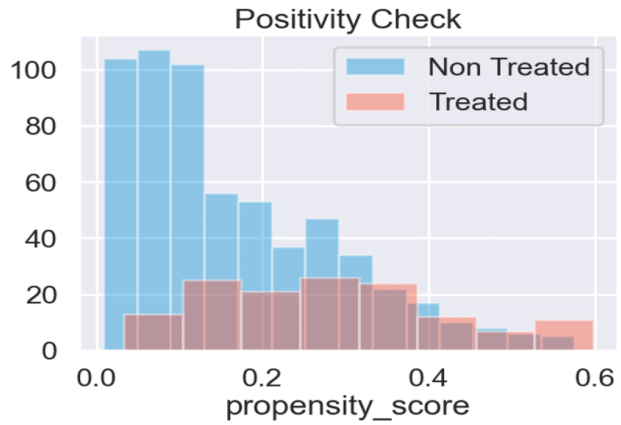
The propensity score weights are used to reconstruct a population where everyone is treated. The goal is to assess whether the weights effectively balance the treated and untreated populations so that each group appears to have the same size regarding their weighted contributions. The print statements display the original and adequate sample sizes for the treated and untreated populations based on the calculated propensity score weights [Figure 10]. The idea here is to verify whether the weights have been appropriately chosen such that the weighted samples for the treated and untreated groups are comparable. If the weights are effective, the treated and untreated populations' effective sizes should be similar, indicating successful balancing based on propensity scores.

Figure 10. Reconstructed population sample size after propensity score weighting.

```
Original Sample Size 747
Treated Population Sample Size 709.0958341206648
Untreated Population Sample Size 747.5434758744693
```

Positivity Check: The distribution plot (histogram) below is used to visually assess the balance achieved in the treated and untreated populations based on the estimated propensity scores. The plot is commonly referred to as a "Positivity Check," and it helps to ensure that there is sufficient overlap in the distribution of propensity scores between the treated and untreated groups [Figure 11].

Figure 11. Histogram to check if the balance was achieved afte propensity score weighting.



- The plot provides a visual comparison of the distribution of propensity scores between the treated and untreated groups.
- If the distributions overlap well, it indicates that individuals with similar propensity scores are found in both groups, contributing to a balanced comparison.
- A well-balanced distribution is crucial for the success of causal inference methods based on propensity scores, as it helps mitigate the risk of bias due to confounding factors.

In summary, "Positivity Check" plot helps to visually confirm that the estimated propensity scores are balanced between the treated and untreated groups, supporting the validity of subsequent causal inference analyses.

Finally, propensity score weighting estimator was implemented to estimate the Average Treatment Effect (ATE). Propensity score weighting is used to adjust for confounding variables and estimate the causal effect of a treatment. One can infer from propensity score weighting that treated individuals to be 3.69 standard deviations above their untreated fellows regarding achievements. If no one got the treatment, one should expect the general level of achievements to be 2.43 standard deviations lower than what it is now. By the same reasoning, one can expect the general level of achievement to be 6.13 standard deviation higher if we have given everyone the treatment [Figure 12].

In summary, one should expect propensity score weighting to estimate the Average Treatment Effect, providing a way to account for potential confounding variables and obtain a more accurate measure of the causal effect of the treatment.

Figure 12. Propensity score weighting estimator statistics.

```
Y1: 6.134963928790556
Y0: 2.4390686519496163
ATE 3.6958952768409423
```

Also implemented the Inverse Probability of Treatment Weighting (IPTW) estimator using a logistic regression model to estimate the propensity score. This performs bootstrapping to obtain an Average Treatment Effects (ATE) distribution and calculates a confidence interval. This step provides an IPTW estimate of the Average Treatment Effect and a confidence interval obtained through bootstrapping. The bootstrap procedure helps quantify the uncertainty associated with the estimated ATE.

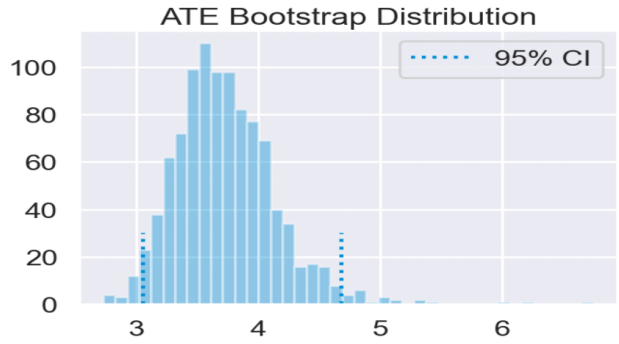
The estimated ATE of 3.73 suggests that, on average, the treatment is associated with a positive change in the outcome variable [Figure 13]. The 95% confidence interval indicates the range of plausible values for this effect, considering the uncertainty introduced by sampling variability. In other words, the treatment is likely to have a positive impact, and one should be reasonably confident that the true effect lies within the specified confidence interval. This information is useful for understanding the potential impact of the treatment and its uncertainty in context of the analyzed data.

Figure 13. Inverse probability of treatment weighting (IPTW) statistics.

```
ATE: 3.730309277814006
95% C.I.: (3.0567299943521333, 4.678959554386958)
```

Below is a visual of what the bootstrap samples look like along with the confidence intervals [Figure 14].

Figure 14. ATE bootstrap distribution with confidence intervals.



Finally, Ordinary Least Squares (OLS) regression model was deployed to estimate the relationship between the observed outcome variable 'y_factual, the treatment variable 'treatment,' and the propensity score 'propensity score.' The output includes the summary tables from the regression results [Table 15].

- The Intercept and treatment effects are statistically significant, indicating a significant relationship with the dependent variable.
- The 'propensity score' coefficient is not statistically significant at the 0.05 level but has a p-value close to 0.1, suggesting it might be borderline significant.
- The overall model captures a significant association between the treatment, propensity score, and the dependent variable. However, the interpretation of the 'propensity score' coefficient should be done cautiously, given its borderline significance.

Table 15. OLS regression statistics for estimating relationship between observed outcome, treatment, and, propensity score.

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	2.2954	0.095	24.248	0.000	2.110	2.481
treatment[T.True]	3.9390	0.151	26.020	0.000	3.642	4.236
propensity_score	0.7051	0.438	1.610	0.108	-0.154	1.565

Also implemented a simple form of nearest-neighbor matching to estimate the treatment effect in the dataset. Below are the results for the same:

- The estimated treatment effect is approximately 3.88.
- This means that, on average, the treated group has an outcome of around 3.88 units higher than their matched counterparts in the control group.

V. LIMITATION

The propensity score does not need to predict the treatment very well. It just needs to include all the

confounding variables. On the other hand, nearest-neighbor matching relies on the assumption that the observed covariates (here, propensity scores) adequately control for confounding. The simplicity of this matching method might not account for all potential confounders, and other more sophisticated matching techniques or statistical methods may be considered for robust causal inference.

In summary, nearest-neighbor matching provides a quick estimate of the treatment effect. However, it is essential to interpret the result cautiously and consider potential limitations and assumptions of the method.

VI. CONCLUSION

The analysis suggests a positive and statistically significant average treatment effect across multiple methods, including propensity score weighting, matching, regression, and bootstrapping. The nearest-neighbor matching approach also indicates a positive treatment effect. Interpretation should be cautious, considering potential confounders and assumptions inherent in each method.

The validity of the results depends on the assumption that observed covariates adequately control for confounding. Further sensitivity analyses and model diagnostics may be considered for a more robust interpretation. Results are specific to the dataset and modelling choices, and context-specific knowledge is crucial for drawing meaningful conclusions.

The analysis employs various statistical and causal inference techniques to estimate and interpret the average treatment effect in observational data. The multiple approaches used provide a comprehensive understanding of the treatment effect while acknowledging uncertainties and potential limitations associated with each method.

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Papers

Education, Curriculum, and Cases

EDU204

Education 4.0: Knowledge, Skills, and Abilities for Supply Chain Entry Level Workers

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Abstract

In this research we investigate the relevant knowledge, skills, and abilities (KSAs) that entry level supply chain professionals need for the Industry 4.0 era. We replicate, with minor modifications, the survey research of Tatham *et al.* (2017), who grouped the KSAs into the three clusters of Maintain Competitiveness, Seize Opportunities and Mitigate Threats, and Sense and Shape Opportunities and Threats (Teece, 2007). We collected survey data from supply chain professionals in the United States, the United Kingdom, and Canada during the CO-VID 19 pandemic, similar to the Tatham *et al.* (2017) study conducted in the aftermath of the 2007-2009 financial crisis. We aggregate our results across all three countries and for each cluster we perform a Spearman correlation and a cluster variables analysis to determine relationships between the KSAs within the cluster. Relationship strength between KSAs indicates these KSAs should be taught in the same course or module of a course. This research emphasizes the importance of both transversal (soft) and disciplinary (hard) skills as key competencies for entry level supply chain employees in the Industry 4.0 era.

CRITICAL THINKING ACROSS THE CURRICULUM: ENHANCING RATIONALITY BY OVERCOMING COGNITIVE BIASES

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ABSTRACT

Employers complain that they have difficulty finding college graduates with critical thinking skills. One way to enhance critical thinking skills is by understanding how cognitive biases work. Cognitive biases are mental shortcuts or heuristics people use when facing complex and uncertain situations. The authors posit that cognitive biases can be easily taught in various courses, such as project management, marketing, statistics, ethics, and diversity and inclusion, so people can be aware of them and make better decisions.

Keywords: critical thinking, cognitive bias, availability bias, base rate bias, self-serving bias, ethical thinking.

According to Lewis [38], knowledge doubles every 12 months. Companies must recruit employees who continuously learn new information and discard outdated knowledge. Once upon a time, a college education was enough to set you up for life. But not anymore. Today, the average employee stays with their employer for just over four years, and the average person changes jobs about 12 times during their working life [35]. This means that the skills you learn in college may not be enough to last your entire career. That's why it's essential to be a lifelong learner. You must constantly develop new skills and knowledge to stay competitive in the job market. Moreover, critical thinking, is a transferable skill needed for most high-level jobs, is one of the most crucial skills an employee must have.

A critical thinker knows when it is time to discard obsolete theories and dated information. About 73% of employers in the United States assert that they have difficulty finding college graduates with crucial soft skills that include critical thinking, communication, and the ability to listen [67]. According to the 2021 AAC&U (Association of American Colleges and Universities) survey, "Six in 10 employers said that college graduates possess the knowledge and skills needed to succeed in *entry-level* positions" ([18], para. 21). This suggests that 40% cannot succeed at even entry-level positions.

Regrettably, academics are often the worst offenders when it comes to imparting outdated theories. For example, **much of economic theory is based on the premise of the 'rational economic man.' The rational economic man (homo economicus) makes decisions based solely on self-interest and wants to maximize utility. However, the theory of the rational economic man may be a theory that is dead or rapidly dying [1].** After the Great Recession of 2008, Alan Greenspan, former Chairman of the Federal Reserve, told Congress: "I made a mistake in presuming that the self-interests of organizations, specifically banks and others, were such as that they were best capable of protecting their own shareholders and their equity in the firms…" **(Coll, 2008, para. 1**). In ([30], p. 374) avows: "Theories can survive for a long time after conclusive evidence falsifies them, and the rational-agent model certainly survived the evidence we have seen, and much other evidence as well."

In ([30], p. 269) the author describes how he was handed an essay written by the Swiss economist Bruno Frey that stated: "The agent of economic theory is rational, selfish, and his tastes do not change." Kahneman was astonished that economists could believe this given that it was apparent to psychologists that "people are neither fully rational nor completely selfish, and that their tastes are anything but stable. Our two disciplines seemed to be studying different species, which the behavioral economist Richard Thaler later dubbed Econs and Humans."

Exploring Cognitive Biases Across the Curriculum

One way to enhance critical thinking skills is by understanding how cognitive biases work. [1] uses the latest research to demonstrate that people are predictably irrational; they use heuristics or rules of thumb to make decisions. Heuristics may be seen as "cognitive shortcuts" that humans utilize when there is a great deal of required information to collect in order to make a correct decision, but time (or desire to do the extensive research) or money is limited [8]. Using rules of thumb may help a person make quick decisions but might lead to a systematic bias. In [58], the author lists 67 cognitive biases that interfere with rational decision-making. A cognitive bias is defined as:

> [A] systematic error in thinking that affects the decisions and judgments that people make. Sometimes these biases are related to memory. The way you remember an event may be

> biased for a number of reasons and that in turn can lead to biased thinking and decision-making. In other instances, cognitive biases might be related to problems with attention. Since attention is a limited resource, people have to be selective about what they pay attention to in the world around them (Chery, 2016, para. 2).

There are about 200 known cognitive biases, and the list continues to grow [19]. Too Much Information; Not Enough Meaning; Need to Act Fast; and What Should We Remember? In [15], groups of 188 cognitive biases were listed in infographic.

Researchers from various disciplines have been examining cognitive biases in order to understand how to improve decision-making in their areas. In [8], the author was concerned with the negotiation process, asserts that "cognitive misperceptions can highly bias human behavior when making judgments and decisions, and this is true in negotiations." The military has been studying cognitive biases to improve decision-making in the US Army. The military has found that "Because these heuristics generalize situations and allow people to make quick decisions despite time constraints or imperfect information, they often result in predictable errors in judgments (cognitive biases)" [45]. The Central Intelligence Agency (CIA) devotes several chapters in its manual to cognitive biases. The following reason is given for studying these biases:

> Psychologists have conducted many experiments to identify the simplifying rules of thumb that people use to make judgments on incomplete or ambiguous information, and to show--at least in laboratory situations--how these rules of thumb prejudice judgments and decisions. The following four chapters discuss cognitive biases that are particularly pertinent to intelligence analysis because they affect the evaluation of evidence, perception of cause and effect, estimation of probabilities, and retrospective evaluation of intelligence reports (Heuer Jr., 2008; see Chapters 9-12).

McCann came up with ten cognitive biases that can result in poor decisions by executives in finance [42]. Cognitive biases have been found to cause patient harm in healthcare facilities [28]. Smith avers that a good marketer must understand cognitive biases for the purpose of converting prospects into customers [58]. In [16], the authors focused on understanding how cognitive biases work in the legal system. They were mainly concerned with how these biases affect the "impartiality" of expert witnesses. They underscore that:

> [A] mere expectation can bias the cognitive and brain mechanisms involved in perception and judgment. It is very important to note that cognitive biases work without awareness, so biased experts may think and be incorrectly convinced that they are objective, and be unjustifiably confident in their conclusion [16].

It is clear that individuals who want to make rational decisions that are unbiased in all kinds of situations, not only negotiations, military intelligence, or healthcare, should attempt to understand the various cognitive biases that distort clear thinking. The best way to reduce or eliminate cognitive biases is to be aware of them.

The authors maintain that the best way to improve critical thinking and decision-making skills is to attempt to integrate cognitive bias research into the curriculum wherever possible. There have been attempts to introduce ethics across the curriculum. However, critical thinking is essential for ethical thinking. Critical thinking skills enable individuals to navigate ethical dilemmas from diverse perspectives and make informed decisions grounded

in reason and logic. Without critical thinking abilities, one will find it challenging to make morally responsible choices. Paul ([47], para. 1) posits that "without critical thinking at the heart of ethical instruction, indoctrination rather than ethical insight results." Siegel ([54], p. 55) underscores that critical thinking is the "enemy of the unjustifiable status quo."

This paper will focus on crucial cognitive biases that negatively impact rational decision-making. Cognitive biases can be easily taught in various courses, such as project management, marketing, statistics, ethics, and diversity and inclusion, so people can be aware of them and make better decisions. To explore a broader range of biases, consider reading [20].

Some Cognitive Biases that Adversely Affect Rational Decision-Making

Actor-Observer Bias

The actor-observer bias refers to a "tendency to attribute one's own actions to external causes, while attributing other people's behaviors to internal causes" [12]. Thus, if someone else cuts in line, it is because he is a jerk. If I cut in line, it is because I am late for a crucial appointment. Zur found that cognitive biases may affect how we perceive enemies' actions [68].

> Research has repeatedly demonstrated how the enemy's hostile actions are more likely to be attributed to natural characteristics, while positive, conciliatory or peaceful actions are more likely to be attributed to situational factors. In other words, when the enemy is acting peacefully, it is because it is forced to do so by external circumstances and not by its own choice. When it acts aggressively, it is due to personal choice or characteristic behavior [68].

Anchoring Bias

Thaler & Sunstein ([61], pp. 23-24) provide an example of how anchoring works: People who are asked to guess the population of Tallahassee will probably have no idea. Suppose subjects are randomly assigned to two groups. Group A is first told that Los Angeles has 4 million people and then asked to guess the population of Tallahassee. Subjects in Group B are first told that the population of Liberty, NY is 9,900. What will happen is that Group A will make a much higher guess than Group B as to the population of Tallahassee. The reason is that the first number they are given is used as an anchor and then adjusted. Group A will modify the 4 million downward, knowing that Tallahassee is much smaller than Los Angeles. Group B will adjust upward, knowing that Tallahassee is larger than Liberty, NY.

Lawyers use anchoring to establish a number in a lawsuit. The lawyer will ask for $30 million in damages, knowing very well that there is no way the jury will award this kind of number for, say, a libelous story in the paper about the client. However, she might get her client a few million dollars since the $30 million will be used as an anchor. Retailers might use phony markdowns (original price $800) to anchor a price and get customers to overpay for a product.

Thompson states: "People don't really like making decisions. We have habits, we like thinking automatically [62]. So sometimes we avoid making choices altogether because it stresses us out." Real estate agents understand this and take advantage of buyers by employing the following techniques.

> Since buying a house is highly consequential and difficult to reverse, rational people should look at a great many options and think them through very carefully. A good agent will show you a few houses that are expensive and not very nice, and then one at almost the same price and far nicer. Many buyers will respond by stopping their search and jumping on this bargain. Our susceptibility to "bargains" is one of the cognitive devices we use to simplify choice situations, and one that companies are conscious of when they position their products ([62], para. 12).

Availability Bias

This refers to the overestimation of risks that are readily available in memory. How easily things come to mind is a heuristic that makes people overestimate the importance of certain kinds of information. If something is difficult to remember, one will assume it is less likely to occur. Kahneman defines availability bias as follows [30]:

> There are situations in which people assess the frequency of a class or the probability of an event by the ease with which instances or occurrences can be brought to mind. For example, one may assess the risk of heart attack among middle-aged people by recalling such occurrences among one's acquaintances. Similarly, one may evaluate the probability that a given business venture will fail by imagining various difficulties it could encounter. This judgmental heuristic is called availability. Availability is a useful clue for assessing frequency or probability, because instances of large classes are usually reached better and faster than instances of less frequent classes. However, availability is affected by factors other than frequency and probability ([30], p. 425).

Availability bias means there is a tendency to overestimate the risks of accidents that are easy to recall. Why are people more worried about being killed with a gun than drowning in a pool? Or, why do we think more people die of homicides than suicides? According to Thaler & Sunstein ([61], pp. 24-26), people "assess the likelihood of risks by asking how readily examples come to mind." Therefore, familiar risks (e.g., those reported in the media) are more frightening to people than those not familiar. Thousands die yearly from injuries resulting from falling in the shower, yet people are more worried about being killed by a terrorist. The danger of being hurt from texting while driving (or even walking) is quite significant. According to Thaler & Sunstein ([61], p. 26): "easily remembered events may inflate people's probability judgments." This is also why people believe that accidents are responsible for as many deaths as disease. It works both ways. Events we cannot bring to mind will have lower probabilities of occurring. Of course, a marketer can make risks familiar by showing them in advertisements.

Two biases that affect availability are recency and salience. Recency refers to the tendency to give more weight to the latest, most recent information or events rather than older information or events. Saliency bias refers to the fact that

> Big, dramatic events, such as explosions, gun battles, and natural disasters, stick in our heads and stay there, undermining our ability to think objectively about things like causation, probabilities, and death rates. Since September 2001, motor vehicle accidents have killed more than four hundred thousand Americans, but how often do you worry or get upset about them? ([9], para. 2).

The media makes us aware of the threat of terrorist attacks. It is, however, statistically much more likely that an American will die in a car accident than being injured in a terrorist attack. There is one chance in a hundred that a person will die in a car accident over a lifetime, and the chance of being killed in a terrorist attack is 1 in 20 million (http://www.lifeinsurancequotes.org/additional-resources/deadly-statistics/).

Backfire Effect

One would think that people would change their beliefs and opinions when presented with facts that contradict them. However, the truth is that what often happens when people's beliefs – especially those firmly held – are challenged by contradictory evidence, these incorrect beliefs get even more potent. It is a daunting task to change people's views with facts.

Certainty and misinformation are compelling and potent, making it difficult for facts to change people's minds. There is evidence that not only do facts not correct misinformation, but they also make it more persistent and potent ([23; [34]; [44]; [65). Colleen Seifert, a researcher at the University of Michigan, states the following concerning misinformation.

> Misinformation stays in memory and continues to influence our thinking, even if we correctly recall that it is mistaken. Managing misinformation requires extra cognitive effort from the individual… If the topic is not very important to you, or you have other things on your mind, you are more likely to make use of misinformation. Most importantly, if the information fits with your prior beliefs, and makes a coherent story, you are more likely to use it even though you are aware that it's incorrect [65].

Base Rate Fallacy

The base rate fallacy is a cognitive bias that occurs when people focus too much on the specific, specialized details of a situation (the individuating information that is distinct) and disregard the overall, general frequency or probability of something occurring (the base rate). In a nutshell, the general probability is overlooked in favor of the specific probability. The specific probability might focus on a particular case or a small sample. This can lead to people making inaccurate judgments or decisions.

The following experiment is discussed in Kahneman ([30], pp. 146- 154): Subjects were told the following about Tom W., a graduate student:

> Tom W. is of high intelligence, although lacking in true creativity. He has a need for order and clarity and for neat and tidy systems in which every detail finds its appropriate place. His writing is rather dull and mechanical, occasionally enlivened by somewhat corny puns and flashes of imagination of the sci-fi type. He has a strong drive for competence. He seems to have little feel and little sympathy for other people, and does not enjoy interacting with others. Self-centered, he nonetheless has a deep moral sense (p. 147).

The above description led people to ignore prior probabilities regarding the relative size of majors in different disciplines. Subjects asked to rank nine fields of specialization indicated that Tom W. was most likely majoring in

computer science and engineering. Essentially, the similarity to a stereotype of a group trumps the actual size of the group (the prior probability).

Flyvbjerg maintains that base-rate fallacy is one of the more serious biases in project management because project planners tend to see their projects as being special and distinctive [19]. Flyvbjerg points out that every individual is distinctive, but the medical profession has made enormous progress by focusing on what people have in common. A project may appear unique in a particular state but might be familiar if one examines how the plan worked in other states and countries.

Bias Blind Spot

People tend to have a bias blind spot, meaning they are likelier to rate themselves as less susceptible to biases (including cognitive biases) than others. We are also more able to detect biases in others than in ourselves. According to one researcher:

> People seem to have no idea how biased they are. Whether a good decision-maker or a bad one, everyone thinks that they are less biased than their peers …This susceptibility to the bias blind spot appears to be pervasive, and is unrelated to people's intelligence, self-esteem, and actual ability to make unbiased judgments and decisions [51].

Thus, physicians believe that gifts from pharmaceutical companies are likely to unconsciously bias decisions made by other doctors. These gifts, however, will not prejudice their own medical decisions [51].

Certainty Bias

Certainty bias is the cognitive bias that makes us overestimate the accuracy of our beliefs, judgments, and opinions. People resist new information that challenges or contradicts their preexisting ideas, attitudes, thoughts, and beliefs. This is because people stick to their views even when there is a preponderance of evidence indicating that they are wrong. Consider the amount of scientific evidence that the planet is experiencing climate change and that vaccines do not cause autism. Millions of people still cannot accept that they are wrong.

With certainty bias, the focus is on the beliefs and opinions of the individual. With overconfidence bias, a type of certainty bias, the emphasis is on people's convictions regarding their knowledge. People tend to overestimate their expertise and are wrongly overconfident.

Certainty Effect (Zero-Risk Bias)

Studies show that people prefer options that reduce a small risk to zero over a more significant reduction in a much more considerable risk. In other words, we prefer the absolute certainty of a smaller benefit (i.e., complete elimination of risk) to the lesser certainty of receiving a more considerable benefit. Generally, people tend to give higher weights to outcomes they perceive as highly probable or certain and lower weights to outcomes they believe have lower probabilities.

The risk of having an autistic child is much smaller than the risk of a child dying from infectious diseases. Yet many parents try to reduce the risk of autism by not vaccinating their children (actually, there is no evidence linking autism to vaccines) and take on the much higher risk associated with infectious diseases such as measles, rubella, and mumps.

In one study, people preferred reducing a given risk by 5%□ from 5% to 0%□ rather than halving a considerable risk of 50% to 25%. The latter option reduced the risk more, yet the public preferred zero risk [17]. People prefer options where risk can be eliminated entirely over better alternatives. Most people would choose a guaranteed $1 million over a 95% chance of $2 million with a 5% chance of 0, even though the expected value of the latter choice is much higher. Money-back guarantees are probably effective because the consumer perceives them as reducing risk to zero [17].

People are willing to pay a great deal to eliminate risk entirely. This sometimes results in laws that focus on attempting to remove all risk regardless of the actual benefits. The cost and effort required to reduce the risk to zero may not be worth it, given the limited resources available to the government. The same can be said of all the tests done by the healthcare system. The costs involved in zero-risk healthcare are enormous, and spending the money on preventive medicine and healthcare for the indigent may make more sense.

Clustering Illusion Bias

People tend to see patterns in what are essentially random streaks. Gamblers tend to do this and attempt to "beat the system" by taking advantage of these phantom patterns in various games of chance, such as cards ("hot hand") or the roulette wheel. People tend to see patterns in price fluctuations of multiple stocks. The Gambler's Fallacy is another cognitive bias that involves a lack of understanding of random streaks.

Confirmation Bias

Once people form an opinion, they "embrace information that confirms that view while ignoring, or rejecting, information that casts doubt on it … Thus, we may become prisoners of our assumptions" [25]. People tend to only listen to information that supports their preconceptions. People may have the ability to see flaws in their opponent's arguments. However, when it comes to their own opinions, that is when they are blind.

Kahneman speaks of "adversarial collaboration," which means bringing together two researchers who disagree and having them conduct an experiment jointly ([41]; [29]). This is a way to reduce the confirmation bias that arises when a researcher consciously or unconsciously designs an experiment in such a way so as to provide support for a particular position [41].

Given the massive amount of research available to scholars, it is not difficult for a researcher to cherry-pick the literature and only reference studies that provide support for a particular opinion (confirmation bias) and exclude others [22]. Even if individual studies are done correctly, this does not guarantee that a researcher writing a state-of-the-art review paper will write an accurate, undistorted synthesis of the literature. Indeed, Celia Mulrow demonstrated that many review articles were biased [22]. Motivated reasoning bias is the flip side of confirmation bias ([40], p. 56).

Conservatism Bias

People tend to favor a prior view even when presented with new information or evidence, i.e., there is a tendency to stick to old information and a reluctance to accept something new. People do not revise their beliefs sufficiently when presented with new evidence because of conservatism bias. Conservatism bias is related to status quo bias. Azzopardi ([3], p. 88) makes this distinction: "The status quo bias is emotional and causes people to hold on to how things are. The

conservatism bias is cognitive and causes people to hold on to their previous opinions and idea frames even though facts have changed." This may help explain why HR professionals are reluctant to consider candidates with different backgrounds and qualifications.

Dualistic Thinking

Some cognitive biases encourage discrimination and prejudice; one of the worst is dualistic thinking, which produces an "us vs. them" approach to life. Dualistic thinking, also known as black-and-white, binary, or polarized thinking, is a general tendency to see things as good or bad, right or wrong, and us or them, without room for compromise and seeing shades of gray. This all-or-nothing cognitive approach leads to poor decision-making and creates polarized groups (think of today's Democrats and Republicans). It interferes with one's ability to be an innovator, which requires one to be open-minded.

This type of dualistic thinking is known in the mental health field as "splitting," which is a "defense mechanism in which people unconsciously frame ideas, individuals, or groups in all-or-nothing or either-or terms (e.g., all-powerful vs. 100% powerless)" ([50], para. 2). It is often seen in people who have a borderline personality disorder [64]. Splitting is a severe problem when dealing with people with different opinions or interacting with those from other races or religions. It is emotionally dysregulating, fostering behavioral issues like aggression and leading to psychic pain and mental illness. It also makes it difficult for people to have constructive dialogue and works against our shared ideals as a society, like love, peace, justice, and unity ([50], para 6).

Dunning-Kruger Effect

This is the tendency of people who are ignorant or unskilled in an area to overestimate their abilities and believe that they are much more competent than they truly are. People who have absolutely no knowledge of, say, Egyptology will not suffer from the Dunning-Kruger Effect. It is people who have a little bit of knowledge that are likely to have a great deal of confidence in their capabilities.

Kruger & Dunning documented this effect in a paper titled "Unskilled and Unaware of It: How Difficulties in Recognizing One's Own Incompetence Lead to Inflated Self-Assessments [36]." They asserted that individuals need a reasonable amount of skill and knowledge to accurately estimate the actual amount of skill and knowledge they possess. A little knowledge is indeed dangerous [49].

Many scholars believe that the Dunning-Kruger Effect is not a valid concept and may be explained by the effects of regression to the mean ([14]; [21]). Time will tell whether this effect is a statistical artefact or an actual cognitive bias.

Expectation Bias

This refers to the tendency for the researcher's expectations to affect the outcome of a study. It also refers to the fact that people remember things the way they expected them to occur; this is why many memories are false. The need for double-blind studies is to minimize expectation bias. Expectation bias is one of the few cognitive biases that has been researched in the field of auditing (Pike, Curtis & Chui, 2013).

Framing Bias

Tversky and Kahneman (1981) were among the first to identify this cognitive bias known as framing.

People respond differently to choices/preferences depending on how they are presented. In particular, there will be

different responses depending on whether the choices are offered as a gain or loss (see loss aversion). Thus, doctors are more likely to prescribe a procedure when it is described as having a 93% survival rate within five years than if it is presented as having a 7% mortality rate within five years (McNeil, Pauker, & Tversky, 1988). Similarly, 9 out of 10 students will rate condoms as effective if they are informed that they have a "95 percent success rate" in stopping HIV transmission; if, however, they are told that it has a "5 percent failure rate," then only 4 out of 10 students rate condoms as being effective (Linville, Fischer, & Fischhoff, 1992). This is why it is more important for a marketer to emphasize what a prospective customer loses by not making a purchase than what they gain by making the purchase (Flynn, 2013).

Fundamental Attribution Error

The fundamental attribution error refers to the tendency of a person observing another person's behavior to attribute it to internal factors or personality and to underestimate the effect of situational causes (i.e., external influences). In other words, we believe others do what they do because of their internal disposition (personality). Thus, if you see someone fighting with another person, you will probably attribute it to someone with a violent temper. Of course, it is quite possible that he is the victim of a mugging attempt and is trying to defend himself. Sherman (2014) provides the following example of the fundamental attribution error:

> A classic example is the person who doesn't return your call. You could go the usual route and think, "He is an inconsiderate slob and my parents were right years ago when they said I should have dropped him as a friend." But the fundamental attribution error would remind you that there might very well be other reasons why this person hasn't called you back. Maybe he is going through major issues in his life. Maybe he is traveling for work. Maybe he honestly forgot (Sherman, 2014).

Gambler's Fallacy (also known as Monte Carlo Fallacy)/Misconception of Chance

Gambler's fallacy is a cognitive bias in which a person mistakenly believes that past outcomes will affect future outcomes even with a random process. For example, if you flip a coin five times and get five heads, one guilty of this bias will expect a tail on the next toss. Of course, since each toss is an independent event, the probability is a constant 50%. People incorrectly believe that random processes are self-correcting and "a deviation in one direction induces a deviation in the opposite direction to restore the equilibrium" (Tversky and Kahneman, 1974, p. 1125). This example is related to this fallacy and is known as the "misconception of chance." The misconception of chance is an example of the *representativeness/similarity* bias discussed by Tversky and Kahneman (1974).

> A coin is to be tossed six times. Which sequence is more likely?
> Sequence 1: H T H T T H
> Sequence 2: H H H T T T

Of course, both are equally likely. However, people will think sequence 1 is more likely than sequence 2 because it appears more random (Tversky & Kahneman, 1974).

This bias was found to influence decision-makers such as refugee asylum judges, loan officers, and baseball umpires. They also made the same mistake in underestimating the probabilities of sequential streaks, such as five baseball strikes in a row or approving asylum for, say, six refugees in a row. Thus, "misperceptions of what constitutes a fair process can perversely lead to unfair decisions" (Chen, Moskowitz & Shue, 2016).

Hyperbolic Discounting

Hyperbolic discounting is a cognitive bias that explains many supposedly irrational behaviors, such as addictions, health choices, and personal financial decisions. McCann (2014) lists it as a critical bias adversely affecting corporate finance decisions. Hyperbolic discounting refers to people's tendency to prefer a reward that arrives sooner rather than wait longer for a larger reward in the future. People discount the value of the award that comes later in the future. A rational person would use a constant discount rate to discount the value of a future reward (this is known as exponential discounting and has been used in economic theory); this means the discount rate should not change across different wait times. In reality, however, people use a time-inconsistent discounting model: The further out in the future the reward, the more we discount it (Kinari, Ohtake & Tsutsui, 2009; Frederick, Loewenstein & O'Donoghue, 2002).

Thus, one may prefer receiving $5000 now to $5200 in 3 months. However, if the choice is $5000 in two years or $5200 in two years and three months, most people would opt for the $5200. People do not mind waiting three months if the wait occurs in two years. What this indicates is that the discount rate used by people is not constant or rational: As delay length increases, the time discount rate decreases.

Illusory Correlation

Illusory correlation is a cognitive bias that makes people believe that two variables or random events are associated when there is no relationship (zero correlation). This can happen because two unrelated events, such as a hitting streak and wearing a particular hat, coincided and made someone believe they were causally related. Likewise, people may assume that the cold weather triggers their migraines or that humidity worsens their joint pain.

Information Overload Bias

People make the mistake of believing that more information means better decisions. Actually, too much information often results in poorer decisions since people cannot handle all the information available to them. The brain can process only a limited amount of information. Information overload can cause increased stress and what has been referred to as information fatigue. Behavioral economists disagree with neoclassical economists and posit that too many choices lead to poorer decisions (Pollitt & Shaorshadze, 2011).

Ariely (2008, pp. 152-153) demonstrates how having too many options often results in the failure to make any decision. For example, someone trying to purchase a laptop might spend several months trying to buy the *best* laptop and not consider the "consequence of not deciding." The difference among the laptops might be minimal. Still, the time spent dwelling over trivial differences and the lost opportunities of not having a computer is not taken into account. We often waste far too much time making a trivial decision when we would be better off flipping a coin to make a choice. To learn more about the problem of offering too many options, read Barry Schwartz's book entitled *The Paradox of Choice: Why More is Less,* or view his TED lecture at http://www.ted.com/talks/barry_schwartz_on_the_paradox_of_choice.html.

Loss Aversion

The pain of losing something we own outweighs the joy of winning by as much as two to one. Thus, for example, the pain of losing $100 that you currently have is roughly double the intensity of the joy you would experience finding $100. This is why a different decision will be made if the same choice is framed as a gain rather than a loss.

Interestingly, researchers believe it takes at least five positive, nice remarks to offset one unpleasant comment in marital interactions. Loss aversion is also an issue in consumer shopping. People reacted more strongly to a 10% increase in the price of eggs than a 10% decrease in the price (Heshmat, 2018).

Loss aversion can also explain why people are more likely to use their income to purchase insurance to protect themselves from a painful loss rather than use the funds to invest in the stock market and possibly earn considerably higher returns (with a chance to lose money). Sticking to the status quo rather than seeking change, even when the change could be advantageous, is also related to loss aversion.

Moral licensing

Moral licensing is a cognitive bias that allows people to act unethically or immorally without feeling like they are contradicting their moral values or compromising their self-image of being an ethical individual. It makes people feel morally justified in engaging in a bad behavior (e.g., cheating on taxes) after doing something good before (e.g., donating to charity). After all, the good deed done in the past makes them feel morally superior and entitled to behave unethically because they have proven that they are good from the previous act.

Men who publicly identify as feminists and contribute to women's rights causes often face allegations of sexual harassment or sexual abuse. Indeed, this is what happened to celebrities such as Harvey Weinstein and others. They were later exposed as sexual predators. Most likely, they used moral licensing to justify this. This is why it is not unusual for people who explicitly rejected sexist hiring practices on paper to still prefer a male candidate for a job. Companies with diversity and inclusion programs may believe this is enough to demonstrate their morality. This may lead them to justify their discriminatory actions towards their minority employees. Moreover, employees who reluctantly participate in seminars or talks on diversity and inclusion may feel they have done their good deed and then bully or mistreat coworkers from minority groups (Collier, 2021).

Marketers use this bias to increase sales. For example, airlines might donate some of their profits to charities so people will ignore how poorly they treat their employees. In the same way, consumers who make a green purchase may feel morally entitled to indulge in a luxury purchase later, using their eco-friendly choice as an excuse for their lavish, self-indulgent spending (Simbrunner and Schlegelmilch, 2017).

Motivated Blindness

Motivated blindness provides a psychological reason that many people engage in unethical behavior. It refers to individuals' psychological tendency to overlook unethical behaviors when it is in their interest to remain ignorant. Once people have a vested interest in something, they can no longer be objective. This is why conflicts of interest are such a

problem; it is almost impossible to behave ethically when a conflict of interest exists. Bazerman & Tenbrunsel (2011a) demonstrate how motivated blindness caused many ethical failures, including the Great Recession of 2008.

> It's well documented that people see what they want to see and easily miss contradictory information when it's in their interest to remain ignorant—a psychological phenomenon known as motivated blindness. This bias applies dramatically with respect to unethical behavior (para. 14).

As noted above, "People tend to have a bias blind spot, meaning that they are more likely to rate themselves as being less susceptible to biases (this includes cognitive biases) than others." Bazerman & Tenbrunsel (2011b, p. 37) observe, "Most of us dramatically underestimate the degree to which our behavior is affected by incentives and other situational factors." On the other hand, we overestimate how others will be influenced by incentives (e.g., paying people to donate blood).

Overconfidence Bias

Overconfidence bias is a type of certainty bias. However, with certainty bias, the focus is on our beliefs; with overconfidence bias, the focus is on our knowledge and talents. People tend to overestimate their abilities and are overconfident. This is an even more significant problem with experts. This overconfidence often results in people taking more substantial risks than they should. Kolbert (2017) highlights, "People believe that they know way more than they actually do." Sloman & Fernbach (2017) also speak of the "knowledge illusion"; we do not understand how little we actually know. With certain kinds of questions, answers that people feel that their response is 99% certain to be correct" turn out to be incorrect 40% of the time (Kasanoff, 2017).

Several books have been written about expert predictions, which usually turn out to be wrong. Experts do only slightly better than random chance. Kahneman (2011, pp. 218-219) cites research conducted by Tetlock (2005) that demonstrates how poorly experts who make a living "commenting or offering advice on political and economic trends" actually perform. They do not do better than monkeys throwing darts on a board displaying the various possible outcomes (Kahneman 2011, p. 219).

Kahneman (2011, pp. 222-233) believes that algorithms often do a better job at predictions than experts. He describes several situations where one should rely on a simple checklist consisting of, say, six relevant characteristics rather than relying on an expert. Kahneman discusses a simple algorithm developed by Dr. Virginia Apgar in 1953 to determine whether a newborn infant was in distress. Her method is superior to the expert judgment of obstetricians since it focuses on several cues. Kahneman does point out the hostility towards using algorithms. Incidentally, Apgar's algorithm, still in use, has saved thousands of lives. Kahneman (2011, p. 226) cites the work of Dawes and claims that a simple formula that uses predictors (i.e., independent variables) with equal weights is often superior to multiple regression models that use complex statistics to assign different weights to each of the predictor variables. Multiple regression models are often affected by "accidents of sampling." Of course, some common sense is needed to select the independent variables most likely to predict the dependent

variable accurately. Dawes claims that the simple algorithm of "frequency of lovemaking minus frequency of quarrels" does an excellent job of predicting marital stability (Kahneman, 2011, p. 226). The bottom line is that we should not be overly impressed with the judgment of experts.

It does, however, sometimes pay to be overconfident. There is evidence that others overrate individuals who are overconfident and sure of their abilities; underconfident individuals are underrated by others as being worse than they happen to be (Lamba & Nityananda, 2014). This may explain why politicians have no problem being so sure of themselves and overpromising (Hutson, 2014).

Overconfidence is being used to explain why there is a gender gap in the corporate world. Men are more egotistical than women, making them appear more capable (Hutson, 2014). Kahneman (2011) believes that one has to be very careful with people who are overconfident and assertive. Before accepting that they know what they are talking about, one has to have some way of measuring this empirically. He concludes that "overconfident professionals sincerely believe they have expertise, act as experts and look like experts. You will have to struggle to remind yourself that they may be in the grip of an illusion."

Planning Fallacy

This bias is related to overconfidence and an illusion of control (McCann, 2014). People tend to underestimate the time and cost it will take to complete a project or task. What often happens when completing a job is that something unforeseen happens. McCann (2014) lists this bias, together with the illusion of control and overconfidence, as special problems in corporate finance. Kahneman (2011: 249-251) cites a survey conducted in 2002 of American homeowners who remodeled their kitchens. They thought the cost of the job would be around $18,658 and ended up spending an average of $38,769.

This happens frequently when the government estimates the cost of a new weapons system or buildings. Kahneman (2011, p. 251) provides a simple solution known as "reference class forecasting." The forecaster should try to gather information about time or cost from outsiders involved in similar ventures and use this information to come up with a baseline prediction. The forecaster should then decide whether they are too optimistic regarding time and cost and see if the baseline prediction needs to be adjusted.

Reactance

Human beings value their freedom and ability to make any choice. Suppose someone tries to restrict their choice, and people feel that they are being forced into a particular behavior. In that case, they will resent the diminution in freedom and act in a manner that restores their autonomy. In other words, they often do the opposite of what the authority figure tells them to do.

Regression Toward the Mean (also known as regression to the mean) Bias

Regression toward the mean bias was first documented by Sir Francis Galton (1886), who examined the relationship between parents' height and their children's height. He found that, in general, parents who are taller than average tend to have children who are taller than average, and parents who are shorter than average tend to have children who are shorter than average. However, in instances where the parents' average height was greater than the average for the population (e.g., suppose the father is 6'8" and the mother is 5'11"), the children tended to be shorter than the parents. Similarly, when the parents' average height was shorter than the average for the population (e.g., suppose the father is 5'1" and the mother is 4'10"), the children tended to be taller than the parents.

Morton and Torgerson (2003) feel that all healthcare professionals should be aware of regression to the mean if they want to make correct decisions.

> Clinicians use diagnostic tests to target and monitor treatment. Regression to the mean can confound this strategy. The preliminary test has a high probability of giving an abnormal result through chance, and initial treatment may be unnecessary. Because of this chance effect, there is a high probability that subsequent measurements will spontaneously regress toward the mean value. This misleads clinicians and patients into thinking that treatment has been effective when the treatment was either not required or ineffective…
> Public health interventions are often aimed at sudden increases in disease and thus vulnerable to the effects of regression to the mean (Morton and Torgerson, 2003, para. 5).

Kahneman (2011, pp. 175-176) describes the mistakes made in teaching flight instructors. The belief that praising trainee pilots for an excellent landing often resulted in a subsequent poor landing is contrary to theories that claim that good performance should be rewarded so that subjects become conditioned to do well. The correct explanation was regression towards the mean.

Kahneman (2011, pp. 181-182) underscores that a statement such as "Highly intelligent women tend to marry men who are less intelligent than they are" will result in many interesting theories involving causality. For example, some people will feel this is because intelligent women do not want to compete with their husbands. In actuality, regression to the mean provides a more straightforward explanation. Tversky and Kahneman (1974) describe "misconceptions of regression" as one of the six cases of the *representativeness/similarity* bias in judgment.

Representativeness Heuristic

This cognitive bias is a mental shortcut that we use when estimating probabilities. As noted above in the discussion of base rate fallacy, *representativeness/similarity* heuristic is a general, shared term that describes various errors individuals make when judging probabilities. Tversky and Kahneman (1974) identified six situations

where representativeness/similarity caused fallacious reasoning: (1) Insensitivity to the prior probability of outcomes; (2) Insensitivity to sample size; (3) Misconceptions of chance; (4) Insensitivity to predictability; (5) The illusion of validity; and (6) Misconceptions of regression (to the mean). One should also add the "Conjunction Fallacy" to this list.

We make decisions regarding the likelihood of a particular event based on calculating how similar it is to an existing belief, stereotype, or mental prototype. The problem with this heuristic is that it may result in disregarding important information and thus making a poor decision. For example, one researcher found that decisions made by jurors could be affected by wearing eyeglasses, which increases the intelligence ratings of defendants and decreases guilty verdicts. The authors also found several interaction effects between the defendant's race and the wearing of eyeglasses (Brown, Henriquez, and Groscup, 2008). Facial tattoos probably can also influence how we perceive someone.

Self-Serving Bias

There is no question that people want to see themselves in a positive light." (Heine et al., 1999; Wang et al., 2015). Self-serving bias, a type of attributional bias, enables people to see themselves in a positive light. It is a type of cognitive bias that involves attributing one's successes to internal, personal characteristics (internal attributions) and blaming one's failures on outside forces beyond one's control (external attributions). In other words, we take personal credit when we succeed (e.g., getting an A+ in a course), but if something does not work out (e.g., getting a D in a class), we tend to deny responsibility and blame outside factors such as a poor teacher or an unfair test. One thing self-serving bias accomplishes is improving one's self-esteem and strengthening one's ego. However, it makes it difficult for a person to desire to improve if s/he believes all failures are due to outside forces.

Status Quo Bias

Status quo bias is a cognitive bias that occurs when people favor the familiar and prefer that things remain the same rather than opting for change. People seem to prefer inaction to making decisions. It also manifests itself when inertia results in people continuing with a previously made decision rather than trying something new. People are more upset about the negative consequences of making a new decision than the consequences of not making any decision (Kahneman & Tversky, 1982). Choosing by default (default may be a historical precedent or a choice made noticeable), an automated choice heuristic, is related to status quo bias.

Stereotyping Bias

Stereotyping is a mental shortcut used by people when making decisions about strangers. When stereotyping, we have certain expectations about the qualities and attributes members of a group (e.g., women, blacks, Jews, homosexuals, Hispanics, Asians, Moslems, etc.) possess. It is much easier for the brain to remember a generalization than specifics because they require less effort. Thus, a generalization like "all _____ are violent" is much easier to recall than dealing with scores of individuals (Benson, 2022). One might make certain assumptions about a person who identifies as a liberal Democrat or conservative Republican. However, many stereotypes are incorrect and based on fallacious beliefs about certain groups. In any case, there is a great deal of variability among individuals that comprise a group.

Survivor Bias

This refers to the tendency to focus on the people or objects that survived or succeeded. We tend to ignore the non-survivors and might completely overlook them because they have become invisible. Unfortunately, in many cases, the non-survivors or failures can provide us with much information. However, because they are not around, we may be unaware of the considerable amount of missing data.

Shermer (2014) provides the following interesting example of survivor bias, citing Gary Smith, author of the book *Standard Deviations*:

> Smith illustrates the effect with a playing card hand of three of clubs, eight of clubs, eight of diamonds, queen of hearts and ace of spades. The odds of that particular configuration are about three million to one, but Smith says, "After I look at the cards, the probability of having these five cards is 1, not 1 in 3 million." (Smith, 2014, para. 2).

Survivor bias is also known as sampling or selecting on the dependent variable. This is where the researcher selects cases where some measure or phenomenon of interest has been observed while excluding the cases where the variable or phenomenon of interest has not been observed. The selected cases are then used to prove the measure or phenomenon of interest. For example, suppose a researcher looks only at successful firms as measured by annual returns. She concludes that these firms were headed by leaders who had humility and that CEO humbleness makes a company great. This finding may or may not be valid. The flaw in the researcher's reasoning is that she also did not examine unsuccessful firms. It is quite possible that humble CEOs also head unsuccessful firms.

In Search of Excellence by Tom Peters and Robert H. **Waterman (1982)** is one of the most popular business books. The authors studied 43 of America's best-run in an effort to determine what made them successful and came up with eight basic principles of management. In other words, they sampled based on the dependent variable of "excellent firms in 1982." The question is, what happened to those firms? Eckel (2013) says that "two-thirds of them underperformed the S&P 500 over a decade. Some faltered badly, and some even went out of business." Kodak, K Mart, and Wang Labs are three examples of firms on Peter and Waterman's (1982) list that went bankrupt. Amdahl, also on the list, was successful until the early 1990s. Then, it started losing money and was eventually taken over. Baum and Smith (2015) also found that the stock performance of these companies did not stand the test of time.

Conclusion

Taylor (2013) underscores that cognitive biases can harm businesses as they frequently lead to suboptimal decisions. To mitigate these biases, he suggests two approaches. Firstly, he recommends developing an awareness of the various types of biases. Individuals can minimize their impact by studying cognitive biases and gaining a comprehensive understanding of them. Secondly, Taylor asserts that collaboration is an effective strategy for reducing cognitive biases. He argues that assembling diverse groups is crucial since groupthink, also a bias, can be avoided through collaboration.

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Application Of The Analytic Hierarchy Process Method For The Selection Of Master's Degree Timeline

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Abstract

With post-secondary education becoming more accessible and vital in the modern-day job market, many students are confronted with the decision of how to best acquire their graduate-level degree. There is a plethora of alternatives ranging from extensive timelines focused on gaining college experience in respective fields of study to accelerated environments that emphasize earning a degree as quickly as possible. This study demonstrates the application of the Analytic Hierarchy Process (AHP) for this higher education problem. A group of freshman students at a higher education institution in the northeastern United States were participants in this study. Four types of programs were identified and ranked using five criteria. We found that our participants valued job competitiveness most when selecting their program preferences, and the highest-ranked alternative was attending a four-year bachelor's program, working in industry, then returning to school to complete a two-year master's program. This study provides a framework for students to implement when choosing their path to a master's degree.

Keywords: Analytic Hierarchy Process, Higher Education, Multi-Criteria Decision Making, Master's Degree

1. Introduction

Now more than ever before, we live in a world where business and technology are progressing at a rapid pace. It has thus become incumbent upon companies to hire educated workers. As such, it has become commonplace for employees in these fields to complete some form of post-secondary education, whether it is an associate, bachelor, master, or doctorate level degree. In this study, we focused our research on students with goals of obtaining a master's degree. Bachelor's degrees serve as the entry-level baseline for many modern-day jobs, therefore a master's degree

is the logical choice for study due to its station as the subsequent stage of education. Additionally, the number of occupations in the United States are expected to grow by 7.4% by 2026, but occupations that require at least a master's degree projected to grow by 16.7%, more than double the former (Rolen, 2019). Hence, master's programs are suitable for our interest and analysis.

In this study, we considered two common academic timelines and two accelerated timelines. First-year students from a higher education institution in the northeastern United States were surveyed and presented with pairwise comparisons, for which they communicated their preferences and levels of importance for each criterion. First-year students were a readily available sample population that both academically and socially related to prospective post-secondary education students that had just completed high school, and thus benefited the study with regard to analyzing subjects that could theoretically be candidates for all given alternatives. As such, their opinions and priorities could be expected to align with future students that may choose to take part in accelerated programs should they be developed and implemented. Our goal was to explore student attitudes toward such programs and rank them by preferability.

2. Literature Review

Singh and Martin (2004) found that of 205 graduate business students, 56% deemed it important to finish their Master of Business Administration as promptly as possible. Additionally, 82% of students surveyed stated they would recommend their school to others if an accelerated program was implemented. We can discern from this that students are generally in support of accelerated programs being offered as an option, and that they expect peers to share that stance. It must be considered, however, that in Singh and Martin's study students of many different statuses were surveyed, including "nontraditional" students who did not continue education immediately following high school and students that were employed full-time and part-time. Thus, the results of their study may be skewed, as nontraditional students may not share the same motivations and priorities as traditional students.

However, Beekie (2006) was of the opposing thought, claiming that "accelerated programs are fast food for the mind," and that they only give students a trivial understanding of the topics of study. He argued that such programs

went so far as to affect the businesses hiring their graduates, as employers expect a standard level of comprehension and skill from graduates, areas that are not fully developed in an accelerated setting. This is a valid concern, as students enrolling in these programs may feel unprepared for the level of education they are receiving if they have not spent considerable time familiarizing themselves with the topics. Brennan (2004) also argues that bachelor's programs help to prepare students for higher levels of study, stating, "Many fine students…arrive at college without [strong time management skills or a commitment to their field of study] and use their undergraduate years to develop them". Therefore, condensing the required time to earn a bachelor's degree may inhibit the development of these areas. Considering this, it would be incumbent upon students choosing to enroll in accelerated programs to develop these skills early in their education.

There is a need for more study in these areas. Most of the reference analyses are over 10 years old, and with the development of online learning and its common use since the Covid-19 pandemic, accelerated programs are much more accessible now than ever before. Research has suggested that students are in favor of accelerated programs being offered (Singh & Martin, 2004), however there is a shortage of research determining whether or not these programs would be preferred over those currently offered by most schools. AHP is a well-established method used for complex decision analysis and is one of the most commonly used forms of muti-criteria decision making (MCDM) (Khan & Ali, 2020), being utilized in a multitude of research fields. The identification of risk factors in hospitals (Singh, 2021), optimal internet technologies to provide coverage in rural Pakistan (Ibrar et al., 2020), and competencies most beneficial to customer service representatives (Shanujas, 2020) have all been analyzed using the AHP method.

The AHP method has seldom been applied when researching education methods. In particular, and to the best of our knowledge, this method has not been used for the selection of a Master's degree timeline. This leaves the education field with room for further research in determining a model for selecting post-secondary education timelines. This research builds upon previous studies exploring academic timelines and addresses this gap by employing the AHP method. Additionally, we propose AHP as a valuable method to assist future students in their decision-making processes.

3. Research Methodology

3.1 AHP model

This study focused on MCDM process as it is related to student preferences toward degree timelines. The AHP method allows for the use of criteria weights to determine the most important factors when making complex decisions, and it determines mathematics-based priorities from the collective research. Developed by Thomas L. Saaty in the 1970s, AHP uses a series of pairwise comparisons to establish levels of hierarchy (Khan & Ali, 2020). Criteria are equated to one another as they relate to each alternative, establishing weight coefficients. Subjective entities are then able to be quantified and compared on a numerical level, thus allowing for these alternatives and criteria to be ranked. This method also considers the possibility of inconsistencies, with a consistency index of <10% being accepted as the standard benchmark that the research is of minimum consistency to hold significance in the decision (Ibrar et al., 2020). The publicly available software SuperDecisions (SuperDecisions (Version 3.2), 2019) was utilized for all computations within this process.

3.2 Alternatives

We chose to explore four alternatives, each with discrete advantages and disadvantages. All are programs that have been implemented within post-secondary institutions across the United States and have published criteria for enrollment. The following timelines have been selected for being both distinct and viable:

i. *Standard* – We will consider this as the baseline: a four-year bachelor's program followed subsequently by a master's degree taking greater than one year to complete. Thus, this will generally take more than five years to complete. Students preferring this alternative have the luxury of time; they are able to indulge in the "college experience" by participating in Greek life, sports, organizations, and other communities within their institution. This alternative accounts for not attending classes during the summer and having a lower workload (15 credits) per semester when compared to other alternatives, so there is a considerable amount of free time, which can be used for jobs, internships, etc.

ii. *Standard with Industry Experience* – Similar to the standard alternative, this involves a four-year bachelor's program and a multi-year master's program. However, upon completion of a bachelor's degree, the student will enter the workforce in their industry of study to gain hands-on experience in a non-academic arena. This will take the longest time of all the alternatives. For simplicity, we will assume the

student will spend a minimum of one year in industry, so this timeline will take at least six years. Employers may look more favorably on graduates with industry experience than those without.

iii. *4+1* – This timeline integrates master's-level courses into the corresponding bachelor's program. It allows students pursuing a master's degree to complete their education in as little as five years. Many of these programs require that students demonstrate a pattern of high accountability and an above average work ethic. Typically, students will apply for this program prior to the third year of their bachelor's curriculum, and a minimum GPA is required to be maintained (Cornell University, n.d.). Students accepted into this type of program do not need to apply to another university for their master's degree, as it is offered through the accepting schools' graduate program, either at their institution or in partnership with another college. This alternative allows students to take part in extracurricular activities, but may require summer courses, which will increase the yearly course load (Northwestern University, n.d.). The total time to complete this program is approximately five years.

iv. *3+1* – This is the most aggressive timeline. It is an extremely condensed program and is typically applied for by incoming first-year students. Those enrolled are expected to follow a specially curated curriculum that mandates summer courses and typically requires 18-credit semesters and a minimum GPA to be maintained (University of Oregon, n.d.). The course load is very high, and students will not have much expendable time outside of classes to take part in extracurricular activities or maintain jobs. Some programs may require incoming students to have a minimum number of college-ready credits such as advanced placement (AP) or college-level examination program (CLEP) credits (University of Pittsburgh, n.d.). This alternative takes the shortest amount of time to complete at four years, but students will finish with little to no work experience, so graduates may not be as competitive on the job market as those with experience.

3.3 Criteria

For this study, we considered the following criteria to cover the spectrum of priorities students may have:

i. *Cost* –Tuition is charged per semester, as are room and board, meal plans, and other fees relating to receiving post-secondary education, so any alternatives involving an accelerated curriculum will decrease the required semesters, and therefore the total cost of education.

ii. *Time* – This refers to the total time to complete both a bachelor's and a master's degree. It will be the intrinsic difference in the alternatives, with each taking four, five, more than five, and more than six years to complete.

iii. *Workload* – This will focus on the number of required courses, their difficulty, and their frequency. The typical bachelor's pipeline takes two 15-credit semesters per year for four years. Adding summer courses or master's-level courses to the bachelor's curriculum or requiring a mandatory third semester each year would be examples of increasing the workload. Requiring less than the standard 15 credits per semester would be an example of decreasing the workload.

iv. *College Experience* – We will refer to the "college experience" as the opportunity for students to take part in sports, organizations, committees, Greek life, and other communities within their institution. Many students value the chance to make new friends, explore new topics, and be involved in the ongoings around their college. We expect our sample to weigh heavily on this criterion, as they make up the majority of most college campuses, and they are surrounded by other students of similar ages with similar interests.

v. *Job Competitiveness* – We will consider how students believe future employers will view candidates based solely on their academic timeline. For example, would an employer prefer a job candidate with industry experience and a master's degree or a candidate who just recently completed their master's degree through a 3+1 program?

4. Results and analysis

The composite priority weights of each participant are shown in Table 4.1. The arithmetic average was then computed and documented to show the collective value placed on each priority. The favored priority among participants was job competitiveness, with 50% of the participants weighing it heaviest in their timeline decisions. Conversely, time was the least prioritized criterion. While it was only ranked by 12.5% of participants to be the last priority, it was in the bottom three of 87.5% of responses, and was not ranked as the top priority by any participant.

Table 4.1: Priority Weights

	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6	Student 7	Student 8	Average
Cost	0.370369	0.230771	0.263129	0.214953	0.169111	0.074714	0.214953	0.214953	**0.219119**
Time	0.129911	0.105915	0.077841	0.158206	0.281745	0.043889	0.158206	0.158206	**0.139240**
College Exp.	0.108441	0.037186	0.443834	0.027130	0.068136	0.540345	0.027130	0.027130	**0.159917**
Workload	0.322529	0.067941	0.153565	0.148175	0.383996	0.164834	0.148175	0.148175	**0.192174**
Job Compet.	0.068750	0.558187	0.061631	0.451536	0.097012	0.176218	0.451536	0.451536	**0.289551**

The preferred timeline alternatives are shown in Table 4.2 using composite weights, and likewise, the arithmetic averages were computed. The most commonly preferred alternative was that of the four-year bachelor's, two-year master's with industry experience, with 37.5% of participants favoring this option.

Table 4.2: Timeline Preferability

	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6	Student 7	Student 8	Average
3+1	0.105298	0.357866	0.072114	0.468909	0.143829	0.109765	0.226639	0.049853	**0.191784**
4+1	0.159487	0.165277	0.125044	0.222073	0.367722	0.165414	0.385424	0.176307	**0.220844**
4B, 2M	0.314971	0.104812	0.514040	0.080543	0.291650	0.497676	0.115601	0.250554	**0.271231**
4B, Work, 2M	0.420244	0.372045	0.288802	0.228475	0.196799	0.227145	0.272336	0.523286	**0.316142**

Comparing these results, it can be seen that students who value job competitiveness most will likely choose to pursue an accelerated degree or gain industry experience in between a four-year bachelor's and a two-year master's degree. These alternatives demonstrate to employers that candidates possess valuable skills above what is typically anticipated from a graduate with no experience (i.e. high accountability, above average work ethic, etc.). However, students who value their college experience most will prefer to earn their degree through a four-year bachelor's, two-year master's program without industry experience. This is due to this alternative maximizing the college experience by not accelerating the courses or adding work to their timeline.

We expected that due to all the participants being of similar age and in similar courses, their priorities and timeline preferences would generally follow similar distributions. However, every alternative was the preferred choice of at least one student. This is further supported by the fact that all but one priority was calculated to be the highest weighted for at least one participant. Additionally, it should be noted that job competitiveness was the highest ranked criterion.

These analyses were conducted on traditional first-year students at a regional higher education institution in the northeastern United States. If this study was instead conducted on adults returning to college, we could have had different results.

5. Conclusions

This study determined that most participants preferred to take part in a four-year bachelor's program, enter the workforce within their respective industries, then return to school to complete a two-year master's program. This gives credence to the highest ranked priority being job competitiveness. Students placed more value in work experience than in specific accelerated programs to make them competitive job candidates following graduation. This could be attributed to direct experience being more applicable to an industry position than academics, or to the students' belief that employers will value experience over workload capacity. Conversely, the least preferred alternative was the 3+1 accelerated master's program. Because time was ranked by the students as the lowest priority, the option that decreased the time required to obtain a master's degree by maximizing the workload, the 3+1 program, was understandably at the bottom of our aggregate rankings.

In this study we provided a framework for prospective master's degree students to decide their direction of education. The results examined provide only some examples of students' ideal selections and their collective average, but this method can be utilized by any student deciding how to best earn their master's degree. Individuals may weigh their criteria differently, and the method implemented in this research considers how each criterion compares to another when determining the best alternative for a student. Outside factors are not considered within this method, so rather than using it as a final decider, students could use it to aid in their decision-making process.

These findings also have practical implications in regard to higher education institutions offering accelerated degree programs. Universities could take these results into account when designing such programs in order to maximize

student interest. For example, courses could be offered in conjunction with businesses in order to give students some form of work experience or tangible results to demonstrate their competencies in the workplace. Possibly, schools could partner with companies via internships in lieu of certain courses that would better be taught in a working environment. It is clear that time alone is not enough to entice traditional first-year students into an accelerated program. As such, developing a way to integrate their high priorities into these programs would play a pivotal role in raising enrollment.

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EVALUATING LARGE LANGUAGE MODEL ACCURACY IN STRUCTURED ACADEMIC SETTINGS: THREE CASE STUDIES

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Abstract

As large language models (LLMs) are increasingly deployed in real-world applications, concerns exist regarding their accuracy and potential for hallucination. However, few studies evaluate performance systematically across academic contexts. This paper summarizes three case studies assessing LLM accuracy on classroom analytics exercises. In the first, students tested ChatGPT 3.5 responses to technical questions in graduate courses over 12 weeks. Over 95% factual concordance was found, with repetition being the primary inconsistency. The second study successfully replicated 167 statistical analyses from an Excel exercise book in ChatGPT 4 covering techniques like regression and inference. No discernible accuracy issues appeared. The third case evaluated Claude 2 and ChatGPT 4 on Harvard Business School case questions across four subjects, with student teams finding perfect alignment with faculty solutions.

Collectively, the case studies reveal three key themes. First, constrained problem scopes limit deviations in accuracy. Second, performance relies on relevant domain exposure during pretraining. Third, high grading agreements position LLMs as credible teaching assistants, though personalization and originality remain inadequate. Overall, contrary to wider benchmarks, LLMs demonstrate high fidelity on academic tasks, allaying concerns about hallucination. Speculatively, restricted interfaces could enhance reliability. Domain-specific finetuning also remains vital. The studies support LLMs' use for automated tutoring and analysis, complementing human educators. Further assessments on more advanced reasoning tasks are still necessary.

Introduction

It is a well-known fact that large language models can sometimes provide incorrect answers to questions. This phenomenon, called hallucination, can be a problem if an analyst relies on these models to provide accurate answers in cases where an answer is not known beforehand. In this paper, we present the results of three separate situations where technical information needed to be supplied accurately. We did not intend for this to be a test of the accuracy of a large language model, but the results appear to be valuable case studies that support the case for using these tools with confidence.

Recent studies have raised valid concerns regarding the accuracy and potential for hallucination in large language models (LLMs) when deployed in real-world settings (Liang et al., 2022). However, few studies have systematically analyzed their performance in structured academic environments. This review summarizes three case studies evaluating LLM accuracy in classroom analytics exercises, with promising results.

Case Studies

In the first case study, Case Study A, we tested ChatGPT 3.5 responses to factual questions in two university-level analytics courses over a 10-week period. Students assessed the accuracy against instructor solutions, finding over 90% concordance. Minor discrepancies were primarily attributable to the LLM's tendency to repeat responses. The choice of LLM was determined primarily by its functionality, its reported accuracy at that time, and the available version (this was a Spring 2023 course, and ChatGPT 4 was not available at the start of the semester).

The research questions Case A helped to answer were: (1) How accurate are the responses from large language models like ChatGPT when used for technical tutoring? and (2) Can the tendency for language models to repeat responses verbatim negatively impact their usefulness as tutors?

In the second study, Case Study B, 32 analytical questions from an exercise book on statistics were completed using Excel and ChatGPT 4 Plus. The LLM successfully replicated all 167 Excel analyses with no discernible accuracy issues.

The research questions Case B helped to answer were: (1) Can large language models accurately replicate quantitative statistical analyses from an Excel exercise book? And (2) Do the concerns around factual inaccuracies and hallucinations in LLMs manifest in mathematical/computational responses?

The third case, Case Study C, evaluated the performance of two LLMs (Claude2 and ChatGPT 4 Plus) to answer Harvard Business School case study questions in four subjects - data analysis, NLP, project management, and finance. The students found that the LLM solutions precisely matched faculty answers for all workshop team assignments.

The research questions Case C helped to answer were: (1) Can LLMs demonstrate high accuracy in business case analysis, spanning domains like data science, NLP, project management, and finance? And (2) Do real-world business scenarios enable LLMs to perform analytics and decision-making tasks reliably?

Literature Review

Introduction

Large language models (LLMs) such as GPT-3, PaLM, and ChatGPT have demonstrated impressive natural language processing capabilities, achieving state-of-the-art performance on many tasks (Brown et al., 2020). Some have reported the high level of accuracy of ChatGPT in solving operations management case study questions (Terwiesch, 2023). However, concerns have been raised regarding their accuracy, especially when deployed in real-world applications where unreliable outputs could potentially cause harm (Liang et al., 2022). As LLMs

continue to advance in scale and performance, rigorously evaluating the accuracy and reliability of their outputs is crucial.

Several recent papers have focused on assessing LLM accuracy across different tasks. Liang et al. (2022) conducted a holistic evaluation, testing multiple LLMs, including InstructGPT, on 9 question answering datasets. They found significant variability in accuracy across models and tasks. For instance, while DaVinci models achieved 90% accuracy on average, curie models averaged around 50-60%. The performance also varied based on question complexity.

Wang et al. (Wang, 2023) evaluated the accuracy of ChatGPT and GPT-4 on a collection of physics, chemistry and math problems. They concluded that while both models failed to solve most problems correctly, GPT-4 marginally outperformed ChatGPT. The key limitations identified were the inability to carry out symbolic reasoning and retrieve requisite factual knowledge.

Evaluating adversarial robustness, Zhu et al. (Zhu, 2023) found contemporary LLMs highly susceptible to inaccuracies when confronted with minor prompt perturbations. For instance, across models, swapping a single word in the prompt led to a ∼20% performance drop. Targeted semantic attacks also successfully deceived LLMs over 30% of the time.

Focusing on factual consistency, Honovich et al. (Honovich, 2022) analyzed several automatic evaluation methods. Transforming existing approaches into binary classification tasks, they determined that natural language inference and question generation/answering based techniques were most effective. The study also emphasized the lack of standardized benchmarks in this emerging area.

Analyzing the factual accuracy of LLM responses, Min et al. (Min, 2023) proposed computing sentence likelihood as a proxy measure. Testing on various estimators, the technique achieved over 30% improved F1 scores. However, accurately quantifying atomic facts remains an open research question.

Themes and Trends

Examining these papers highlights certain common themes. Firstly, accuracy levels are generally high for simpler tasks but deteriorate rapidly as complexity increases. Performance also varies significantly across models, even those from the same model family, indicating extensive scope for improvement.

Additionally, adversarial evaluations reveal LLMs to be remarkably brittle. Minor input perturbations readily confuse most models. The objectivity of current testing methodologies has also been called into question. Existing approaches focus narrowly on specific sub-tasks and are poorly representative of broader robustness.

Certain themes emerge across the case studies. First, in structured academic settings, LLMs demonstrate high factual accuracy even handling quantitative analysis, outperforming expectations. Susceptibility to hallucination appears reduced, potentially due to the limited problem scope constraining deviations.

Second, domain content covered during training likely enhances accuracy. All exercises related to fields - analytics, business - frequented in LLM pre-training corpora. Performance may thus be leveraged in allied application areas but could suffer in unfamiliar domains.

Third, the automated grading concordance implies LLMs can reliably mark student work, assisting educators. Although feedback personalization and originality remain lacking, continual progress addressing these limitations is anticipated.

Comparative Analysis

Comparing findings across studies, davinci appears the most accurate model family, significantly outperforming curie and babbage. ChatGPT demonstrates competitive performance but lags behind GPT-3.5 and 4.0. Claude and LLaMA rank the highest among open-source LLMs.

In terms of task performance, accuracy on closed book QA and summarization is high, potentially supporting deployment. However, failures on more advanced logical reasoning highlight risks in critical applications. Susceptibility to factual inconsistencies further emphasizes the need for caution when utilizing outputs directly.

Future Research Directions

Our analysis reveals several promising research directions. Developing testing methodologies that better encapsulate complex real-world scenarios is vital for reliable evaluations. Constructing standardized benchmarks would also enable easier comparisons across studies.

Exploring techniques to enhance accuracy and reduce brittleness merits attention. Retrieval-augmented approaches appear promising by facilitating factual grounding. Integrating LLMs within hybrid systems under human supervision could enable safer adoption. Further interdisciplinary collaboration between researchers and practitioners is critical to guide progress.

Overview of Case Studies

Contrary to expectations, three case studies found LLMs highly accurate in handling constrained academic exercises. The first case evaluated ChatGPT’s responses to technical questions across two postgraduate analytics

courses. 90%+ factual concordance was recorded over 12 weeks with students as assessors with 100% concordance by the faculty SME. The repetition tendency was the main inconsistency observed.

The second case study successfully replicated 167 statistical analyses from an Excel exercise book in ChatGPT, encompassing data exploration, modeling and inference techniques. The LLM perfectly matched all original solutions, indicating competence in handling quantitative tasks.

The third case assessed ChatGPT and Claude2's performance on Harvard Business School case questions across four subjects - data analysis, NLP, finance, and project management. Student teams unanimously found LLM responses aligned perfectly with faculty provided answers.

Emerging Themes

The case studies reveal certain collective themes regarding LLM accuracy in academic contexts. First, contrary to wider benchmarks, constrained problem scopes appear to limit deviations. Metrics like hallucination and uncertainty are reduced. Speculatively channeling generation through restricted interfaces could enhance fidelity.

Second, advanced accuracy relies on relevant domain exposure during pretraining. Performance clearly declined on unfamiliar tasks relative to core competencies. Fine-tuning on pertinent data would thus remain vital for bespoke applications. Hybridization with rule-based solvers may also assist symbol manipulation.

Finally, graded agreement levels position LLMs as credible teaching assistants. Automated content generation and evaluation could transform pedagogy by complementing educators through personalization and scalability. Although individualization and originality are still inadequate, steady progress is expected.

Case Studies – Methods and Results

Case Study A

As a technical instructor, I often encounter challenges in communicating new concepts to my students. To facilitate their learning process, I explored the possibility of using a robotic helper, such as ChatGPT, to answer questions for them (a robot tutor). My theory is that ChatGPT could serve as a more effective and easier-to-use question-answering tool compared to existing resources like Wikipedia or Google. However, the accuracy of its responses is a concern. Therefore, I am conducting an experiment with two of my classes, where I have teams of five students evaluate the accuracy of ChatGPT's answers to "what" and "how" questions. I am also assessing the variability of its responses. After two weeks of testing, my students have reported a high level of accuracy and variability. I would appreciate any feedback regarding this experiment.

Data Warehousing and Data Mining Course Description

In an increasingly competitive information age, data mining and data warehousing are essential in business decision-making. This course teaches students concepts, methods and skills for working with data warehouses and mining data from these warehouses to optimize competitive business strategy. In this course, students develop analytical thinking skills required to identify effective data warehousing strategies such as when to use outsource or in-source data services. Students also learn to Extract, Transform and Load data into data warehouses (the ETL process) and use the CRISP approach to data mining to extract vital information for data warehouses. The course also teaches students how to secure data and covers the ethical issues associated with the uses of data and data models for business decisions.

Text Data Mining Course Description

This course will cover the primary techniques for data mining and analyzing text data to discover interesting patterns, extract practical knowledge, and support decision-making, emphasizing statistical approaches that can be generally applied to arbitrary text data in any natural language with no or minimum human effort. Detailed analysis of text data requires an understanding of natural language text, which is a difficult task for computers. However, several statistical approaches have been shown to work well for the "shallow" but robust analysis of text data for pattern finding and knowledge discovery. You will learn the basic concepts, principles, and major algorithms in text mining and their potential applications. We shall learn to perform keyword analysis, semantic analysis, create visual representations of the text, perform qualitative data analysis, similarity scoring of texts, entity and topic extraction, and latent semantic analysis of text data.

The reflective assignments in both classes specified that students in teams create answers to two factual review questions using a ormer based on the session's topics using an LLM. They were required to analyze the answers offered by the chatbot to judge their accuracy and compare them to the provided class solution for similarity.

Questions:

*How would you judge the **accuracy** of the answer you just posted that generated by the chatbot? Select only one answer: (4) accurate, (3) mostly accurate, (2) it has many errors, and (1) it is totally inaccurate.*

*How would you judge the **similarity** of the answer you just posted to that was generated by your instructor with the chatbot? (3) They are exactly the same; (2) They are essentially the same with some differences (cover the same concepts, steps, and processes in slightly different phrases or expressions); and (1) They are very different (they use different phrases, concepts and terminology throughout).*

Weekly Topical Questions

Session	Data Warehousing and Data Mining Course	Text Data Mining Course
1	What is Data Warehousing?	What is text data mining?
1	How is Data Warehousing done?	How is text data mining done?
2	What is Data Warehousing?	What does it mean to frame analytical questions?
2	What are factors to be considered in the design of a data warehouse?	How do analysts frame analytical questions?
3	What is the grain of a data warehouse?	What does it mean when a data analyst has to prepare data?
3	How is the grain of a data warehouse determined?	How is data preparation done in text data mining?
4	What is ETL in Data Warehousing?	What is term frequency analysis?
4	What is the process for ETL in data warehousing?	How is term frequency analysis done?
5	What is SQL? use only known facts	What is keyword analysis?
5	How is SQL used in the setting up and maintenance of a data warehouse?	How is keyword analysis done?
6	What is CRIP-DM?	What is sentiment analysis in text data mining?
6	How are analytical questions framed, starting with an information need?	How is sentiment analysis in text data mining done?
7	What are the characteristics of a flat file in Excel?	What is qualitative data analysis using coding in research?
7	What is the data preparation process in data mining?	How is qualitative data analysis using coding done?
8	What is Exploratory Data Analysis?	What techniques are used for data visualization in text data mining?
8	How is Exploratory Data Analysis done?	How is a word cloud constructed?
9	What is Multivariate Linear Regression done?	What is text similarity scoring?
9	How is Multivariate Linear Regression done?	How is cosine text similarity scoring done?
10	What is Logistoc Regression?	What is entity recognition in text data mining?
10	How is Logistic Regression done?	How is entity recognition in documents done?
11	What is a decision tree in machine learning?	What is topic extraction in text data mining?
11	When using machine learning how are decision trees created?	How is topic extraction done in text data mining?
12	What is Clustering Analysis Data Mining?	What is fuzzy logic in text data mining?
12	How is Clustering Analysis done in Data Mining done?	How do you build a fuzzy logic model in text data mining?

Figure 1 – Typical “what” and “how” used in the team reflective exercises for both courses for all 12 weeks of the semester.

Results of the Weekly ChatGPT Tutor experiment.

By the end of the experiment we had collected ten weeks' worth of data. ChatGPT 3.5 had so far being accurate and repeatable. No surprises from what we have found all semester.

The details of the results of the experiment are tabulated in Figure 2. From these results, we can conclude four things:

1. ChatGPT 3.5 repeats itself a lot (Which is significant since it implies students may not rely on it to give original answers to questions for assignments or exams without considerable risk of plagiarism).

2. ChatGPT 3.5 is accurate for technical questions. (Significant since it means students and teachers can confidently use it as a robot tutor.)

3. The fact that, for some cases, students thought ChatGPT was inaccurate to some degree (when it is not) should tell the instructor that students may not have understood the lesson or are confused about a concept or the robot gave an answer that was not covered in class.

Totals Responses				Score	Purpose	Evaluator	Type	Course
4	3	2	1					
49	11	0	0	95%	accuracy	Student	What	Data Mining
55	0	0	0	**100%**	accuracy	Instructor	What	
47	12	0	0	95%	accuracy	Student	How	
60	0	0	0	**100%**	accuracy	Instructor	How	
	25	35	0	81%	repeatability	Student	What	
	27	30	3	78%	repeatability	Student	How	
44	14	1	0	93%	accuracy	Student	What	Text Mining
59	0	0	0	**100%**	accuracy	Instructor	How	
50	9	0	0	96%	accuracy	Student	How	
54	0	0	0	**100%**	accuracy	Instructor	How	
	16	34	10	64%	repeatability	Student	What	
	14	34	6	68%	repeatability	Student	How	

Legend	
Accuracy questions	**Repeatability questions**
4= Accurate	3= Exactly the same
3= Mostly accurate	2= Some differences
2= Many errors	1= Very different
1= Totally wrong	

Figure 2 – Details of the results of the reflection exercise experiment.

4. The best summary of the results is to show the percentage of the time students in both classes thought the robot was wrong and how often the answers differed when the robot was queried at different times. We also show a subject matter expert's (SME) opinion of the robot's accuracy as the baseline. The resulting graphs are given in Figure 3.

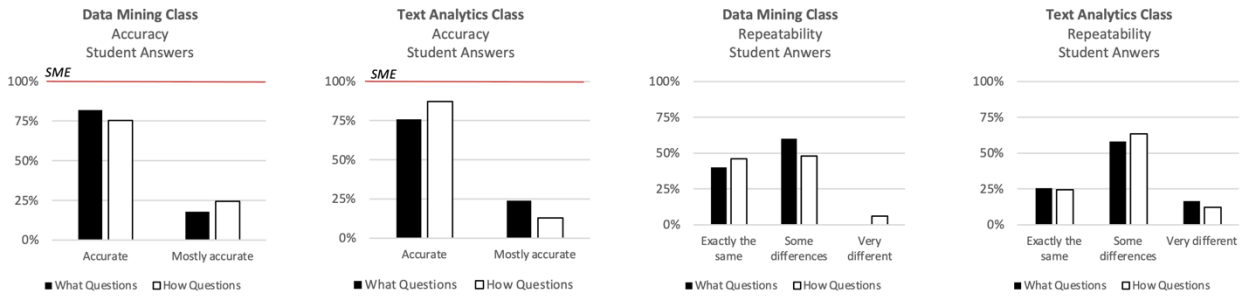

Figure 3 – Summary of the results of the experiment in Case Study A.

Implications for Future Reflective Exercises

What do the results of this case study mean? Pedagogically, we know that if students use reflection exercises several days after a lesson to try to remember what they learned, they retain more of the information. Reflective exercises of this nature have reported their beneficial effects in retention of information (Fortino, 2019). In this experiment, the weekly graded reflection exercises, students were also asked to recall what two concepts did they learn in the last session. In the future, and with the aid of an AI chatbot, perhaps we should ask students to: "*Create a two-3 sentence explanation of a central concept you learned last session. Enter that into ChatGPT and*

prompt the robot to correct you if it needs correction. Rate how accurate your own statement was." That will probably be more effective than a simple recall exercise.

Case Study B

Data Analytics Exercises for Exercises from a Statistical Book using LLMs

An exercise book (Fortino, 2020) used to teach basic statistical techniques for a data visualization certificate program needed updates for more advanced methods. The book covered various statistical techniques such as exploratory data analysis, data preparation, histograms, linear regression, and some inferential statistical techniques. The earlier edition of the book had exercises based on Excel, but the new edition was updated to include exercises using R and Python computer languages. With the advent of LLMs and specifically ChatGPT with Code Interpreter, it was also deemed appropriate to show how to use GenAI techniques to complete the exercises.

We tested whether AI-powered chat models like ChatGPT could provide accurate and complete answers in various scenarios. Specifically, we wanted to see if the level of hallucination, as mentioned in the literature, would cause any issues. However, we found no discernible problems and were able to complete the exercises using ChatGPT successfully.

The book covers essential statistical techniques in various chapters, each consisting of around 4 to 5 thousand case studies, tabulated in Figure 4. The same case studies are repeated in different chapters, but they serve different analytical purposes based on the presented technique. In total, there were 32 analytical questions that required computations using Excel, resulting in 167 separate Excel analyses. These analyses have been replicated in ChatGPT 4 Plus to provide the same answers.

Topic	Case Studies	Analytical Questions	Excel Computations
Descriptive Statistics	5	7	41
Histograms	2	4	20
Scatter Plots	3	4	28
Correlation and Linear Regression	3	5	16
Multivariate Linear Reg	2	3	14
Forecasting and Time Series	4	6	30
Inferential Statistics	3	3	18
Total		32	**167**

Figure 4 – Tabulation of statistical techniques covered in the exercise book, giving a total number of cases, analytical questions, and Excel computations presented.

Case Study C

The last and third case study, where we used AI for teaching and learning, is a new offering to teach the basics of AI applied to business to graduate students in a technology management program. The course, *Working with Robots: Business Innovation with Generative AI,* explores applying Generative AI technology to business processes. The course focuses on understanding this new technology and its capabilities, as well as how it can be used to improve various aspects of a business. Students learn about automation, process optimization, data analysis, and decision-making and have the opportunity to apply their knowledge through hands-on projects and case studies. By the end of the course, students had a strong understanding of how to implement and integrate generative AI technology into their organizations effectively and to drive innovation and growth. The course prepares students for the role of business transformation analysts based on Generative AI tools.

Team Workshops

At the end of each weekly session, there is a team workshop exercise. The enrolled students are divided into five teams, with five students each. All teams work on the same exercise. They are given about 30 minutes to complete the workshop at the end of the session. If they need more time, they have until the end of the next day to complete and submit their solution. Since it is a team-based exercise and a team submission, there has to be an agreement on what the team will do. All the workshops presented below are based on Harvard business case studies.

Course Cases for Analysis

1. **Generative AI for Data Analysis and Decision Making** – How generative AI can be used to analyze data and make decisions. Using generative AI to analyze and make decisions based on a dataset. Harvard Case Study: Rocket Fuel- Measuring the Effectiveness of Online Advertising (Katona, 2017).

   Team Assignment: Answer the case study questions at the end of the case. Extract the background of the case from the case document by uploading it to Claude-2 and asking for a summary. Input the summary into ChatGPT and ask what is the situation that needs analysis. Using the case data set ask ChatGPT the questions at the end of the case one by one. Document the answer and check against the case answer. Make sure that the AI's answer is correct in each case.

   Result: all team submissions had the correct answers to the exploratory data analysis questions as well as the case questions as given by HBS.

2. **Generative AI and Natural Language Processing** – Overview of NLP and its Applications. How generative AI can be used to improve NLP. Case studies of companies using generative AI for NL. Harvard Case Study: Understanding Text Mining and Sentiment Analysis in Hotel Booking (Kashef, 2019).

   Team Assignment: Ask ChatGPT to give you term frequency lists (using 1- and 2-grams) for the review text field in the database. Get a list of keywords and a word cloud. Document all these in an answer document to be uploaded as a deliverable. Ask ChatGPT to do a sentiment analysis of the reviews. Document the results.

Ask Claude to do a sentiment analysis of the reviews as well. Document that result. Comment on whether they are the same or different and why. Compare the results from the LLM to the case study answers.

Result: all team submissions had the correct answers to the sentiment analysis and the case questions as given by HBS.

3. **Generative AI in Project Management** – Overview of the project management and its use of AI. How generative AI is being used to improve project management. Case studies of companies using generative AI in PM. Using GenAI to create a WBS. Harvard Case Study: Project Management at Kuehchic Desserts- Refreshing A Traditional Business (De Meyer, 2022).

   Team Assignment: Extract the background of the case from the case document by uploading it to Claude-2 and asking for a summary if needed (ChatGPT may not be able to analyze the case from the case PDF). Input the case or summary into ChatGPT. Be sure to also upload the spreadsheet data with the tasks in case. Ask ChatGPT the questions at the end of the case one by one. Compare the answers by the LLM to the case answers provided by the instructor.

   Result: all team submissions had the correct answers to the case questions as given by HBS.

4. **Generative AI in Finance** – Overview of the finance industry and its use of AI. How Generative AI is being Used to Improve Finance. Case studies of companies using generative AI in finance. Team Hands-On Workshop 7: Using generative AI to analyze financial statements and computer financial ratios. Harvard Case Study: Introduction to Financial Ratios and Financial Statement Analysis (Bruns, 2004)..

   Team Assignment: Upload financial statements into ChatGPT. Compute the required ratios: ROI, ROIC, ROE, ROA, EPS, Profit Margin, Day's Receivable, Inventory Turnover, Solvency Ratio, Current Ratio, Acid Test, Debt Ratio. Document the meaning of each ratio with the computed answer and compare the answer. Compare the answers by ChatGPT to the case solutions.

   Result: all team submissions had the correct answers to the ratios and case questions as given by HBS.

Answers to the Research Questions

Case Study A

1. *How accurate are the responses from large language models like ChatGPT when used for technical tutoring?* Case A provides quantitative evidence that ChatGPT can provide highly accurate responses to factual "what" and "how" questions in graduate-level analytics courses. Over 90% concordance was recorded by the students, with 100% concordance by the SME.

2. *Can the tendency for language models to repeat responses verbatim negatively impact their usefulness as tutors?* Case A found that ChatGPT's repetition tendency was its main shortcoming. This implies a risk of plagiarism if students rely on it for original written work. Monitoring and further improvements to answer diversity are needed.

Case Study B

1. *Can large language models accurately replicate quantitative statistical analyses from an Excel exercise book?* Case B demonstrates that ChatGPT successfully matched 167 Excel-based statistical computations from 32 analytical questions, covering techniques like data visualization, regression, and inference.

2. *Do the concerns around factual inaccuracies and hallucination in LLMs manifest in mathematical/computational responses?* Case B found no discernible accuracy issues in ChatGPT 4 perfectly concordant Excel replications, allaying fears about quantitative analysis fidelity. Monitoring on more complex analyses is still prudent.

Case Study C

1. *Can LLMs demonstrate high accuracy on business case analysis, spanning domains like data science, NLP, project management and finance?* Case C found Claude and ChatGPT solutions precisely matched faculty answers across HBS case workshops in an MBA-level AI in Business course.

2. *Do real-world business scenarios enable LLMs to reliably perform analytics and decision-making tasks?* The end-to-end concordance of LLM recommendations with case solutions in Case C signifies their credibility in assisting business analysis versus narrow academic exercises.

Conclusion

The case studies reveal certain collective themes regarding LLM accuracy in academic contexts. First, contrary to wider benchmarks, constrained problem scopes appear to limit deviations. Metrics like hallucination and uncertainty are reduced. Speculatively, channeling generation through restricted interfaces, such as fine-tuned chatbots, could enhance fidelity.

Second, advanced accuracy relies on relevant domain exposure during pretraining. Performance clearly declined on unfamiliar tasks relative to core competencies. Finetuning on pertinent data remains vital for bespoke applications. Hybridization with rule-based solvers may also assist symbol manipulation.

Finally, graded agreement levels position LLMs as credible teaching assistants. Automated content generation and evaluation could transform pedagogy by complementing educators through personalization and scalability. Although individualization and originality are still inadequate, steady progress is expected.

In all three cases, we see that if the large language model tense to hallucinate as reported in the literature and is well known to happen, it did not seem to disturb these academic exercises. In all three cases, the generative AI models appear to provide accurate answers to the analytic questions. They also provided accurate responses to basic technology and informational questions. We can safely conclude that, if for nothing else in an academic

environment and for teaching purposes, these tools provide an adequate platform for analysis and learning. It can also be relied upon for tutoring on technical subjects.

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DraftKings: A Sports Betting Giant Case Study

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Abstract

This case is regarding DraftKings, the Sports Betting and iGaming giant, that has taken the digital gaming industry by surprise. For more than ten years, DraftKings has been continuing to upgrade its technology to compete with an increasingly popular market. With the rise in popularity of this industry, there are more threats that direct competitors of DraftKings have had to deal with. DraftKings must increase its cybersecurity, all while protecting its client base and informational databases. With cyber hacking and AI technologies evolving, it is important that anti-money laundering methods, detecting identity theft, and keeping personal information safe is at the forefront of cybersecurity. As this relatively new company tries to juggle their newfound success, they also have to make sure that they are protecting and covering their bases. It will discuss what measures DraftKings is taking to prevent cyber hacking, as well as keeping up with Know Your Customers (KYC) and Anti-Money Laundering (AML) procedures.

Case Description

The online gaming industry has been growing for years now. As the industry grows, so do the threats against it. The main goal of this case is to explore the threats the industry is facing, and specifically threats to DraftKings. This case will analyze the current technologies being used by DraftKings, as well as expand upon what this company can do better in order to protect itself from these new threats.

Case Synopsis

Elliott Crawford, the Chief Technology Officer at DraftKings, had opened his phone to an article claiming that there had been a cyberattack at a popular casino, Amethyst Casino, in Atlantic City, New Jersey. This cyberattack shut down all computer operations for ten days while the casino's IT department worked on ways to improve firewalls and other tactics to prevent cyber hacking. Amethyst Casino admitted that having their computer systems down for ten days cost them about $75 million in what would have been normal daily revenue. Seeing that this news had come out, a rival casino, Jade Casino, admitted that they had also been the victim of a cyberattack only two weeks prior. In Jade Casino's case, their computer operations had not ceased due to any issues, but they were unable to confirm if any personal information belonging to customers had been compromised. Jade Casino ended up paying $10 million of a $20 million ransom request in hopes that the cyberhackers would secure the leaked data.

This news worried Crawford considering DraftKings had an affiliation with Emerald Casino, which was only a few minutes away from both Amethyst Casino and Jade Casino. It reminded him of an instance the previous year where the company had faced a credential stuffing attack. During this attack, hackers were able to breach customer accounts and steal around $300,000 of customer funds. DraftKings then had to reimburse the customers for what had been stolen from them. Crawford and his team were able to find out that the hackers had managed to succeed in this credential stuffing attempt by logging into accounts of customers who only had single-factor authorization enabled. Crawford was worried that DraftKings or Emerald Casino could be one of the next victims of a cyberattack of a similar magnitude.

Crawford decided to first bring this concern up to the Chief Compliance Officer, Evelyn Pearson, and the Chief Legal Officer, Austin Chambers. Once these three had met and discussed the issues at hand, they decided it was important enough to bring it to the attention of Chief Executive Officer, Holden Rogers. The group concluded that cybersecurity should become one of DraftKings' biggest concerns and that Elliott, Evelyn, and Austin should plan to pitch a collective solution to Holden by the following week. Holden's main concern was that a similar cyberattack could happen to the company, which would then leave customers feeling unsure and unsafe of whether to continue with the company. He was worried that something negative like this could set the company back financially and even lead to ramifications for not protecting their customers to the best of their ability. The team immediately got to work considering how time sensitive an issue like this could become, especially because they had already been victimized last year. Waiting any longer to solve an issue like this could mean letting the cyberhackers take control of confidential information or costing the company a large sum of money.

Introduction

DraftKings was created in Boston, Massachusetts in 2012 by Jason Robins, Matt Kalish, and Paul Liberman. The three had worked at Vistaprint together and shared a love of fantasy sports. They decided that they wanted to make it a daily and accessible platform for themselves and like-minded people. DraftKings first started with baseball betting, which in turn got the MLB to invest in the company in 2013. By 2014, the company was seeing fifty-thousand daily players and one million registered players and secured a two-year deal with the NHL to be their official sports betting service. By 2015, DraftKings was taking its operations overseas to the United Kingdom, opening an office in London, England. Based on the successful integration of its international business, the company was able to begin operations in Malta in 2016, which meant that they would be able to operate anywhere in the European Union. Business was booming for the company only four years into operation.

In addition, there was an attempt to merge with FanDuel in 2016, another leading sports betting giant in the industry. These two companies merging would have meant they were in control of 90% of the industry, so the Federal Trade Commission ended up rejecting the merger on grounds of monopolization. DraftKings' next big move after this minor setback was to become a public company. DraftKings partnered with SBTech, a technology solutions company based in Europe, and Diamond Eagle Acquisitions, a Californian acquisition firm, in order to go public. By April 2020, DraftKings was on the Nasdaq stock exchange under 'DKNG.' Shares began trading at $19 per share. This was a risky time to go public due to the COVID-19 Pandemic shutdowns and the questions of whether sports games would continue to be played. Luckily, the company was able to stay afloat, however, they are still not profitable as of 2023.

By May of 2022, DraftKings acquired Golden Nugget Online Gaming which meant that DraftKings would now be offering online casino games rather than just sportsbook betting. Offering online casino games meant breaking into a whole new industry of iGaming. With this industry came new responsibilities such as adopting better strategies for safe gaming and compliance. This included adopting affiliates such as the American Gaming Association, BetBlocker, EPIC Risk Management, and many more companies created to assist in making sure DraftKings demonstrated safe and legal gambling practices, which, alone with compliance, are crucial in the online gaming industry. Not only do these practices enable gambling addicts to seek help, but they also encourage companies to stay up to date with safety practices through monetary penalties. . DraftKings has since opened twenty-one physical sportsbook locations across the United States and is operating online in twenty-three states.

Current Problems and Challenges

The online gambling industry has started facing new challenges with cybersecurity and cyberhackers. In an industry that is ever evolving, it is important that DraftKings remains up to date with cybersecurity technology and protocols, so they can avoid once again becoming the victim of a cyberattack. Cyberhackers and criminals are becoming smarter and are learning how to commit more crimes without being detected. What makes the online gambling industry such a big target is the fact that actual customers are storing their information and money that they are going to spend and have won, in an online account. Keeping that money in an online account is not as secure as keeping it in a bank account, which means it is easier for hackers to gain access and steal money and personal information without ringing any alarm bells until it is too late. Identity thieves have also started signing up for illegitimate accounts in hopes that they will be able to launder money using someone else's form of identification. In some cases, these fake identifications are even AI generated. It is extremely important that there are checks and balances to the online gambling industry and that each and every online casino follows the same procedures to keep their customers safe.

One method of preventing money laundering or identity fraud is Know Your Customer, or KYC. KYC is used so that employees of a casino can learn about a customer and see if they have a history with the casino. KYC is meant to identify and verify a customer and keep that information in a database while the person is trying to gamble. This is useful because customers in this industry are constantly trying to deposit and withdraw a multitude of funds. This can be seen as very suspicious if a person is depositing and withdrawing a large amount of funds and does not have a prior history with that casino. Once someone has gone through the process of a KYC, the casino they are depositing and withdrawing from will remember them in future transactions.

Another important part of KYC is making sure that a person trying to deposit money is not self-excluded. Self-exclusion means someone has decided to stop gambling, most commonly due to addiction, and is put on a self-exclusion list. This self-exclusion list makes it so that a person can no longer sign up for anything casino related and in turn, casinos can no longer advertise to these people. Having access to the list makes it very useful when going through the KYC process. In addition to the KYC process, it is very important that the funds someone is trying to deposit is verified. Risk and payment analysts will ask for proof of address and proof of bank account. Geolocation is another important input because analysts will be able to see if someone is located in a state where gambling is legal. If they are located somewhere that does not allow gambling, their account will be blocked. These steps are necessary to make sure that someone is being completely truthful about where the money is coming from and where the money will be going.

Another method of preventing money laundering or identity fraud is Anti-Money Laundering, or AML. AML is a compliance-based practice that ensures safety when it comes to money laundering. AML practices include customer due diligence, enhanced due diligence, employee training, reporting methods, customer monitoring, and AML audits. Customer due diligence is used to verify the identity of a person. This is similar to the KYC process in the way that there are checks and balances that ensure a person is who they say they are and uses a legitimate identity. This also includes a check of self-excluding lists. Enhanced due diligence occurs when it is more likely that someone could be capable of money laundering. These checks include verifying identification and funds. Funds can be verified by proof of a bank account or paycheck. It is extremely important to keep employees up to date on these practices as criminals are getting better at faking identification and transactions. When something seems suspicious, it is important to report it to law enforcement so a person can be caught and refrained from committing this act against another casino. AML audits can be useful because independent auditors will be able to give feedback on AML practices and what they think a casino could be doing better.

In the past year, DraftKings has faced credential-stuffing attacks. This type of attack occurs when someone can use a corrupted account in order to gain access to databases that hold information. In DraftKings' case, the hacker was able to make off with $300,000. Users noticed that they had been locked out of their accounts and their funds had been drained. DraftKings co-founder, Paul Liberman, said that it was possible that usernames and passwords had been compromised and the company could not confirm whether these cyberhackers had made off with any patrons' personal information. Cyberhackers are becoming smarter which means they will wait to attack when there are big weekends in sports, with more people betting and being paid out by DraftKings. This is more of a hectic time for risk and payment analyzers, which can unfortunately allow some criminals to fall through the cracks. Using this time to steal money and information leaves DraftKings defenseless until the hacker has made off with what they wanted to take. After the $300,000 loss, DraftKings had to pay back their customers using their own funds. DraftKings also found that 68,000 individuals had their information compromised.

Root of the Problem

One of the biggest problems DraftKings is having is the lack of cybersecurity that they use. The company has blown up in recent years in regard to the number of users that they have. As of November 2023, DraftKings sees 2.3 million monthly users, which is a 40% increase from the year prior. This is an extremely large amount of people considering DraftKings is only legal in twenty-three out of fifty states. This alone can raise the problem of geolocation and making sure

that people from states where DraftKings is not legal are not using the sportsbook. It is becoming easier to mask a location using software like VPN, so DraftKings needs to stay vigilant when it comes to KYC and AML practices. DraftKings has not yet witnessed a large attack in comparison to what their competitors have had to go through, though the smaller attack in 2022 should have alerted them to the dangers that are poor cybersecurity and cyber hacking. As criminals grow smarter, the company should also become smarter and use greater defense when it comes to keeping its patrons safe.

DraftKings does not force their users to use two-factor authentication which is very problematic in relation to the technologies we have today. Single-factor authentication makes it easier for a hacker to get into someone's account resulting in stolen money and stolen personal information. Two-factor authentication can be useful because it gives an account an extra layer of protection. Since DraftKings stores bank account information on file for its customers, there should be greater practices when it comes to keeping this information secure and out of the hands of cyberhackers and criminals. Having such large weekends in sports means that hackers will be ready to take control of accounts and steal as much money and information as they can get their hands on. Not being able to keep these attacks at bay is where DraftKings is certainly going wrong.

Solutions

Holden Rogers was very upset to find out that the company being previously hacked could have been since the company's cybersecurity measures were not as sophisticated as he believed they were. Elliott, Evelyn, and Austin had spoken with their respective teams, as well as each other, to come up with what they believed could be the best solution for the company moving forward. They had been analyzing different aspects of Amethyst Casino and Jade Casino to see where their weaker spots were and how these instances of cybercrime had transpired. They noted that these casinos were using one-factor authentication for their customer portals and had not had AML audits since two and three years prior. Austin spoke to legal contacts that he had within the Division of Gaming Enforcement to make sure they could set up a time to be independently audited by the state. Being audited meant that the state could find any issues that the company would be having with KYC and AML practices. Before that audit, the team made sure that they would have a plan set in motion and executed to make sure that they were doing the best they could.

Elliott, Evelyn, and Austin told Holden Rogers that DraftKings' cybersecurity was not as effective as it once had been when it was first implemented. They told him about how the cyberhackers had become smarter and found ways around their

current methods. The plan they wanted to execute meant increasing the power of their firewalls, making sure all accounts were using two-factor authentication, and having their risk and payment analysts attend courses on KYC and AML practices so they were more up to date with the latest protocols. Holden Rogers agreed that these were all extremely important factors and promised that there would be an allotment of DraftKings' budget that would go towards cybersecurity upgrades and the training of their staff. Elliott, Evelyn, and Austin got the right to work on improving cybersecurity for their company.

Conclusion and Recommendation

The online gambling industry is changing every single day. This means that there should be evolving practices to keep this industry safe. The more technology evolves, the easier it becomes to hack individuals and companies. Making sure that two-factor authentication is used for accounts storing personal information needs to become an industry standard. It is also extremely important that KYC and AML procedures are constantly audited and improved upon. Not only does this help prevent money laundering, but it also helps catch identity thieves. In a world where AI technologies are only becoming better and better, it is extremely necessary that risk and payment analysts can recognize when there are AI generated forms of identification. There should be more technologies implemented to make sure that there are multiple background checks done when verifying identifications and bank accounts. Though these procedures may seem extreme to customers who have no ill intent, it is very important to have these checks and balances to prevent cyber hacking and money laundering. Cybersecurity needs to remain at the forefront of companies' minds so personal information and funds stay intact and criminals fail to succeed.

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Papers

Healthcare Analytics

Using Analytics to Support Customized Training for Time-Dependent Patient Prioritization

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Abstract

This article proposes a nurse training application that can address challenges in prioritizing time-dependent patient needs in healthcare practices. The effectiveness of prioritizing is compromised when new technologies are introduced or nurses work on rotational assignments. The methodology includes data collection with nursing professionals, a time-dependent priority queue simulation that generates customized training examinations, expert nurse recommendations, examination scoring, and feedback. The approach creates unbiased and realistic scenarios that generate random patient queues for specific hospital departments. Although an example is provided that focuses on a cardiac care unit, the application's adaptability to specific departments underscores its practicality. This project can contribute to healthcare decision-making by increasing the speed at which inexperienced nurses gain relevant prioritization experience.

1.0 Introduction

In the bustling environment of a hospital unit, nurses grapple with the task of prioritizing patient needs, such as assisting with personal hygiene, dispensing medication, changing bandages, turning elderly patients, and responding to device alarms. These real-time decisions must consider both the severity of the patient's need and the time duration since the patient's need became apparent. Experienced nurses rely on their accumulated expertise, training, and education to make these real-time priority decisions. This decision process is depicted in Figure 7, where patients will have multiple needs (A to G), and nurses will return to the next highest priority patient after completing a service.

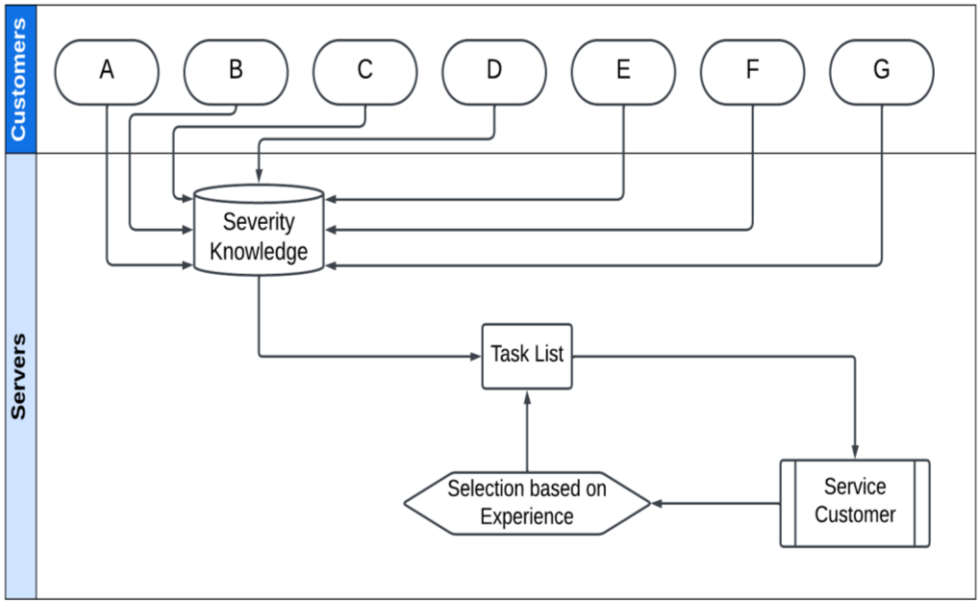

Figure 7: Experienced Nurse Decision Process

Recent changes in healthcare practice have caused concern among medical professionals regarding patient prioritization. A study coordinated by the US National Institutes of Health showed a triage error rate of 28.3%, which highlighted potential threats to patient safety (Smith et al., 2022). Errors of this type stem from at least two factors: (a) the introduction of innovative and complex technologies, which even experienced clinicians have difficulty understanding and hence can result in prioritization uncertainties; and (b) the adoption of flexible nurse scheduling, which aims to boost nurse efficiency and retention but can hamper a nurses' ability to gain the requisite experience needed to make effective prioritization decisions. The resulting dynamic environment makes it difficult for many nurses to prioritize time-sensitive patient needs effectively.

The work aims to develop a customized application to support nurse training by creating realistic scenarios that trainees will use to test their real-time prioritization capabilities. A prototype system was developed in collaboration with nursing professionals that incorporates analytical methods to represent real-world scenarios. The article begins with a literature review placing the work in an academic context. Then, the methodology is described including a customized simulation of a hospital department that generates representative queues with patient needs. The two-phase nurse training application includes a one-time set-up phase where scenarios are generated and the Analytical Hierarchy process (AHP) determines the best outcome for each scenario. The application's implementation phase consists of an examination that is repeated for each training session. The article concludes with a discussion of future work on this topic.

2.0 Literature Review

New technologies and nurse rotation can only increase the multitasking challenges that nurses have always faced (Kalisch & Aebersold, 2010). The emergence of new technologies can compromise nurses' competence to effectively deal with patients (Huston et al., 2013). This problem can be mitigated by customized training to keep nurses up to date with the newest innovations, software, and technologies (Kuna et al., 2022). Many hospitals use flexible nurse scheduling (sometimes called rostering) to maximize nurse availability during times and in places where they are needed (Chen et al., 2023). Flexible scheduling can compromise quality of work when they place less experienced nurses in situations requiring significant expertise, although effective cross-training can mitigate these effects (Pinker & Shumsky, 2000). O'Shea (1999) suggests that medication error rates are influenced by nurse scheduling procedures.

Priority queueing systems have been studied at call centers where both random inbound and scheduled outbound calls exist, which has similarities that are consistent with nursing practice (Stolletz & Helber, 2004). Jayatilake & Ganegoda (2021) provide a comprehensive overview of machine learning (ML) applications in healthcare, including their use to reduce human mistakes. Luo et al. (2019) used several ML algorithms to develop policies that help prioritize patient needs based on the experiences of health-care professionals. Due to the complexity of clinical workflows, simulation models are employed to provide quantitative insights that are closely aligned with real-world scenarios (Pepino et al., 2015). Corlu et al. (2020) used a simulation model to evaluate priority decision schemes in a hospital setting where nurses make real-time decisions.

Training has always been an important activity in healthcare because patients prioritize the technical aspects of their treatments (Attree, 2001), while also appreciating that empathy builds trust between the patient and the clinician (Sinclair, 2016). Nurses need to provide effective care in the present distractions that can increase errors (Brixey et al., 2007) and compromise patient safety (Monteiro et al., 2015). Often, the beneficial impact of communication and prioritization training on medical students' confidence, and ability to carry out these skills, is addressed in a simulated clinical environment (Seale et al., 2019).

The challenge of ranking many decision options in multi-criteria settings has been addressed using the AHP (Saaty, 1980). The basis of the AHP is to create a tiered decision framework while quantifying ranking decisions based on a series of pairwise comparisons (Schmidt et al., 2015). It has been used to support a variety of decisions, including software selection (Maleyeff & Webster, 1994), environmental prioritization (Jaiswal et al., 2014), and product innovation choices (Costa et al., 2015). The AHP has been used for prioritization in healthcare to allocate ventilators based on the priority of COVID-19 patients (Prasetyo & Wardoyo, 2022).

3.0 Methodology

The work began by interviewing eight nursing professionals who provided information about how nurses make decisions to prioritize patients in various healthcare environments. There are three models used in the simulation and subsequent training system. The priority model captures how the severity of a patient's need grows over time. The customizable simulation model

generates realistic patient care scenarios considering factors like patient needs, nurse responses, and task completion times. The training model forms the foundation for training nurses in the effective and nuanced prioritization of patient care in diverse healthcare settings.

3.1 Priority Model

The nurse interviews provided the basis of a time-dependent priority model, which is shown in Figure 8. When a patient need becomes evident (e.g., because of a scheduled medical intervention, a device alarm signal, or a random patient request), there will be an initial severity (S_0) consistent with the urgency that a nurse should react to. While the patient waits to be serviced by the nurse, the severity of their need may increase over time. The model assumes that the severity increase is linear over time and reaches a maximum of S_1 after T_1 time units. For some patient needs, S_0 will equal S_1 because the severity level will remain unchanged while the patient is in the queue.

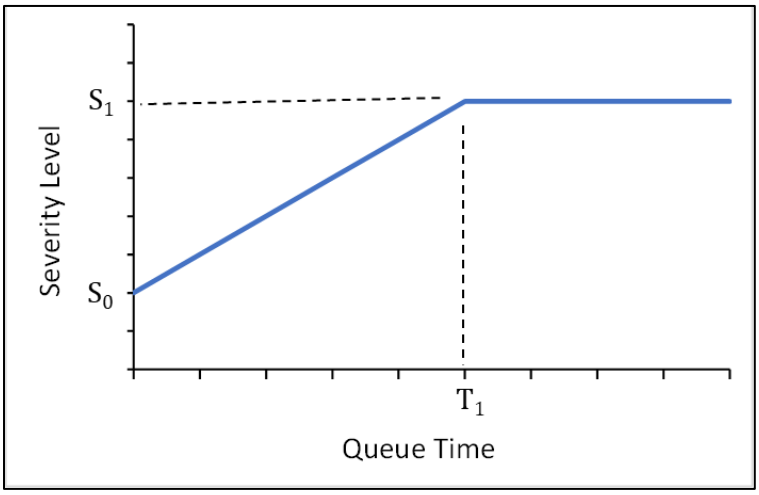

Figure 8: Dynamic Severity Model

The parameters of the severity model would be customized for each hospital department based on the treatments provided and the demographics of its patient population. To determine the parameters of the priority model, a nurse with sufficient expertise would be asked to list the set of patient needs, as well as estimates for S_0, S_1, and T_1 for each need. It is noteworthy that, unlike typical priority queuing systems where priorities remain unchanged over time, the priority determination for nurses in these settings needs to account for both the patient's need and the length of time they have spent in the queue. Because the severity model plays a role in the simulation that generates realistic queue scenarios, it is not critical for the parameters to be perfectly accurate.

3.2 Simulation Model

A customizable simulation model was created to generate realistic and unbiased decision scenarios using the framework shown in Figure 9. Although the simulation can have various uses during the training, here the focus is on the development of an examination. The simulation was written in Python 3.9 using packages Tabulate, NumPy, Pandas, and Matplotlib. The nonterminating discrete-event simulation included five key assumptions:

1. Patient needs are generated as scheduled (constant time between patient needs) or random (exponential time between patient needs) based on a database of need parameters.
2. One nurse within a group of interchangeable nurses addresses each patient’s need; the patient’s need is added to a queue if all servers are busy.
3. Tasks are dispatched according to the priority model, which accounts for the severity of each need and how much time has elapsed since the patient entered the queue.
4. Task completion times are modeled with a shifted gamma distribution.
5. After a patient is served, their next need is generated (as described above).

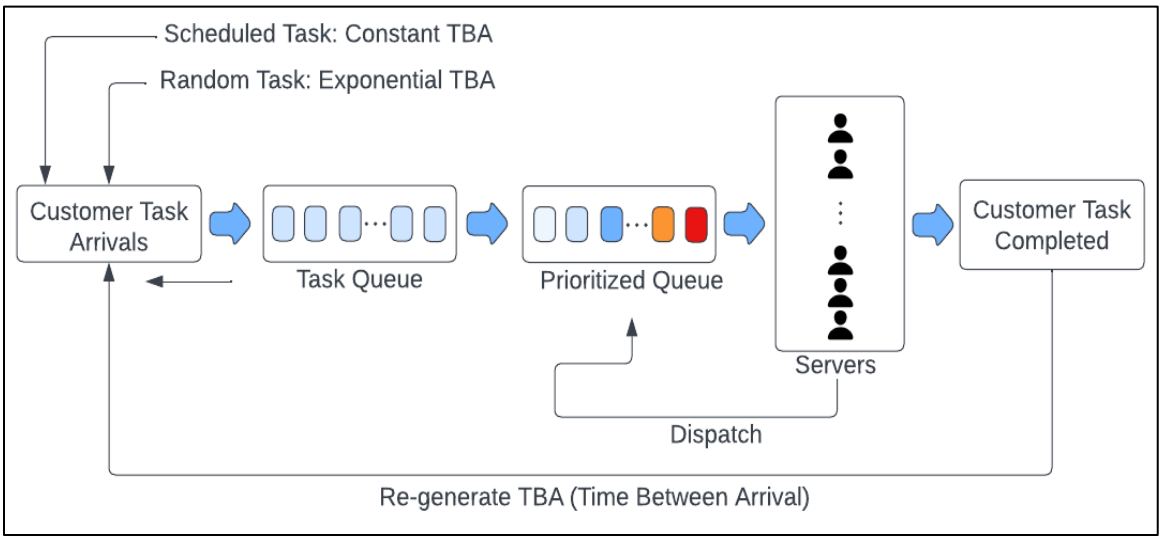

Figure 9: Dynamic Priority Simulation Model

To set up the simulation for use in a specific department, an experienced nurse would provide estimates regarding the time between the arrival of each patient need (including how often they take place and whether they are scheduled tasks or occur randomly) and the service completion time information. The Poisson assumption for random generation of patient needs is valid because patient needs arrive independently across patients. For the service time distribution, the nurse estimates the average, minimum, and maximum service time. These values are used to estimate the parameters of the shifted gamma distribution, which is appropriate because treatment times in healthcare often follow similar gamma patterns (Millhiser & Veral, 2019). Like the parameters of the priority model, the parameters required for the simulation need only to be approximate because the role they play is to generate realistic patient queues.

3.3 Training Model

Figure 4 shows the two-phase framework of the proposed support tool for customized nurse training that accounts for complexities present in the hospital unit for which the nurse is being trained. It consists of a one-time setup phase where the simulation creates an examination by capturing a random selection of queue configurations, and an implementation phase where the examination is administered and graded. A unique aspect of this examination is that students need to take into account both the urgency of a patient's need and the time since that need became known. Nurses are also tested on their ability to prioritize needs based on a mixture of scheduled and random tasks.

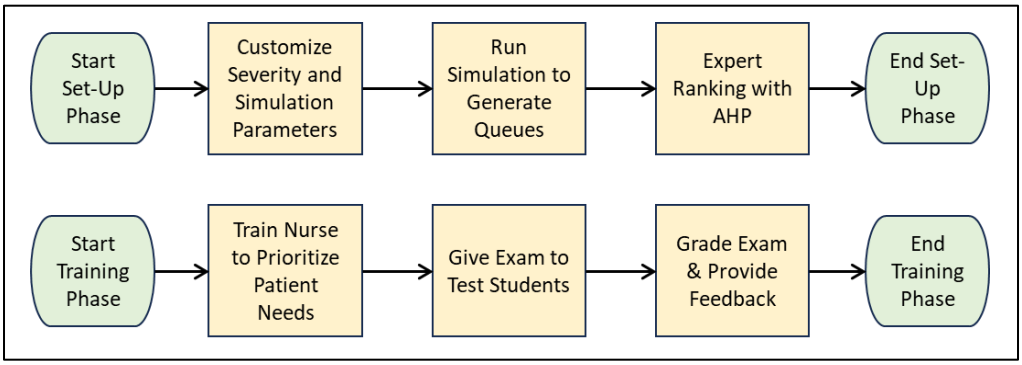

Figure 10: Nurse Training Process

The setup phase begins with configuring the simulation to become consistent with the priority-setting environment for which the nurses are being trained. This customized simulation is used to generate sets of random needs by periodically capturing the patient queue. This activity results in a series of questions, with each question consisting of a description of the patients in queue (i.e., their need and waiting time). Expert nurses rank these patients according to their priority using the AHP pairwise comparison approach. The AHP results show the priority scores for patient needs in the queue that sum to one.

In this way, differences in priorities across the patients will be apparent, so that students can earn partial credit for incorrect, but close, answers.

The implementation phase would take place during each training session, using the same examination for similar priority-setting environments. An experienced nurse will teach students how to assess the severity associated with the dynamic set of patient needs. The students will then be given the examination. For each question (i.e., queue), they are required to choose the patient with the highest severity (i.e., the patient who should be served first). Grading would be on a variable scale depending on how close the student's answers aligns with the expert answers. The grading system will give credit for each answer on a 0-1 scale. The grading metric is shown in Equation 1, where P_i^* is highest priority AHP score for question i, P_i is the priority of the patient chosen by the student in question i, and n is the number of examination questions. This metric will give a score of 1.0 for a question when a student makes the same choice as the expert. Scores for incorrect answers will range from 0 and 1 depending on the ratio of the student choice's priority and the expert choice's priority. This metric awards more credit to students who do not choose the highest priority patient but the severity of the patient they choose is close to the severity of the expert's choice.

$$\text{Score} = \frac{1}{n}\sum_{i=1}^{n}\frac{P_i}{P_i^*} \tag{1}$$

4.0 Nurse Training Process

The implementation of the customized nurse training application is presented using an example of a cardiac care department in an acute care hospital, which is representative because about 30% of hospital patients are admitted with a primary cardiac problem (Walker et al., 2012). A nurse's service to these patients is extremely important in a cardiac care unit because of the range of urgencies associated with patients' needs and patients' demographics. Table 8 was created based on extensive interviews with an experienced cardiac care nurse (for brevity, it is shortened but remains representative). Twenty-four patient needs are listed, along with the parameters associated with their severity, service times, and arrival information. The shifted gamma distribution service time parameters (i.e., scale, scale, and threshold) are α, β, and δ. The arrival rate of patient needs (after completion of the same service for the same patient need) is λ.

Table 8: Patient Needs Database

Patient Need	Type	α	β	δ	S_0	S_1	T_1	$1/\lambda$
Sanitary	random	1.74	1.15	4	3	6	15	240
Turn	scheduled	1.74	3.44	8	1	5	75	105
Catheter	random	1.74	2.30	4	3	7	60	360
Eating	scheduled	1.74	0.69	8	2	5	30	240
Bathing	random	1.74	0.46	24	1	3	60	600
Mobility	scheduled	1.74	1.15	12	1	5	120	240
Medication	scheduled	1.74	2.30	4	5	7	30	90
Sensor	random	1.74	2.30	2.4	6	7	10	600
Visit	scheduled	1.74	0.69	4	0	3	30	75
Oral	scheduled	1.74	4.59	8	1	3	90	360
Teach	random	1.74	3.44	8	1	3	120	360
Discharge	random	1.74	3.44	24	3	6	30	600
Procedure	scheduled	1.74	1.15	36	2	4	150	600
Bandage	scheduled	1.74	2.30	12	5	8	60	600
Oximeter	random	1.74	3.44	4	2	4	30	720
Clean tube	random	1.74	17.22	4	3	5	15	720
Bed alarm	random	1.74	4.59	4	9	9	0	600

Table 9 was created based on the approximate proportion of patients who would experience each of the patient needs, using a binary format (where k patients exist, and P_i is patient i). For example, the first patient will need assistance for random needs of sanitary and bathing, and their care plan also includes scheduled activities of turning, walking, giving medications, visits, and oral hygiene practices. This patient is scheduled to be turned every 105 minutes. Their initial severity is 1 then increases to 5 after 75 minutes. Their service time follows a gamma distribution with parameters 1.74, 3.44 minutes, and 8 minutes (the minimum threshold includes travel to the patient location).

Table 9: Patent Needs Assignments

Patient Need	P_1	P_2	P_3	...	P_{k-2}	P_{k-1}	P_k
Sanitary	1	1	0	···	0	1	1
Turn	1	1	1	···	1	1	0
Catheter	0	0	0	···	1	0	0
Eating	0	0	0	···	0	0	1
Bathing	1	1	1	···	1	0	1
Mobility	1	1	0	···	1	1	0
Medication	1	1	1	···	1	1	0
Sensor	0	0	0	···	0	0	0
Visit	1	1	1	···	1	1	1
Oral	1	1	0	···	0	1	0
Teach	0	1	1	···	0	0	1
Discharge	0	0	0	···	0	0	0
Procedure	0	1	1	···	1	0	1
Bandage	0	0	0	···	0	0	0
Oximeter	0	0	0	···	1	0	0
Clean tube	0	0	0	···	0	0	0
Bed alarm	0	0	0	···	1	0	0

The simulation was customized based on these parameters, and an appropriate number of nurses was input based on preliminary runs of the simulation. These runs also established a suitable warm-up period to stabilize the queue. The queue information was captured after every 500 sets of patient needs. If the queue was too short (e.g., 2 or less patients) it was ignored. If the queue was too long (e.g., 6 or more patients), it was reduced manually to a number between 3 and 5 patients. Figure 11 shows two example questions that were generated after running the simulation to randomly generate patient queues. They would represent a sample of the number of questions deemed appropriate by the training team (a suitable number may be approximately 25 questions).

Severity Prioritization Training Examination

1. Choose the patient with the highest priority according to these needs:
   A. Give medication, waiting 9 minutes.
   B. Turn patient, waiting 1 minute.
   C. Check oximeter, waiting 27 minutes.
   D. Walk patient, waiting 43 minutes.

2. Choose the patient with the highest priority according to these needs:
   A. Teach patient, waiting 48 minutes.
   B. Check sensor, waiting 12 minutes.
   C. Replace bandage, waiting 37 minutes.
   D. Turn patient, waiting 22 minutes.
   E. Help w/eating, waiting 3 minutes.

Figure 11: Example Training Examination Questions

4.1 Question Scoring

For Question 1, it will be assumed that an experienced cardiac care nurse completed an AHP matrix as shown in Figure 12. The standard 1-9 rating scale is used where 1 means equal priority and 9 means extremely more important. The nurse determined that administering medication for a patient who has been waiting 9 minutes was somewhat more important than walking a patient who has been waiting 43 minutes (and so on). The resulting priority scores are shown as the column to the right of the AHP table (these scores are the average fraction across a row of the ratios of AHP score to total column score). In this case, $P_1^* = 0.537$ because giving medication was the highest priority need for patients in the queue.

	(A)	(B)	(C)	(D)	Score
(A) Give Medication - Waiting 9 Minutes	1	7	3	4	**0.537**
(B) Turn Patient - Waiting 1 Minute	0.143	1	0.167	0.2	**0.050**
(C) Check Oximeter - Waiting 27 Minutes	0.333	6	1	2	**0.250**
(D) Walk Patient - Waiting 43 Minutes	0.25	5	0.5	1	**0.164**

Figure 12: Expert Nurse Evaluation Question 1

For Question 2, as shown in Figure 13, the experienced nurse determined that checking a on a device waiting 12 minutes was moderately more important than teaching a patient about a procedure who has been ready for 48 minutes (and so on). In this case, $P_2^* = 0.383$ because replacing a bandage for a patient was the highest priority need for patients on the queue. It should be noted that, in this case, the priority associated with a sensor check almost equates to this score. This similar will be reflecting in the robust scoring system, as illustrated below.

	(A)	(B)	(C)	(D)	(E)	Score
(A) Teach Patient - Waiting 48 Minutes	1	0.2	0.167	0.5	1	**0.067**
(B) Check Sensor - Waiting 12 minutes	5	1	1	5	7	**0.381**
(C) Replace Bandage - Waiting 37 Minutes	6	1	1	4	6	**0.383**
(D) Turn Patient - Waiting 22 Minutes	2	0.2	0.25	1	2	**0.107**
(E) Help w/Eating - Waiting 3 Minutes	1	0.143	0.167	0.5	1	**0.062**

Figure 13: Expert Nurse Evaluation Question 2

4.2 Question Grading

Consider Figure 14 that shows examination results for three students for Questions 1 and 2, and their respective test scores (using Equation 1). The scores for Tina Yang (Question 2) and Jake Harris (Question 1) were 1.00, because they chose the highest priority patient need. Partial credit ranged from a low of 0.28 (when Jake Harris chose D for Question 2, which had severity 0.107 compared to the highest severity of 0.383) to a high of 0.99 (when Siana Patel chose B for Question 2, which had severity 0.381 compared to the highest severity of 0.383).

	Question 1		Question 2	
	Choice	Score	Choice	Score
Tina Yang	D	0.30	C	1.00
Jake Harris	A	1.00	D	0.28
Siana Patel	C	0.47	B	0.99

Figure 14: Example Scores

Providing students with the expert severity scores for each question can help them understand in a comprehensive way how their expert counterparts assigned severity. Ideally, trainers will be closely aligned with experts' thought processes and should be able to provide the rationale for the expert ranking in a robust matter.

5.0 Limitations and Future Work

This article describes a customized training tool that used simulation modeling and a decision science application. The first limitation is that it mainly focuses on a specific application within a cardiac care unit based on information derived from nurses with expertise in a limited number of hospital settings. For the findings to be more robust, the research needs to include a wider range of hospital departments with varying patient profiles. The second limitation is that the approach has not been tested in a live setting. The authors plan to approach other nursing professionals who would be interested in collaborating to recreate the application in an area with which they are familiar and for which they have training responsibilities. The third limitation is that the priority model assumes a linear increase in the severity of patient needs over time. Considering patient conditions can change in non-linear and unpredictable ways, the severity model should be improved to reflect the complexity and variability of patient conditions more accurately. Although not a limitation, the authors will also explore other uses of the customized simulation, but these uses must be considered in light of the approximation of each important parameter.

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Papers

Marketing and Consumer Behavior

Similarity-Novelty Metric: An Alternative Algorithm for Efficient Audience Extension

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Abstract

In digital advertising, the goal of advertisers is to ensure that they reach the targeted audience. The targeted audience consists of original customers who are part of customer history and potential prospects that can be turned into future customers. A pertinent challenge advertisers face involves curating target constraints that will act as criteria for select prospects. Tapping into a section of a novel audience in search of future customers to expand the size of the current audience base is referred to as audience extension. One of the common methodologies used by advertisers to perform audience extension is through the implementation of the greedy cover algorithm. However, one of the pitfalls of this algorithm is that it only takes the size of the total audience into account without considering any performance metrics. This paper proposes a new metric and algorithm for audience extension. This algorithm includes a greedy cover algorithm as a special case but is more flexible, allowing the incorporation of multiple performance metrics. We illustrate the new approach by analyzing several case studies.

Keywords: digital advertising, audience extension, greedy algorithm, novelty metric, tar- geted marketing

1 Introduction

Over the years, the landscape of advertising techniques has undergone a significant trans- formation. Traditional advertising approaches, which relied on broadcasting campaigns to large audiences, have lost their effectiveness in the face of changing consumer behavior and technological advancements [1][2]. In response to this shift, digital advertising techniques have taken center stage, with a major portion of advertising budgets now allocated to precise targeting of audiences at the right time and place [3]. Data management platforms (DMPs) have emerged as indispensable tools in this new era of advertising, enabling the collection and integration of vast amounts of data from various sources [4]. DMPs store valuable infor- mation such as historical campaign data, demographics, credit scores, and more, empowering advertisers with insights to make informed decisions about their audience targeting strategies [5]. In this context, the problem of audience extension has gained prominence. Advertisers often encounter situations where manually created audience segments cover only a fraction of the total target population [6]. As a result, they need to expand their audience reach to meet desired performance metrics [7]. Audience extension refers to the process of creating

new segment that resembles the initial audience cover but also includes novel members with the potential to become future customers [8]. Among the common approaches to audience extension is the ”greedy cover” algorithm, which is widely used in digital advertising [9][10]. However, this algorithm is not without its limitations, and researchers have identified several pitfalls that can hinder its performance [11][12]. Therefore, it is essential to investigate the shortcomings of the existing algorithm and explore modifications that can lead to optimal results in addressing the audience extension problem [13]. The aim of this research is to thoroughly examine the ”greedy cover” algorithm and its effectiveness for audience exten- sion. By reviewing existing literature and conducting empirical analysis, this study seeks to provide valuable insights into the strengths and weaknesses of the algorithm, along with potential enhancements to achieve superior audience targeting outcomes [14][15]. Figure 1 shows a sample advertiser segment.

This paper is organized as follows: In section 3 we introduce the most common method used by advertisers for audience extension and the limitations associated with it. Then, in section 4 we introduce two mathematical metrics that we will use in our proposed method that is aimed at providing better performance at reasonable costs while performing audi- ence extension. In section 5 we define our proposed methodology for audience extension. In section 6 we provide 3 examples to illustrate and compare the performance of the greedy cover algorithm and the similarity-novelty based approach for audience extension. In 7 we summarize the pertinent findings from our research that generalize the results that we have obtained.

2 Literature Survey

Consider the global e-commerce giant, Amazon, and its strategic foray into a new market. When Amazon expands to a new region, it faces the challenge of building a customer base from scratch while ensuring a high rate of engagement and conversions. Traditional mar- keting methods, although reliable to some extent, do not provide the granularity needed for targeted outreach in a new market. Here’s how Amazon employs advanced audience exten- sion techniques to overcome these challenges, ensuring a successful market entry. Imagine Amazon launching its services in a country where it has no prior customer base. To maximize its reach, Amazon creates an initial audience segment based on basic demographics, online behavior, and product interests. However, this segment is relatively small, considering the vast population of the new market. To thrive, Amazon needs to expand this segment intelli- gently, targeting individuals who are not only likely to buy but also become long-term, loyal customers. Amazon utilizes its wealth of data and machine learning algorithms to analyze a multitude of factors. These include social media interactions, search queries, wish lists, and even cursor movements on their platforms. By processing this data, Amazon identi- fies patterns that indicate potential customers’ preferences, interests, and purchasing intent. Machine learning algorithms predict behaviors, allowing Amazon to pinpoint individuals who are highly likely to engage and convert [1]. With the insights gained, Amazon tailors its marketing strategies. Personalized product recommendations are sent to the identified potential customers. These recommendations are not generic; they are meticulously curated based on individual preferences, ensuring relevance and resonance. This tailored approach

significantly increases the likelihood of click-through and conversions, as customers feel a per- sonal connection to the offerings [2]. Amazon doesn't stop at the initial outreach. Through real-time monitoring of customer interactions, Amazon continuously adapts its strategies. For instance, if a particular segment of the audience shows more interest in electronics, Amazon fine-tunes its outreach efforts to emphasize technology products. This adaptability ensures that marketing efforts remain relevant and compelling, maximizing the return on investment (ROI) [3]. Amazon employs a robust analytics system to measure the success of its audience extension efforts. Metrics such as click-through rates, conversion rates, and customer lifetime value are meticulously tracked. Amazon compares these metrics with those from markets where similar strategies were not employed. By quantifying the impact, Ama- zon validates the effectiveness of its audience extension techniques empirically [9]. Beyond immediate sales, Amazon's strategic audience extension efforts have a profound long-term impact. Satisfied customers from the initial outreach phase tend to become loyal patrons. They not only make repeat purchases but also contribute positively to Amazon's brand reputation through word-of-mouth and online reviews. Amazon's focus on quality audience extension thus builds a robust customer ecosystem, ensuring sustained growth and market dominance in the new region. The Amazon example underscores the power of advanced audience extension in reshaping market entry strategies. By harnessing big data, machine learning, and personalized experiences, Amazon transforms a mere audience segment into a thriving customer base. This case study demonstrates that in the digital age, precision and personalization in audience extension are not just advantages; they are imperatives for businesses aiming not only to expand but to thrive in new markets. Amazon's success story serves as a testament to the transformative potential of strategic audience extension efforts in the realm of global e-commerce.

3 Greedy Cover Algorithm

We start with the description of the greedy cover algorithm presented in [16]. For advertisers, it is crucial to explicitly define a range of quantitative metrics by which the extended audience segment should be evaluated. In majority of instances, advertisers seek an expanded audience size that surpasses a specific threshold, while also achieving elevated retention rates compared to the initial coverage, all accompanied by notably improved performance metrics such as clicks and conversions. [11][17]

$$\mathrm{sim}(S, S') > \alpha;$$
$$\mathrm{perf}(S') - \mathrm{perf}(S) > \beta;$$
$$|\mathrm{aud}(S \cup S')| >> |\mathrm{aud}(S)|$$

The predominant approach frequently employed for audience extension is the greedy cover algorithm. This method is an extension of the greedy set cover algorithm presented in this. Before delving into the workings of this algorithm, it is imperative to elucidate a few core concepts underpinning audience segments. Let us assume that the advertiser has delineated an audience segment based on a set of features $\{c_1, c_2, c_3, \ldots, c_n\}$. Consequently, any poten- tial audience member belonging to this segment must encompass these features. However,

this does not necessarily dictate that these features constitute the entirety of the audience members' attributes. The greedy cover algorithm aspires to encompass the initial audience coverage while simultaneously augmenting the audience's scale to reach a predetermined threshold. The procedure employed in the greedy approach is explicated in Algorithm 1.

Algorithm 1 Greedy Cover algorithm to extend audience

Require: Initial Segment S, Inventory of available segments Ω, required audience size N
Ensure: Extended audience cover A_{ext}

1: Sort available segments in Ω in descending order by size
2: Initialize $A_{ext} = \{\}$
3: **for** each segment $S' \in \Omega$ with $S' \supseteq S$ **do**
4: **if** $|S'| \geq$ N **then** Add S' to A_{ext}
5: **end if**
6: **end for**
return A_{ext}

Although the greedy cover algorithm is a substantially easy-to-apply algorithm, it may not provide the advertiser with the best audience cover. Here are some of the pitfalls of the greedy cover algorithm:

- The algorithm does not take into account the percentage of novel audience added the advertising segment. The algorithm accepts the extended audience cover as long as it covers the initial segment and surpasses the cumulative audience size required by the advertiser.
- The algorithm fails to consider the cost for a certain number of impressions when incorporating an extended audience cover.
- The algorithm does not compare the initial audience and the extended audience cover with respect to various performance metrics (clicks, return on investments, conversions, etc.)

Therefore, the subsequent sections of this paper endeavors to devise an approach that would perform the imperative task of overcoming the limitations of the greedy cover algorithm. To perform a quantitative analysis of the novel audience added we use various statistical measures which are described in detail in the next section. [9]

4 Similarity and Novelty Metrics

When extending an audience segment, two significant quantitative variables come into play, determining the viability of the extended segment for achieving better performance compared to the initial coverage [9][18]. The term *similarity* denotes a quantitative estimate indicating the degree to which the original audience coverage is preserved within the extended segment

[17]. On the other hand, *novelty* represents an estimation of new audience members included in the extended segment who were not part of the initial coverage. To express these concepts mathematically, we denote the original coverage and the extended audience segment as S and S', respectively. The mathematical formulations for the similarity and novelty metrics are as follows:

$$\text{Sim}(S, S') = \frac{|S \cap S'|}{|S|}$$

$$\text{Nov}(S, S') = 1 - \frac{|S \cap S'|}{|S'|}$$

In a previous research paper[19], a similar methodology was employed where the similarity between the advertisement campaign and multiple campaigns which are part of the historical dataset were calculated using the Hamming and the Jaccards distance. A subset of nearest neighbors is formed which consists of historical campaigns which have the value of similarity below a certain threshold. In this way, the algorithm augments the cumulative impressions of the target advertisement campaign to meet the demands of the advertiser. The approach that we propose, however, is aimed at providing the best-extended cover that covers the original customers while at the same time adding candidates who have the potential to become customers in the future. Ideally, advertisers seek a balanced relationship between these two metrics. The extended audience segment should encompass a substantial portion of the initial coverage while simultaneously introducing novel audience members [11]. Figure 2 and Figure 3 illustrate the similarity and novelty between the original segment (S) and the new audience segment (S').

The performance of the extended audience segment is predicated on the similarity and novelty value. Advertisers determine whether to accept an extended audience cover based on these performance metrics. The value of both these statistical metrics lies between 0 and 1. When the value of the similarity metric is 1 and the novelty metric is 0, the extended audience cover overlaps with the initial cover. However, when the novelty metric is 1 and the similarity metric is 0 then the advertiser would target a completely new audience base without retaining any existing customers. Both these extreme situations are worst-case scenarios for advertisers as in the first case the result is more or less similar to the results obtained through the greedy cover algorithm. On the other hand, in the second case, the advertiser would be losing its customer base to a new set of audiences that may or may not provide the desired results. Apart from these far-end conditions, there are a multitude of cases that may come to the foreground. These are described below in detail:

4.1 Case I: Maximum Similarity, No Novelty ($S = S'$)

In Figure 4, the original and the extended (new) segment are exactly the same. The similarity metric is 1 while the novelty metric is 0.

4.2 Case II: Maximum Similarity, High Novelty ($S \subset S'$)

In Figure 5, the extended segment covers the original segment along with adding a significant amount of novel audience members. The similarity metric is 1 and the novelty metric is quite

high.

4.3 Case III: Low Similarity, No Novelty ($S' \subset S$)

In Figure 6, the extended segment is a subset of the original segment, therefore there is abysmal similarity and no novelty. The similarity metric is low and the novelty metric is 0.

4.4 Case IV: No Similarity, Maximum Novelty ($S \cap S' = \emptyset$)

Figure 7 illustrates the scenario where the initial cover and the extended audience segment are disjoint. Here, the value of the similarity metric is 0 but the novelty metric is the 1.

4.5 Case V: Finite Similarity, Finite Novelty (($S \cap S' \neq \emptyset$) and ($S \cap S' \neq S$) and ($S \cap S' \neq S'$))

When there is a finite overlap between the initial cover and the extended segment, the values of the similarity and the novelty metrices exist between two extremities. As one increases the other decreases. Therefore, there are two broad sub-cases that exist when neither of the two metrices are leaning towards extreme values. The detailed description of the sub-cases are mentioned below:

4.5.1 Case V(a): Low Similarity, High Novelty

In Figure 8, the extended segment has a small overlap with the original segment. Therefore, the novelty metric is high with a low value of similarity metric.

4.5.2 Case V(b): High Similarity, Low Novelty

In Figure 9, the original segment overlaps significantly with the new segment. This is the exactly the opposite of case IV, here the similarity metric is high whereas the novelty metric is low.

After analyzing all the five scenarios, we can surmise that ideally advertisers would want the extended audience segment to cover the initial audience at the same time add a sig- nificant amount of novel audience members. Therefore, the advertiser wants the extended segment to achieve maximum similarity (similarity metric should be ideally 1) along with a high value of the novelty metric. Out of all the scenarios mentioned above, Case II gives the best result. In the next section, we will describe our proposed algorithm to overcome some of the pitfalls associated with the greedy cover algorithm and obtain better performance.

5 The Proposed Similarity-Novelty Metric Based Algorithm

Refinements to the greedy cover algorithm involve the computation of the novelty metric for the extended segment concerning the original coverage. The advertiser must establish a threshold for an acceptable level of novelty within an extended audience coverage. From the array of selected covers that meet the novelty threshold, the advertiser should proceed with the extended segment that boasts a considerable audience size and conversion rate, all achieved with an optimal cost per thousand impressions. Algorithm 2 comprehensively captures the novelty-similarity metric approach. Similar to the greedy cover algorithm, the initial cover consists of a segment of the population satisfying a broad spectrum of conditions based on a set of features. When the advertiser perceives that campaign requisites are unmet by the initial cover, they relax the stringent criteria applied to the features. This approach enables the similarity measure between the original and extended segments to attain its peak while simultaneously amassing a novel set of audience members to the population. It is important to note that there is a clear distinction that we observe in this approach. Unlike the greedy cover algorithm that returns a set of possible inventories, this approach returns a single extended audience segment that provides the best quantitative result to the advertiser. To test this method we will perform a case study of a sample Kaggle dataset which consists of conversion data from previous advertisement campaigns.

Algorithm 2 Novelty-Similarity metric based algorithm

1: **Input:** Initial cover $\{S\}$, Inventory Ω, User-defined Novelty threshold $0 \leq \alpha \leq 1$, required additional impressions N
2: **Output:** Optimal extended segment

3: **procedure** SIMILARITY-NOVELTY ALGORITHM(S, α)

4: Initialize variables: MaxImps=Imps(S), MaxCR=CR(S), MinCPTI=CPTI(S)
5: **for all** $S' \in \Omega$ **do**

6: **if** Nov(S, S') > α & Imps(S') >N & CR(S') > MaxCR & CPTI(S') > MaxCPTI **then**

7: Update MaxImps
8: Update MaxCR
9: Update MinCPTI
10: **end if**

11: **end for**

12: **Return** S' with MaxSize, MaxCR, and MinCPTI

13: **end procedure**

6 Case Study: Kaggle Conversion Data

To comprehend the effectiveness of the modifications applied to the conventional greedy ap- proach algorithm, we will examine a practical implementation of the novelty-similarity-based approach described in the earlier section using the Kaggle conversion dataset. This dataset

comprises advertisement campaigns with three target features: Age, Gender, and Interest. The advertiser chooses the initial coverage while imposing conditions on each constraint. For every initial coverage, we will generate six extended audience segments by gradually relaxing one or multiple constraints. We shall then compare the initial coverage with the extended audience segments using a variety of performance metrics, ultimately determining the most favorable outcome among the extended segments. The metrics used to compare the perfor- mance of various extended segments are number of impressions (Imps), cost incurred (Cost), cost per thousand impressions (CPTI), number of clicks the campaign garners (Clicks), total conversions (Conv), approved conversions (App), conversion rate (CR). We present three case studies that illustrate unique situations that surface with the changing novelty thresh- old and the difference in the overall performance of the various extended covers. In these cases, we primarily observe how the results obtained from the greedy cover algorithm differ from what the novelty-similarity metric-based algorithm generates. The three cases can be broadly described as:

- The first case study we present is the most commonly observed scenario where the choice of the best audience cover differs with the changing novelty threshold and these results are different from what the greedy cover algorithm provides.
- The second case study is the best possible outcome that any advertiser would want. Here, we will observe that the results from both approaches overlap providing a segment with the highest audience size, maximum impressions, a reasonable cost, and high conversion rate.
- The third case study is a specific subset of the first case study as it provides the same result for different novelty thresholds in the novelty-similarity approach but this result differs from the one provided by the greedy cover algorithm.

6.1 Case Study 1

We present in-depth information about our initial coverage and we have identified six ex- tended segments corresponding to this initial coverage (Refer to Table 1). We have chosen the six extended segments in a way that maximizes the similarity metric between the original and the extended audience while at the same time incorporating new audience members into its fold. Table 2 shows a comparative analysis of the quantitative performance of various extended audience covers on a multiplicity of mathematical metrics. These are measured against the initial cover to surmise the best performance scenario at a reasonable cost and high conversion rate. Table 3 shows the value of the novelty metric for each of the extended audience covers with respect to the initial cover. To observe how the extended covers per- form against the initial cover especially when it comes to the cost incurred for thousand impressions and conversion rate, we have used bar charts in data visualization (see Figure 10 and Figure 11).

Table 4 captures the results obtained from novelty-similarity metric and the greedy cover algorithm ($\alpha = 0$). The greedy cover algorithm gives segment 5 as the best extended audi- ence segment as it encapsulates the maximum audience size. The novelty-similarity metric

algorithm result changes with the values of α. At α = 0.95 segment #1 did not qualify as it did not qualify the novelty threshold.

6.2 Case Study 2

We present in-depth information about our initial coverage and we have identified six ex- tended segments corresponding to this initial coverage (Refer to Table 5). We have chosen the six extended segments in a way that maximizes the similarity metric between the original and the extended audience while at the same time incorporating new audience members into its fold. Table 6 shows a comparative analysis of the quantitative performance of various extended audience covers on a multiplicity of mathematical metrics. These are measured against the initial cover to surmise the best performance scenario at a reasonable cost and high conversion rate. Table 7 shows the value of the novelty metric for each of the extended audience covers with respect to the initial cover. To observe how the extended covers perform against the initial cover especially when it comes to cost incurred for thousand impressions and conversion rate, we have used bar charts in data visualization (see Figure 12 and Figure 13).

Table 8 shows the most desirable result for advertisers. In this case, the results obtained from the greedy cover algorithm and the novelty-similarity metric algorithm for every value of α are the same. Here, audience segment #5 has the maximum audience size, highest conversion rate, highest impressions, and the highest novelty score at a reasonable cost per thousand impressions.

6.3 Case Study 3

We present in-depth information about our initial coverage and we have identified six ex- tended segments corresponding to this initial coverage (Refer to Table 8). For each of these extended segments, we have computed the novelty metric and the final audience size (Refer to Table 10). Performance metrics, including cost per thousand impressions and conversion rate (See Figure13 and Figure14), have been computed for both the initial audience coverage and the extended segment (Refer to Table 9).

Table 12 shows the results pertaining to this case. In this example, the novelty-similarity metric based algorithm gives the same result for all values of α due to its high novelty value. However, the results are different from what is obtained through the greedy cover algorithm. In summary, we have explored three broad situations that encapsulate many different re- sults that we may get when we apply the greedy cover algorithm and the novelty-similarity metric-based algorithm with varying thresholds to a given advertisement campaign. The first instance is a general case where the results of both algorithms are different and these change with the changing threshold for novelty-similarity metric. The second instance is the most favourable outcome for the advertiser where he gets the best aspects from both the algorithms. The third instance is a specific outcome that can further be described as a subset of the first instance where although the results do not vary within the varying values of the novelty threshold but it is different from the one given by the greedy cover algorithm.

7 Conclusion

The aim of our study is to introduce novelty and similarity metrics and propose a new algorithm for audience extension. The proposed algorithm includes the conventional greedy- cover algorithm as a special case but is more general. Our approach to audience via similarity and novelty metrics allows advertisers a flexible strategy to achieve audience extension and maximize returns.

In future work, we would like to consider using the proposed similarity and novelty in collaborative filtering used in recommendation systems, This would give the advertisers additional tools for specific product recommendations to target segments.

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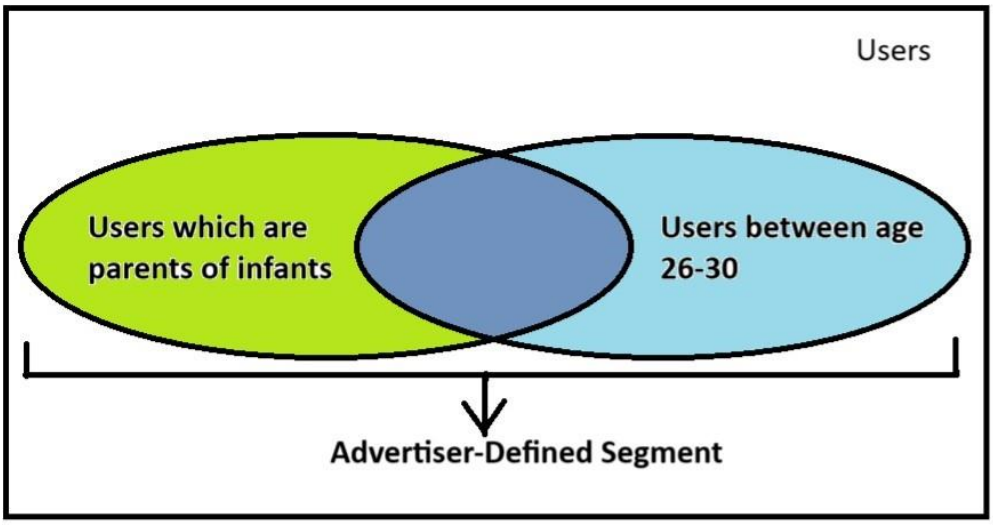

Figure 1: An example of an advertiser segment

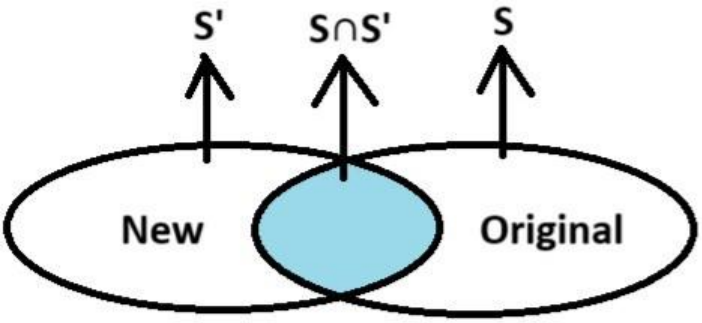

Figure 2: Similarity between original segment (S) and novel segment (S')

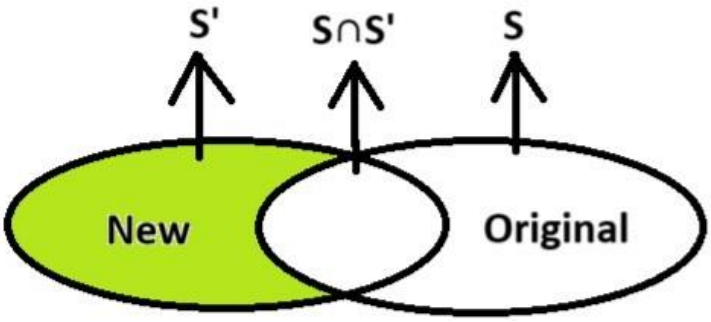

Figure 3: Novelty between original segment (S) and novel segment (S')

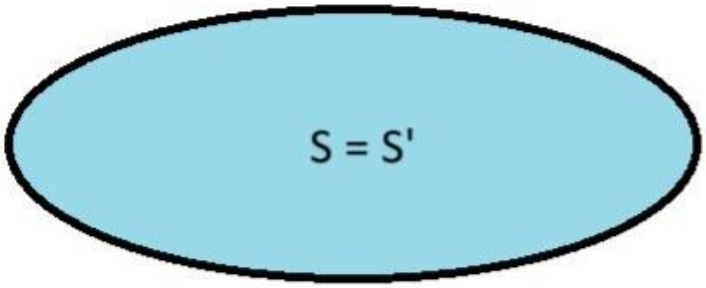

Figure 4: Maximum similarity, No novelty

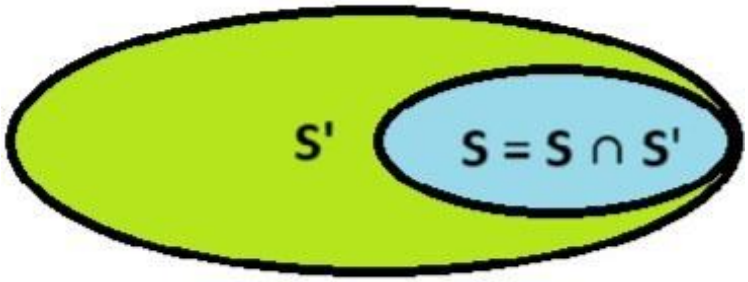

Figure 5: Maximum similarity, High novelty

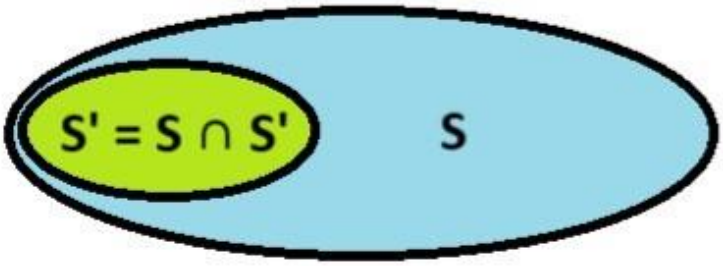

Figure 6: Low Similarity, No Novelty

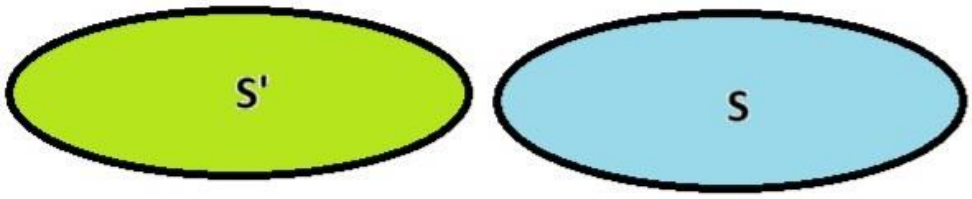

Figure 7: No Similarity, Max Novelty

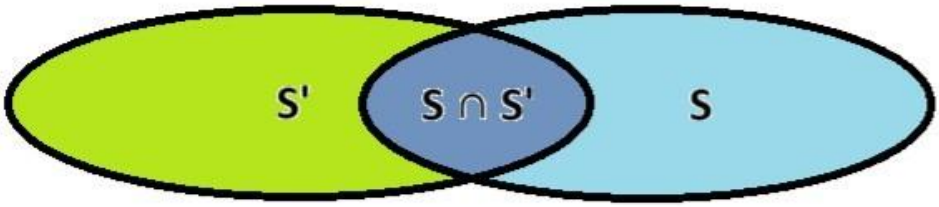

Figure 8: Low Similarity, High Novelty

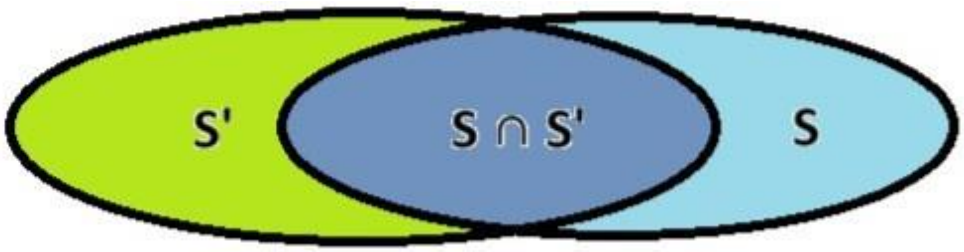

Figure 9: High Similarity, Low Novelty

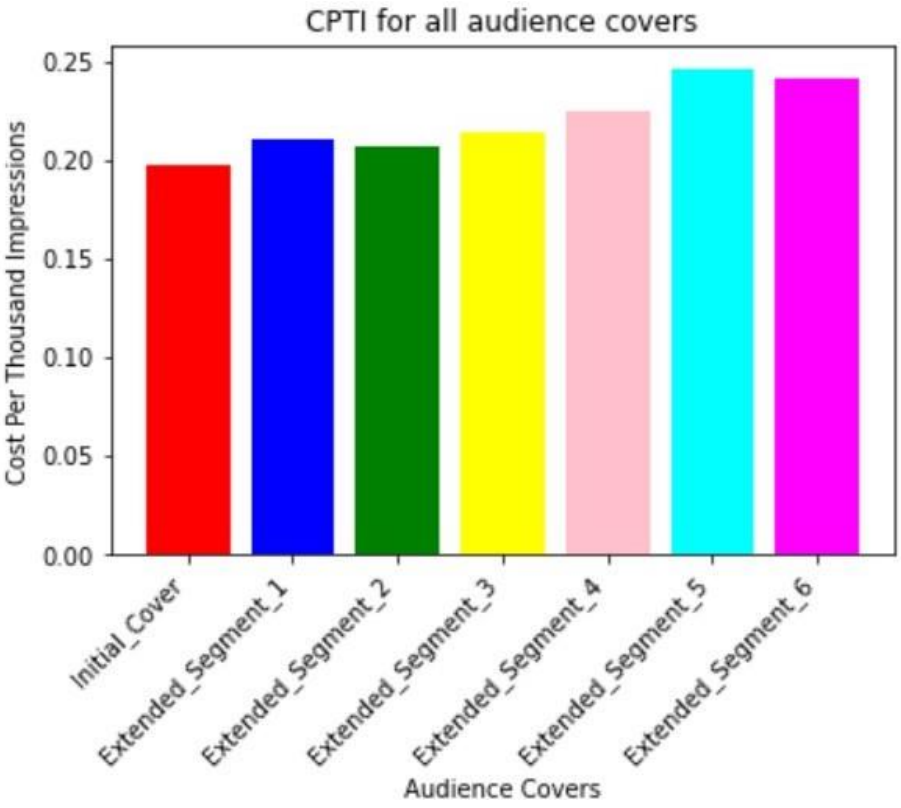

Figure 10: Cost per thousand impressions for Case Study 1

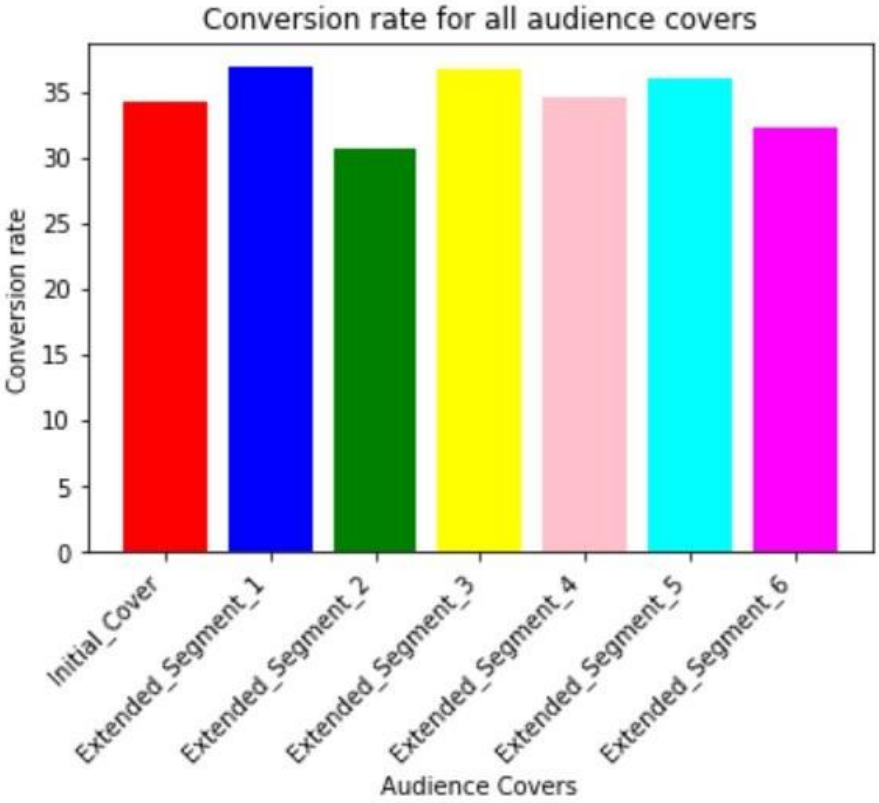

Figure 11: Conversion Rate for Case Study 1

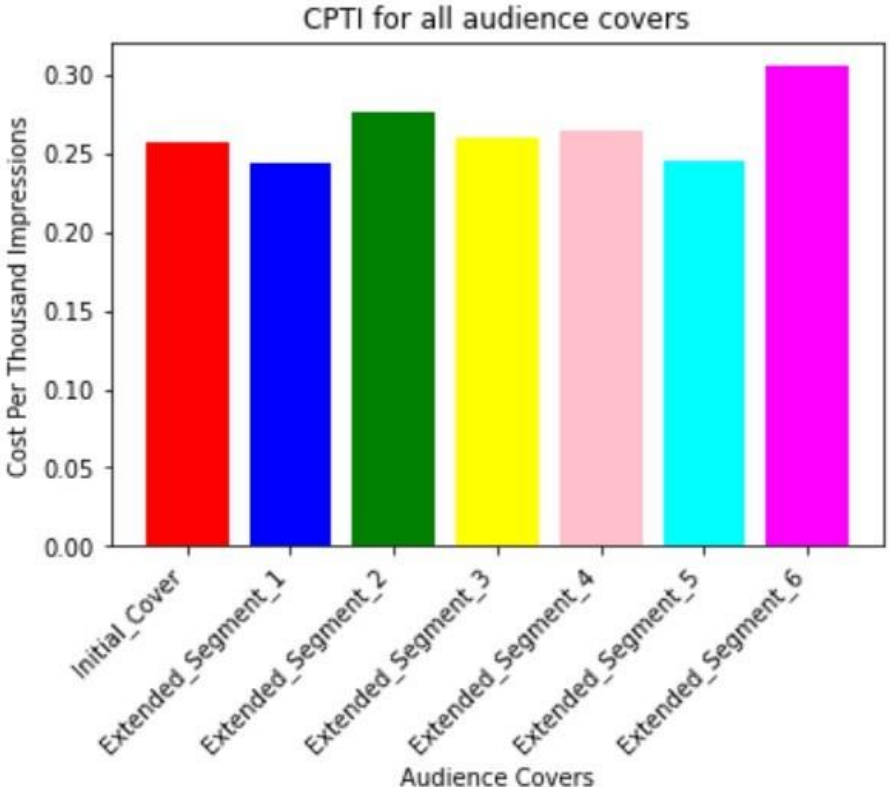

Figure 12: Cost per thousand impressions for Case Study 2

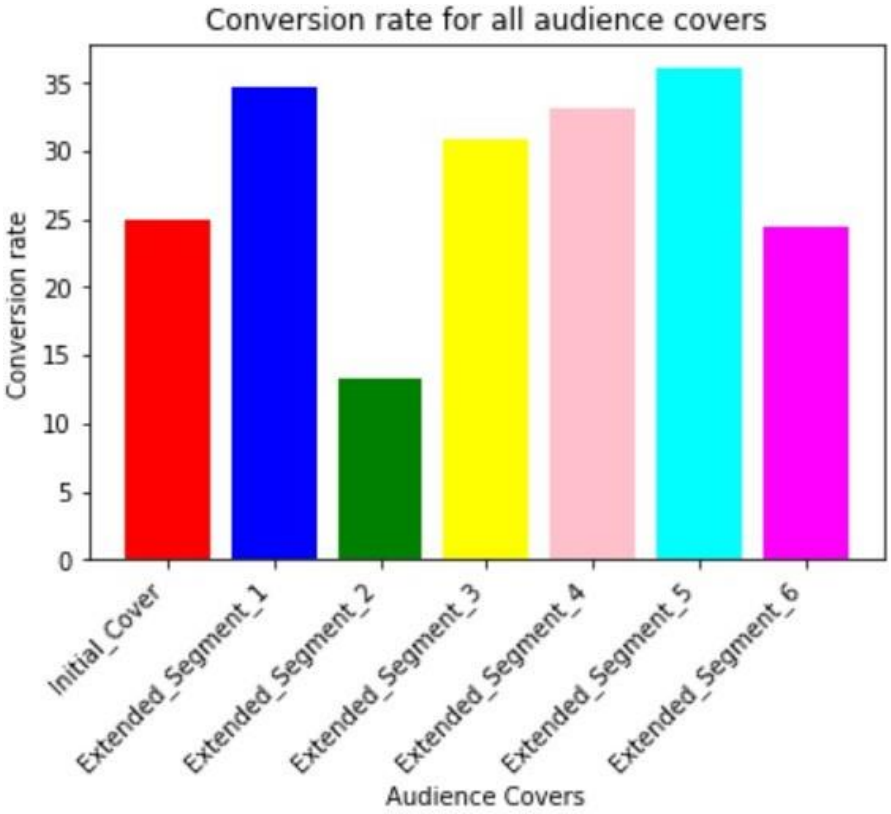

Figure 13: Conversion Rate for Case Study 2

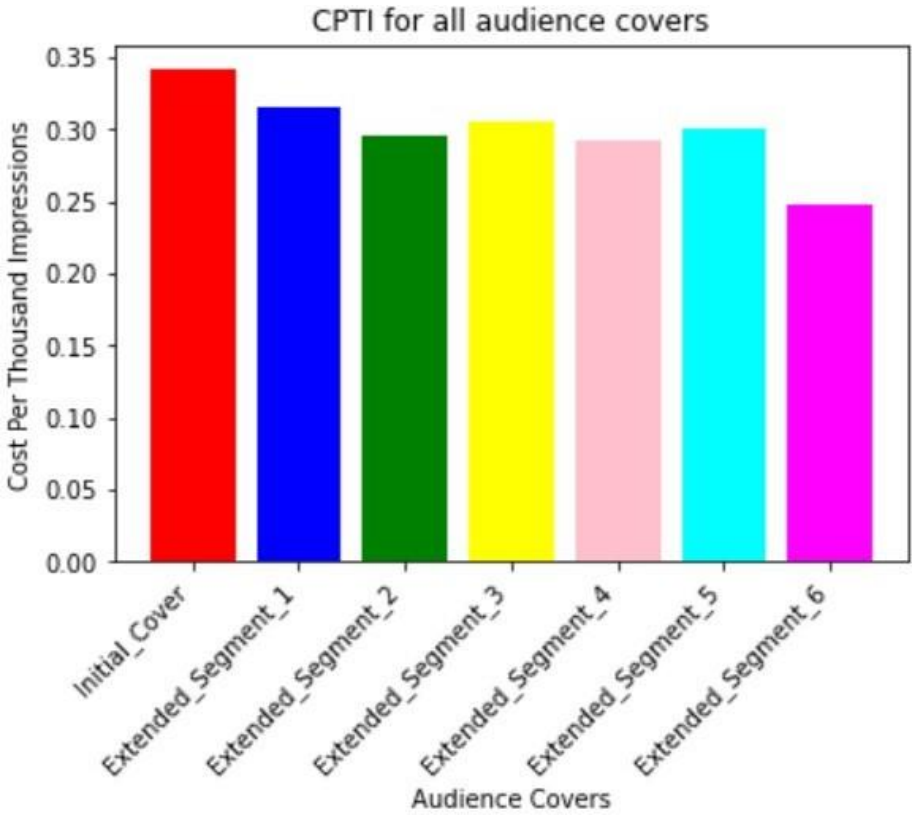

Figure 14: Cost per thousand impressions for Case Study 3

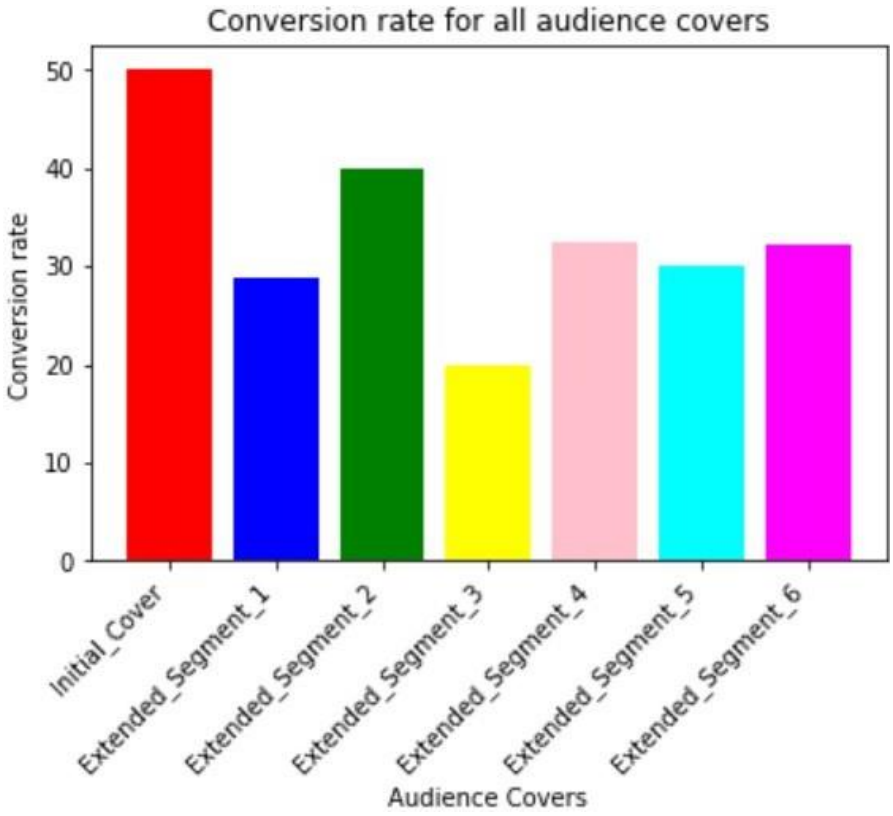

Figure 15: Conversion Rate for Case Study 3

List of Tables

Table 1: Audience segments for case study 1

Audience Segment	**Target Constraints**
Initial Cover (Segment 0)	(Age=30-34 and Gender=M and Interest=15)
Extended Segment 1	(Age=30-34 and Gender=M)
Extended Segment 2	(Age=30-34 and Interest=15)
Extended Segment 3	(Gender=M and Interest=15)
Extended Segment 4	(Age=30-34)
Extended Segment 5	(Gender=M)
Extended Segment 6	(Interest=15)

Table 2: Performance Metric Analysis for case study 1

Segment	Imps	Cost	CPTI	Clicks	Conv	App	CR
0	4,846,178	956.90	0.197	510	108	37	34.26
1	36,421,443	7,640.92	0.209	4,384	812	299	36.82
2	6,515,339	1,348.51	0.206	772	147	45	30.61
3	7,002,876	1,496.33	0.213	847	131	48	36.64
4	67,993,019	15,252.40	0.224	9,483	1,431	494	34.52
5	98,571,981	24,202.61	0.245	14,287	1,620	584	36.04
6	10,745,856	2,597.26	0.241	1,609	195	63	32.30

Table 3: Calculating final quantitative measures for case study 1

Audience Segment	Novelty Score	Audience Size
1	0.93	229
2	0.34	23
3	0.50	30
4	0.96	426
5	0.97	592
6	0.70	51

Table 4: Comparison of Similarity-Novelty Approach and Traditional Greedy Approach for Case Study 1

α	**Accepted Segments**	**Best Segment**	**Imps**	**CPTI**	**Conv Rate**
0 (Greedy)	1,2,3,4,5,6	5	98,571,981	0.245	36.04
0.5	1,3,4,5,6	1	36,421,443	0.209	36.82
0.7	1,4,5,6	1	36,421,443	0.209	36.82
0.9	1,4,5	1	36,421,443	0.209	36.82
0.95	4,5	4	67,993,019	0.224	34.5

Table 5: Extended Audience Covers for case study 2

Extended Segment	**Target Constraints**
Initial Cover (Segment 0)	(Age=35-39 and Gender=M and Interest=25)
Extended Segment 1	(Age=35-39 and Gender=M)
Extended Segment 2	(Age=35-39 and Interest=25)
Extended Segment 3	(Gender=M and Interest=25)
Extended Segment 4	(Age=35-39)
Extended Segment 5	(Gender=M)
Extended Segment 6	(Interest=25)

Table 6: Performance Metric Analysis for case study 2

Segment	Imps	Cost	CPTI	Clicks	Conv	App	CR
0	472,984	121.37	0.256	72	04	01	25
1	20,665,139	5,051.08	0.244	2,933	322	112	34.78
2	830,612	229.67	0.276	149	15	02	13.33
3	2,647,123	687.23	0.26	413	42	13	30.96
4	42,104,644	11,112.43	0.264	7,094	626	207	33.06
5	98,571,981	24,202.61	0.245	14,287	1,620	584	36.04
6	5,251,719	1,603.86	0.305	1,066	78	19	24.36

Table 7: Calculating final quantitative measures for case study 2

Audience Segment	**Novelty Score**	**Audience Size**
1	0.978	139
2	0.625	08
3	0.70	10
4	0.987	248
5	0.994	592
6	0.884	26

Table 8: Comparison of Similarity-Novelty Approach and Traditional Greedy Approach for Case Study 2

α	**Accepted Segments**	**Best Segment**	**Imps**	**CPTI**	**Conv Rate**
0 (Greedy)	1,2,3,4,5,6	5	98,571,981	0.245	36.04
0.7	1,3,4,5,6	5	98,571,981	0.245	36.04
0.75	1,4,5,6	5	98,571,981	0.245	36.04
0.95	1,4,5	5	98,571,981	0.245	36.04
0.98	4,5	5	98,571,981	0.245	36.04

Table 9: Extended Audience Covers for Case Study 3

Extended Segment	**Target Constraints**
Initial Cover (Segment 0)	(Age=40-44 and Gender=F and Interest=7)
Extended Segment 1	(Age=40-44 and Gender=F)
Extended Segment 2	(Age=40-44 and Interest=7)
Extended Segment 3	(Gender=F and Interest=7)
Extended Segment 4	(Age=40-44)
Extended Segment 5	(Gender=F)
Extended Segment 6	(Interest=7)

Table 10: Performance Metric Analysis for Case Study 3

Segment	Imps	Cost	CPTI	Clicks	Conv	App	CR
0	89,378	30.51	0.341	24	02	01	50
1	23,396,175	7,396.57	0.316	5,177	322	93	28.88
2	333,393	98.57	0.295	72	05	02	40
3	535,040	163.92	0.30	115	15	03	20
4	39,604,307	11,589.73	0.292	7,736	523	170	32.50
5	114,862,847	34,502.62	0.30	23,878	1,644	495	30.11
6	2,612,839	648.93	0.248	410	59	19	32.20

Table 11: Calculating final quantitative measures for Case Study 3

Audience Segment	**Novelty Score**	**Audience Size**
1	0.971	107
2	0.40	05
3	0.70	10
4	0.985	210
5	0.994	551
6	0.875	24

Table 12: Comparison of Similarity-Novelty Approach and Traditional Greedy Approach for Case Study 3

α	**Accepted Segments**	**Best Segment**	**Imps**	**CPTI**	**Conv Rate**
0 (Greedy)	1,2,3,4,5,6	5	114,862,847	0.30	30.11
0.5	1,3,4,5,6	4	39,604,307	0.292	32.50
0.75	1,4,5,6	4	39,604,307	0.292	32.50
0.90	1,4,5	4	39,604,307	0.292	32.50
0.98	4,5	4	39,604,307	0.292	32.50

What Matters? The Quantity, Quality, and Valence of Reviews in New Releases

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Abstract

Reviews play a vital role, particularly for new releases, as they provide customers with information and allow businesses to deliver details through feedback from experienced customers. However, limited research has been conducted to understand the three review metrics simultaneously: review quantity, quality, and valence, specifically in the context of new releases. This paper investigates how customers evaluate these metrics and examines their individual and collective influences, drawing upon signaling theory. A research model was tested by tracking over 600 new releases across six categories for 24 weeks. The results reveal that review quantity has the greatest impact on purchase decisions. Furthermore, when high review quantity aligns with high review quality, it creates a more compelling signal that resonates with customers. The three-way interaction of high review quantity, high review quality, and positive valence further reinforces purchase decisions. This study provides valuable insights into review management strategies for new products.

Keywords: Review Quantity, Review Quality, Review Valence, New Releases

Introduction

Crowd-sourced reviews on online platforms have played a pivotal role in empowering potential customers (A. A. Choi, Cho, Yim, Moon, & Oh, 2019; Deng, Zheng, Khern-am-nuai, & Kannan, 2022). They provide valuable product information from experienced customers, assisting potential customers make informed decisions (Hou & Ma, 2022; Jabr & Rahman, 2022). In the public space of review platforms, customers actively engage in social interaction by creating and consuming reviews. Given the usefulness of online reviews, customers often review a selection or all of the review metrics to ensure they make the best purchases. Online reviews come from a diverse range of customers with different backgrounds, preferences, and experiences, and this diversity provides a holistic view of the product. As e-commerce continues to gain popularity, reviews have become indispensable not only for customers but also for businesses and platform owners. As such, various efforts and incentives have been implemented to enhance the quantity, quality, and valence of reviews (Deng et al., 2022; Hou & Ma, 2022).

However, it is not uncommon to come across numerous reviews, sometimes in the hundreds or even thousands, for a specific product. While these reviews are meant to provide valuable insights into a product, navigating through such a large volume of reviews can be overwhelming. The abundance of available information clearly leads to a situation where customers experience information overload. Previous studies have indicated that prospective customers need to grapple with the costs associated with processing what may seem like an excessive amount of information and often employ simplifying heuristics (Jabr & Rahman, 2022).

First and foremost, the sheer volume of ratings and written reviews can provide a level of confidence in the overall quality of the product (Yu, Khern-am-nuai, & Pinsonneault, 2022). As more positive ratings accumulate, it builds trust with potential customers and increase the likelihood of future purchases. Consequently, the number of ratings is generally considered to be a critical factor in the online success of a product. It is also true that customers tend to consider not only the quantity of ratings but also the quality and valence when making purchase decisions. The quantity of ratings can give a sense of how popular and widely used the product is. The quality of reviews can provide an indication of the overall satisfaction of previous customers. The valence of reviews can give the overall sentiment or tone of the reviews. These factors are interrelated and can influence a customer’s decision-making processes.

While reviews are generally valuable for any product, their significance is particularly high for newly released products (Topaloglu & Dass, 2021). These products often have limited information available to potential customers, and insights from

early adopters become even more valuable. Given the presence of competing products in the market, positive or negative reviews play a crucial role in building trust and differentiating a new release from alternatives. Although reviews are subjective and individual experiences may vary, review metrics exploring the quantity, quality, and valence of reviews for new releases are especially beneficial for potential customers to obtain a well-rounded understating. Understanding how customers interpret these metrics can provide guidance to businesses and platform owners in optimizing their review management strategies, enhancing customer satisfaction, and ultimately driving sales.

It is crucial for academicians and practitioners to understand the implications of review quantity, quality, and valence in the context of new releases. The purpose of this paper is to investigate how customers evaluate these review metrics as well as examine their respective influential roles. The review metrics also give practical implications for merchandisers and platforms owners who strive to inform customers about the product's worth. The refined research questions addressed in this study are as follows:

> *RQ1: Do the quantity, quality, and valence of reviews contribute to the performance of a product in the context of new releases?*
>
> *RQ2: Are there interaction effects of review quality and valence on the relationship between review quantity and performance in the context of new releases?*
>
> *RQ3: What matters? What is the comparative significance of the three review metrics, and how do they play different roles? Which metric demonstrates a higher sensitivity to performance?*

By addressing the research questions, this paper contributes to the existing literature by exploring the individual and collective impact of the quantity, quality, and valence of reviews on product performance. Online reviews serve as important checkpoints for customers' purchase decisions, yet few studies have examined the relationships between the three review metrics and performance. Although research on online reviews have garnered attention from researchers, this study represents the first attempt, to the best of our knowledge, to consider the three factors in the context of new releases. The findings of this study will enrich the literature by shedding light on direct and interactive impacts of the three metrics simultaneously for customers, businesses, and platform owners.

Information Signals and Signaling Theory

With the advancement of information systems and the popularity of review platforms, customers now have access to a wealth of information through crowd-sourced online reviews. However, this abundance of information provisioning often leads to information overload, causing inefficiency and, at times, confusion for customers. To address this issue and reduce uncertainty in purchase decisions, platform owners have developed review metrics that integrate reviewers' responses with various indicators. These review metrics include the number of ratings, average 5-star rating, distribution of 5-star ratings, and answered questions. The goal is to assist customers in effectively navigating online reviews and making well-informed choices.

These review metrics provide information signals that assist customers in gaining a better understanding of products and insights from those who have already used them. Research has shown that these signals play an important role in purchase decisions (Jabr & Rahman, 2022). In this study, we employ signaling theory (Connelly, Certo, Ireland, & Reutzel, 2011; Jabr & Rahman, 2022) to explain the overall dynamics of online reviews and further examine how the quantity, quality, and valence of signals from customer feedback measures interact and influence purchase decisions.

The term "signal" refers to any informational attribute that delivers underlying characteristics of a product. Signaling theory suggests that "a product unobservable quality is signaled through observable information that the platform synthesizes from crowd-sourced content" (Jabr & Rahman, 2022, p. 1520). The impact of information overload on product choices has been an intriguing subject of research (Jabr & Rahman, 2022). While information overload resulting from the abundance of information provisioning is overwhelming, information signals derived from this information overload provide specific attributes that are synthesized from a large volume of information. These signals serve as condensed pieces of information available to customers and hold significant impacts, particularly in the context of online stores where customers have limitations in physically touching and feeling products. Signaling theory helps explain the mechanisms of information provisioning, information overload, and information signals. Our research framework is rooted in signaling theory as we analyze decision-making of reviewers and firm performance.

Individual Effects of Review Quantity, Quality, and Valence

When considering information signals from review metrics, it is crucial to take into account three important aspects simultaneously: review quantity, quality, and valence. This study defines review quantity as the number of ratings available for a specific product. A large quantity of reviews can provide more comprehensive opinions and insights. In general, high review quantities offer more reliable and representative information about a product in e-commerce (Teng, Khong, Chong, &

Lin, 2017). However, it is important to note that that review quantity alone may not capture all the aspects customers should consider before making a purchase decision. Review quality, on the other hand, pertains to the overall credibility, depth, and usefulness of reviews. Reviews with poor quality may lack substance, coherence, or objectivity, rendering them less reliable or informative. Therefore, it is essential to assess quality of reviews to gain a better understanding of the product (H. S. Choi & Leon, 2020). The third aspect explored in this study is review valiance, which refers to the sentiment or emotional tone expressed in reviews. Valence plays a crucial role as it influences the overall perception of a product (Deng et al., 2022). Positive reviews can encourage potential customers, while negative reviews may lead them to reconsider their decision. To gain a comprehensive understanding of reviews, it is important to consider all three aspects of review quantity, quality, and valence together. This study aims to examine the individual and collective impacts of the review metrics and their joint relationship on customer decisions.

The number of ratings on a product is a critical factor that customers often consider when making purchase decisions. It serves as an important signal of other customers' interest and confidence in the product quality. A high rating volume, indicating that many customers have rated the product, can significantly influence potential customers' perception. It is a reassuring sign that the product is popular and has been received by others. Moreover, a high rating volume generally provides more reliable information about the product's quality. For example, let's consider a scenario of two products with different ratings. Product A has an average rating of 4.5 stars based on 500 ratings, while Product B has an average rating of 5 stars but based only on 5 ratings. In this scenario, the product with a larger sample size of ratings (i.e., Product A) is likely to be more reliable because it offers a more accurate representation of overall customer satisfaction. Additionally, rating volumes can have an impact on the visibility of a product on e-commerce platforms. Products with higher rating volumes often receive increased exposure, making them more visible to potential customers. This increased visibility can further influence customer decisions and enhance the product's market presence.

> *H1: In the context of products recently added to online stores, a higher quantity of reviews within review metrics has a greater impact on purchase decisions.*

While rating volume is important, it is essential to acknowledge that the quality of review can vary within the context of crowd-sourced online reviews (Q. B. Liu & Karahanna, 2017; A. X. Liu, Li, & Xu, 2021). Customers have access to a vast amount of information, but they often face challenges when sorting through large review volumes due to cognitive limitations (Mullins & Sabherwal, 2022). Customer may experience a high mental burden when trying to process a large quantity of

reviews (Yin, Bond, & Zhang, 2014; A. X. Liu et al., 2021). The literature suggests that review length (A. A. Choi et al., 2019; Deng et al., 2022; Yu et al., 2022), helpfulness votes (Deng et al., 2022; Yu et al., 2022), and average ratings (Jabr & Rahman, 2022) are indicators of review quality. Therefore, although the number of ratings is a contributing factor in influencing purchase decisions, it is not the sole determinant. Other factors, such as the quality of the review, may also play a significant role. The length of reviews can provide valuable insights in the depth and detail of the product, thereby enhancing the credibility of reviewers' opinions. Average 5-star ratings provide an overall indication of customer satisfaction and serve as a concise summary measure. Review engagements, such as answered questions and helpfulness votes, indicate feedback and interactions among customers. These collaborative elements further boost customers' confidence in the product. In essence, review quality informs potential customers during their purchase decision-making process, ultimately enhancing product performance.

> *H2: In the context of products recently added to online stores, the availability of higher quality reviews signals an increase in the perceived value of the product and can influence purchase decisions.*

As mentioned earlier, review valence indicates the sentiment expressed in reviews, reflecting the opinions of experienced customers with regard to purchased products. To effectively convey review valence and offer valuable insights to potential customers, it is important for reviewers to provide detailed explanations of their perceptions. By providing specific details and explanations, reviewers can help readers understand the reasoning behind their opinions and make more informed decisions about the product. This level of detail adds depth and credibility to the review, making it more valuable and influential in the eyes of potential customers. Research suggests that negative reviews are more informative for potential customers (Yu et al., 2022). Review valence helps customers understand the strengths and weaknesses of the product, align their needs with product offerings, and make informed decision. When positive tones dominate review valence, potential customers' confidence is reinforced, leading to an expected increase in purchases. Conversely, if negative valences are prevalent in reviews, customers may hesitate to purchase the product and seek alternatives. In other words, customers consider the overall valence when making purchase decisions. By evaluating the sentiment of reviews, customers can gauge the overall sentiment towards a product. This sentiment, expressed in reviews, carries significant implications that can influence customers' decisions.

> *H3: In the context of products recently added to online stores, the presence of positive (negative) review valence within review metrics increases (decreases) the likelihood of purchase decisions.*

Synergistic Effects of the Three Review Metrics

We argue that review quantity, quality, and valence, while individually important, do not singularly determine a review's importance. We present that there is a synergistic effect among these three crucial factors. The argument is based on the concept of signal consistency in signaling theory, where concordant signals reinforce persuasiveness, while conflicting signals can confuse receivers (Jabr & Rahman, 2022). When these aspects align, they create a more powerful and persuasive signal for potential customers.

Some studies suggest that the impact of information volume may reach a plateau or even decline after a certain threshold (Mullins & Sabherwal, 2022). In other words, beyond a certain number, additional ratings have diminishing marginal returns on product sales. This may occur because customer start to feel satisfied by the sheer number of ratings and look for other indicators for effective purchase decisions.

The synergistic effect emerges when review quantity is combined with review quality or review valence, or both, thereby strengthening the credibility and persuasiveness of the reviews. A large number of ratings enhances the overall impact on customer behavior. When customers come across a product with a significant quantity of positive reviews that are also of high quality, they are more likely to perceive the product favorably and be influenced in their purchasing decision. Similarly, when customers notice a product with positive (negative) valence along with review quantity, it clarifies their purchase decision. Signaling theory asserts that additional information reinforces outcomes (Connelly et al., 2011; Jabr & Rahman, 2022).

> *H4a: The impact of review quantity within review metrics on purchase decisions is moderated by review quality, such that the relationship becomes stronger in the presence of high review quality in the context of products recently added to online stores.*

> *H4b: The impact of review quantity within review metrics on purchase decisions is moderated by review valence, such that the relationship becomes stronger in the presence of positive (negative) review valence in the context of products recently added to online stores.*

In particular, we argue for the three-way combination of the number of ratings, the average 5-star rating, and positive valence and their significant influence on purchase decisions. These variables are specifically selected as they are readily visible to customers when reviewing products on platforms like Amazon. A high review volume suggests popularity and interest in the

product, indicating that many customers have taken the time to provide feedback and share their experiences. A high average 5-star rating signifies a high level of satisfaction with the product, as customers consistently rate it with higher stars. Positive valence means shared positive experiences and feedback in detailed reviews, furthering signaling the desirability and positive aspects of the product. When combined, these factors imply that the product has received a substantial number of positive reviews, serving as an additional signal that it is well-regarded by experienced customers.

> *H5: The impact of positive valence within review metrics increases the moderating effect of the average rating between rating volume and purchase decisions, such that the interactive impacts among rating volume, average rating, and positive valence become strong in the context of products recently added to online stores.*

Data and Empirical Settings

To address our research questions, we constructed a panel dataset from Amazon. This data specifically focused on new releases in six categories: baby, beauty & personal care, automotive car care, pet supplies, toys & games, and tools & home improvement. The selection of new releases was crucial to effectively observe the impact of reviews on sales performance over time. This is because established products already have numerous reviews, which made it less suitable for assessing the influence of reviews on performance. We chose the six categories because we believed that customers highly prioritize reviews in those categories when making informed decisions. While a product has a unique product number, called ASIN, on Amazon, the platform pools reviews for all related versions, even if they differ in color or the number of products in a bundle. Therefore, to avoid redundancy, we removed all duplicates and retained only one version of each product in our dataset.

For our analysis, we utilized a hundred products from Amazon's new releases for our analysis. In cases where certain products disappeared for some reason, we identified new products in the following week to ensure a minimum of a hundred products in each category. The six categories were tracked on a weekly basis over a period of 24 weeks in 2022 and 2023. The constructed panel dataset contained all the review-related information obtained through web crawling methods. Some categories did not have the same start time in the data collection process, but they were collected for 24 consecutive weeks.

Dependent Variable

As a proxy of the product's performance, this study used Amazon's best sellers rank as a response variable. Amazon's best sellers rank is a number assigned to a product once it has made at least one sale. A product ranked #1 indicates much higher sales compared to a product ranked #1,000. The best sellers rank serves as a reliable indicator of the product's performance on Amazon. Since a product can be sold in multiple categories on Amazon, it is common for a product to have multiple best

sellers rank for each product category. Consequently, we utilized a category-specific best sellers rank for each product category. For instance, new releases in the baby category used the best sellers rank for baby products.

Independent Variables Measuring Review Quantity, Quality, and Valence

To assess the quantity of reviews, we employed rating volume as a proxy. It is worth noting that rating volume and the number of actual reviews may differ, as some customers may rate the product without writing actual reviews. Because rating volume is one of the first review metric that customers encounter when reviewing a product, we used rating volume to measure review quantity. In terms of review quality, we followed the established literature that widely accepts certain indicators as measures of review quality. These indicators include review length (A. A. Choi et al., 2019; Deng et al., 2022; Yu et al., 2022), helpfulness votes (Deng et al., 2022; Yu et al., 2022), and average 5-star rating (Jabr & Rahman, 2022). Additionally, we considered answered questions as Amazon prominently displays the review metric, capturing customers' attention. To represent review valence, we utilized *LIWC-22* (Linguistic Inquiry and Word Count - 22), a tool that analyzes positive and negative tone within each review as part of natural language processing. *LIWC-22* examines each word in the review based on its built-in dictionary. For example, if it identifies 50 words with positive emotions in a 1,000-word review, the tool will calculate the percentage as 5 percent. To ensure data quality, reviews with fewer than 50 words were excluded, as *LIWC-22* suggests a certain level of skepticism when analyzing text with fewer than 50 words. This step was taken to maintain the reliability and accuracy of the analysis.

Control Variables

To better understand the impact of review quantity, quality, and valence, this study incorporated control variables such as price, prime, prime one day, free returns, ratios, and the standard deviation of 5-star ratings. Price plays a crucial role in influencing customers' behavior and purchasing decisions on the platform (Evangelidis & Gunadi, 2023). By controlling for this effect, this study more accurately explored the impact of review quantity, quality, and valence. Given the nature of e-commerce, some customer may prefer fast deliveries with the option of prime or prime one day. The availability of free returns is an important consideration for customers, as it provides them with an option to return the product if it fails to meet their expectations. The ratio indicates the count of 1-star reviews relative to 5-star reviews, offering insights into the relative prevalence of negative feedback compared to positive feedback. Additionally, the standard deviation of all reviews' 5-star ratings measured the dispersion or spread of these ratings. A higher standard deviation indicates greater variability among the ratings. Controlling for these effects enabled us to gain deeper insights into customers' decisions and the influence of review

quantity, quality, and valence on their purchasing behavior. Table 1 shows the descriptive statistics of our variables. When applying a logarithmic transformation to a numerical value, we added 1 to the value before taking the logarithm to avoid undefined values.

Insert Table 1 Here

Empirical Models and Results

Our analysis investigates the impact of review quantity, quality, and valence on product performance in the context of new releases. Equation (1) presents our empirical model.

$$\begin{aligned}\ln(SalesRank_{it+1}) &= \ln(RatingVol_{it}) + AvgRating_{it} + \ln(AnsQue_{it}) + \\ &\ln(Length_{it}) + \ln(HelpfulVotes_{it}) + \ln(PosTone_{it}) + \ln(NegTone_{it}) + \\ &\ln(Price_{it}) + Prime_{it} + PrimeOneDay_{it} + \ln(Ratio_{it}) + \\ &SD_{it} + FreeReturns_{it} + \alpha_i + \varepsilon_{it}\end{aligned} \quad (1)$$

where i refers to the product and t refers to the weekly observation. The best sellers rank, denoted as $SalesRank_{it}$, represents the ranking data for particular product i in week t.

To invert the ranking order and align it with the conventional understanding that higher values correspond to better rankings, the ranking data were multiplied by -1. This inversion ensures that the directionality of the data is consistent with the commonly accepted notion of higher values indicating superior rankings. The rating volume, denoted as $RatingVol_{it}$, represents the number of ratings received by a particular product i in week t. $AvgRating_{it}$ represents the average 5-star ratings of reviews received by the same product and week. $AnsQue_{it}$ represents the number of answered questions received by the product in that week. $Length_{it}$ represents the word count of reviews received by a particular product i in week t. $HelpfulVote_{it}$ represents the number of helpfulness votes received by a particular product i in week t. $PosTone_{it}$ represents the percentage of positive tones in a review received by a particular product i in week t, while $NegTone_{it}$ represents the percentage of negative tones in a review received by the same product and week. $Price_{it}$ indicates the price of a particular product i in week t. $Prime_{it}$ and $PrimeOneDay_{it}$ represent the status of prime memberships, particularly providing two-day or one-day shipping on eligible items by Amazon by a particular product i in week t. $Ratio_{it}$ represents the count of 1-star reviews in relation to 5-star reviews for a particular product i in week t. SD_{it} represents the standard deviation of all reviews'

5-star ratings for a particular product i in week t. $FreeReturns_{it}$ represents the possibility of free returns for a particular product i in week t. SD_{it} represents the standard deviation of all reviews' 5-star ratings for a particular product i in week t. α_i is time-invariant unobservable characteristics of product i, and ε_{it} represents the error term.

In order to account for unobserved heterogeneity and time-invariant characteristics in our panel data, a fixed effects regression model was employed (Ilk, Shang, Fan, & Zhao, 2021; Karhade & Dong, 2021). A fixed effects model allows for more reliable causal interpretations of the estimated effects. To examine individual and synergic effects of review quantity, quality, and valence, this study presented a control model, followed by a direct model, together with two-way and three-way interaction models, as shown in Table 2.

Insert Table 2 Here

Direct Model

The empirical results of the fixed effects regression model provided valuable insights into the relationships between various variables. Firstly, this study found that review quantity, measured by rating volume, was positive and significant ($\beta = 0.126, p < 0.01$), supporting H1. The finding aligns with the understanding that new releases benefit from increased customer reviews, which enhances attention and ultimately drives sales.

In terms of review quality, this study examined several indicators, including average rating, length, answered questions, and helpfulness votes. The results, presented in Table 2, revealed that both averaged rating and length, denoted as $AvgRating$ ($\beta = 0.202, p < 0.01$) and $Length$ ($\beta = 0.118, p < 0.05$), were statistically positive and significant effects on sales performance. In contrast, answered questions, $AnsQue$ ($\beta = -0.080, p < 0.05$), were statistically negative and significant impact, while helpfulness votes, $HelpfulVote$ ($\beta = -0.022$), demonstrated no statistical significance. Essentially, this suggests that the average 5-star rating and the length of reviews directly influence product sales. Although the unexpected results for the other two variables in review quality, they exhibited synergistic impacts on products sales, which will be further explored in the section of interaction effects.

The empirical results also found that positive valence, $PosTone$ ($\beta = 0.327, p < 0.05$), had a positive influence on sales performance. This indicates that the positive tones in reviews reinforce potential customers' confidence in their purchase decisions. On the other hand, negative valence, $NegTone$ ($\beta = 0.116$), did not show statistically significant impact on sales

performance when considered individually. However, the combined effect of negative valence will be examined in the context of two-way interaction effects.

Empirical Results of Two-Way Interactions

As previously mentioned, we examined two-way interactions between review quantity and review quality, as well as between review quantity and review valence. The results were presented in Table 2. The interaction term between rating volume and average rating, $RatingVol \times AvgRating$ ($\beta = 0.103, p < 0.05$), was statistically significant and positive. This implies that the impact of rating volume will be amplified when accompanied by a higher average 5-star rating. Another interaction term between rating volume and answered questions, $RatingVol \times AnsQue$ ($\beta = 0.019, p < 0.10$), indicated that the result was statistically significant at the 10% level. In other words, the effect of rating volume on product sales was strengthened by the present of a higher number of answered questions. However, it is important to note that these results should be interpreted cautiously due to the weak statistical significance. The empirical results of the interaction term between rating volume and length, $RatingVol \times Length$ ($\beta = -0.023$), showed that it was statistically insignificant. Although both variables had individual effects, their interaction did not yield a notable effect when considered together. The interaction between review quantity and review quality, specifically the interaction of rating volume and helpfulness votes, $RatingVol \times HelpfulVote$ ($\beta = 0.064, p < 0.01$), is noteworthy. Notably, although the variable of helpfulness votes was insignificant in the direct model, review quantity became instrumental in influencing sales performance, when a high level of helpfulness votes was present.

The interaction effects between review quantity and review valence also yielded interesting findings. The interaction of rating volume and positive valence, $RatingVol \times PosTune$ ($\beta = -0.235, p < 0.01$), showed negative influences. While each variable had a positive and significant individual effect, the interaction between rating volume and positive valence diminished the positive impact of each variable on sales performance when considered independently. This suggests that an excessive number of positive comments in online reviews raises customer suspicion with regard to the credibility of the product. Similarly, the interaction effect of rating volume and negative valence, $RatingVol \times NegTone$ ($\beta = -0.205, p < 0.01$), also exhibited negative impacts on sales performance. Although negative valence alone did not significantly impact sales, its presence modified the positive effects of rating volume, leading to a decrease in sales. It is worth mentioning that

the interaction between review quality and review valence had the most significant impact on sales performance in the two-way interaction model.

Empirical Results of Three-Way Interactions

This paper also explored the three-way interaction among review quantity, quality, and valence, aiming to capture more nuanced relationships among these variables. The empirical results for the interaction of rating volume, average rating, and positive tone, $RatingVol \times AvgRating \times PosTone$ ($\beta = 0.171, p < 0.01$), was statistically positive and significant. In contrast, the three-way interaction among rating volume, average rating, and negative valence, $RatingVol \times AvgRating \times NegTone$ ($\beta = 0.029$), was found to be insignificant. These findings suggest that the combined effect of rating volume, average rating, and positive valence exceeded the sum of their individual effects.

Robustness Checks

This paper controlled for time-invariant omitted variables by using a fixed effects model and used a one-week time lag between review metrics and product performance to mitigate endogeneity concerns arising from reverse causality (Karhade & Dong, 2021). We also used instrumental variables available in our datasets to address endogeneity. The Cragg-Donald Wald F test ($F = 49.17, p < 0.01$) suggested that instruments were relevant and had a strong association with the endogenous variable. The paper also used the Sargan-Hansen test for overidentification restrictions. The results also passed overidentification test, suggesting that they are valid instruments (Sargan's $J = 4.925, p = 0.09$). In other words, it suggests that the instruments are valid and satisfy the overidentification restrictions.

Discussion

The rise of review platforms has attracted numerous customers, businesses, and platform owners, and has transformed the nature of business (Deng et al., 2022; Hou & Ma, 2022; Jabr & Rahman, 2022). Customers rely on reviews to assess whether a product aligns with their needs and expectations, while businesses leverage crowd-sourced reviews to establish trust and credibility for their products. Recognizing the significance of online reviews, platform owners have made efforts to develop review metrics that enable customers and businesses to easily understand the overall value of reviews and increase product sales. In particular, this study aims to investigate the impact of review quantity, quality, and valence on product performance, specifically in the context of new releases. It also explores the individual and combined effects of these three review metrics

simultaneously to identify which ones have a stronger influence on product performance. In this section, we delve into theoretical and practical impactions derived from the results of this study.

Theoretical Implications

This study makes a valuable contribution to the existing literature by comprehensively examining the three fundamental review metrics – quantity, quality, and valence –

in the context of new releases. Previous research has focused on various aspects of online reviews, such as review quality (Mousavi, Raghu, & Frey, 2020; Deng et al., 2022; Hou & Ma, 2022), monetary incentives (Qiao, Lee, Whinston, & Wei, 2021; Yu et al., 2022), and reviewers' personality (A. X. Liu et al., 2021). However, this study takes a step further by providing a holistic view of the three review metrics and their individual and collective impacts on newly introduced products. By considering the influences of quantity, quality, and valence of reviews together, this study offers a more comprehensive understanding of the dynamics of online reviews. Examining these factors collectively is critical to unraveling the intricate relationships between review metrics and product performance. The findings of this study reveal that among the three aspects of reviews, review quantity has the most substantial impact. Furthermore, when combined with average rating and review engagement metrics such as the number of helpfulness votes and answered questions, the count of ratings reinforces product sales. Moreover, the three-way combined effects of review quantity, quality, and valence, measured by rating volume, average rating, and positive valence, respectively, are shown to further enhance product sales in the context of new releases. These findings highlight the importance of considering these review metrics collectively to maximize their impact on customer decision-making and product success. Overall, these findings contribute to the evolving understanding of the dynamics of online reviews and offer valuable insights to the literature.

This study also contributes to the existing literature by examining the value of signaling theory in understanding the dynamics of online reviews. Signaling theory offers valuable insights into the process of information provisioning, information overload, and the significance of information signals (Connelly et al., 2011; Jabr & Rahman, 2022). In the context of e-commerce, where customers make purchases without physically experiencing products, signaling theory becomes particularly relevant and useful. With the proliferation of review platforms, crowd-sourced reviews have become easily accessible to customers. However, the abundance of information can lead to information overload, where customers struggle to process all the available information within their limited cognitive capacity. In this context, any type of signal becomes crucial in helping customers navigate through the overwhelming amount of information. Review metrics serve as

valuable signals, and the consistency of signals provided by review quantity, quality, and valence plays a significant role in facilitating product performance. The review metrics act as information signals that customers rely on to make informed decisions. By applying signaling theory to the context of online reviews, this study offers useful insights into the role of signals in influencing customer behavior and decision-making processes. It highlights the importance of understanding how customers perceive and interpret these signals and how businesses can strategically utilize review metrics as effective signals to enhance customer trust, confidence, and purchase decisions. In summary, this study contributes to bridging the gap between signaling theory and the context of online reviews.

Practical Implications

This study offers practical implications for customers, businesses, and platform owners seeking to optimize the value of online reviews in enhancing customer satisfaction and sales. The findings shed light on the relative significance of review metrics and their combined effects, providing practical recommendations for various stakeholders. For business, it is critical to prioritize generating a higher count of ratings for their products. Encouraging customers to leave ratings and reviews can have a significant impact on sales. Additionally, business should recognize the synergistic relationships between review metrics. This may involve actively encouraging customers to rate, engage with reviews, and provide helpful feedback. By doing so, businesses can leverage the combined effects of review quantity, quality, and valence to influence customer decision-making positively. In order to facilitate the decision-making process for customers, platform owners should ensure that review metrics are easily understandable and accessible. This can be achieved by presenting review metrics in a clear and concise manner along with visual aids. This would enable customers to quickly identify the most valuable and informative reviews in the midst of information overload. This study emphasizes the significance of comprehending customers' perceptions and interpretations of these signals, as well as the strategic utilization of review metrics by businesses to bolster customer trust, confidence, and purchasing choices.

Conclusion

This study highlights the critical role of online reviews in shaping customer perceptions and purchase decisions for newly released products. The findings demonstrate that review quantity, quality, and valence are significant factors that influence product performance. It provides a comprehensive understanding of how review quantity, quality, and valence individually and collectively influence product performance. The insights gained from this research can guide businesses and platform owners in developing effective review management strategies, enhancing customer satisfaction, and driving sales. By

leveraging the power of online reviews, businesses can build trust, credibility, and ultimately establish a strong competitive advantage in the online marketplace.

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Table 1. Descriptive Statistics

Variable	Description	Mean	St. dev.	Max	Min
Best Sellers Rank	Numerical ranking system that indicates the popularity and sales performance of a product within a specific category. (log transformed; negated)	-8.13	1.32	0	-14.11
Rating Volume	Total number of customers who have purchased and rated a product (log transformed)	5.68	3.57	11.18	0
Average Rating	Average score received when customers rate a product or service using a 5-star rating system	4.44	0.39	5	0
Answered Questions	Total number of questions that has received responses (log transformed)	1.65	2.48	6.31	0
Length	Number of words in a customer's written review for a product (log transformed)	7.68	2.37	11.74	4.62
Helpfulness Vote	Total number of helpfulness votes (log transformed)	4.05	3.18	9.60	0
Positive Tone	Ratio of a positive or optimistic sentiment in written text (Log transformed)	0.84	0.64	1.98	0
Negative Tone	Ratio of a positive or optimistic sentiment in written text (Log transformed)	0.43	0.44	1.28	0
Price	Product price (Log transformed)	3.28	2.21	7.06	0.17
Prime	Dummy variable indicating whether the product is available on Prime (1 if Yes, 0 Otherwise)	0.50	0.50	1	0
Prime one day	Dummy variable indicating whether the product is available on Prime one day (1 if Yes, 0 Otherwise).	0.24	0.43	1	0
Ratio of rating extremes	Ratio of the count of 1-star reviews in relation to 5-star reviews (log transformed)	0.54	1.20	3.00	0
Std. deviation of review ratings	Standard deviation of all reviews' 5-star ratings (log transformed)	0.65	0.44	1.34	0
Free returns	Dummy variable indicating whether the product has free returns (1 if Yes, 0 Otherwise)	0.81	0.39	1	0

Table 2. Fixed Effects Regression Results

DV: Best Sellers Rank	Control	Direct	2-Way Interaction	3-Way Interaction
$Price$	-0.169* (0.100)	-0.200** (0.100)	-0.316*** (0.101)	-0.307*** (0.101)
$Prime$	0.254*** (0.070)	0.239*** (0.070)	0.227*** (0.069)	0.234*** (0.069)
$Prime\ One\ Day$	0.273*** (0.078)	0.259*** (0.078)	0.250*** (0.077)	0.259*** (0.077)
$Ratio$	0.213** (0.086)	0.191** (0.087)	0.158* (0.087)	0.157* (0.087)
SD	0.028 (0.047)	-0.067 (0.057)	-0.040 (0.057)	-0.032 (0.057)
$FreeReturns$	0.142* (0.076)	0.128* (0.075)	0.117 (0.075)	0.113 (0.074)
$RatingVol$		0.126*** (0.024)	-0.230 (0.156)	0.352 (0.202)
$AvgRating$		0.202** (0.093)	-0.078 (0.129)	-0.088 (0.129)
$AnsQue$		-0.080** (0.031)	-0.236*** (0.079)	-0.248*** (0.079)
$Length$		0.118** (0.059)	0.271** (0.121)	0.249** (0.121)
$HelpfulVote$		-0.022 (0.052)	-0.429*** (0.116)	-0.416*** (0.116)
$PosTone$		0.327** (0.131)	1.633*** (0.339)	1.677*** (0.339)
$NegTone$		0.116 (0.160)	1.241*** (0.414)	1.191*** (0.414)
$RatingVol \times AvgRating$			0.103*** (0.029)	-0.027 (0.059)
$RatingVol \times AnsQue$			0.019* (0.010)	0.020** (0.010)
$RatingVol \times Length$			-0.023 (0.019)	-0.021 (0.019)
$RatingVol \times HelpfulVote$			0.064*** (0.018)	0.062*** (0.018)
$RatingVol \times PosTone$			-0.235*** (0.055)	-1.011*** (0.276)
$RatingVol \times NegTone$			-0.205*** (0.068)	-0.328 (0.252)
$RatingVol \times AvgRating \times PosTone$				0.171*** (0.059)
$RatingVol \times AvgRating \times NegTone$				0.029 (0.053)
Product-Fixed Effects	Y	Y	Y	Y
F	6.544***	7.363***	8.868***	8.437***
AIC	7081.9	7032.3	6964	6958.4
BIC	9493	9485.6	9453.5	9460
Panel	437	437	437	437
Observations	3,502	3,502	3,502	3,502

Note: * p < 0.1, ** p < 0.05, *** p < 0.01. Standard errors are in parentheses.

Papers

Operations Management/Operations Research

INCREASING PROJECT EFFICIENCIES BY AVOIDING CRASHING

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ABSTRACT

This paper focuses on developing pre-planning strategies to help avoid crashing in production to increase overall production efficiency and avoid lateness. In project management a company has to follow a detailed work schedule to ensure a project is completed on time. In some instances, crashing, where the duration of a project is shortened, is used to make a deadline on time, make up for lost time or fix an unforeseeable event. The outcome of crashing is a higher cost for the client. Although crashing is seen as a viable option to execute projects, unrealistic proposed timelines and high costs, pre-planning options such as proactive scheduling, analyzing data and creating a company culture that focuses on the overall company goal rather than individual tasks are more realistic options that will provide greater efficiency to companies and help with long-term planning and project execution. The findings reveal that a project's success is determined by the involvement of employees, taking the time to schedule a project and creating a lessons-learned environment.

INTRODUCTION

In today's business world, operations managers are constantly being challenged by budgetary constraints, limited resources, and pressing deadlines. Among these challenges is the common issue of a project falling behind schedule or a project's timeline being forced forward (Heizer, Render, & Munson, 2017). One of the most common remedies to delayed projects is project crashing (Diaby, Cruz, & Nsakanda, 2011). This solution, however, can lead to high costs and is often considered a band aid to an already existing problem of poor planning. "Crashing is usually accomplished through the commitment of additional resources, such as personnel, equipment, and budget, to individual activities of the project. This results in a trade-off between the project completion time and the cost of crashing" (Kerzner, 2013). Although useful in many industries, project crashing is not always effective. This may lead to increased delays, hindered team dynamics, and is sometimes impossible to achieve due to preceding activities (Project-Management, 2018). To increase the likelihood of a project ending on budget and on the original timeline proposed, we suggest that more resources and time be spent on forecasting and implementing more effective operational strategies to achieve better results in the long-term for a project management company. This

paper will explore possible solutions to help increase project efficiencies and therefore avoid the short-run fix that is project crashing.

"Schedule and cost are the two most important indicators in project practice" (Ou-Yang & Chen, 2019). Managers need to consider these factors and keep in mind right from the beginning of the project to avoid crashing or have a project go over the deadline. Crashing is a costly solution to keep projects finishing on time and must be determined before the project begins to avoid additional costs and disorganization during the project duration. To logically crash a project companies, have to add additional resources to the project such as people and materials. To determine how long companies can crash a project for, companies have to look at the slack time of each activity. The slack time is the length of time an activity can be delayed without delaying the entire project. If the project requires crashing, the goal is to keep the crash costs as low as possible. This results in looking at activities on the critical path and crashing the activity that costs the least. However, the danger is that there is too much emphasis on the critical path and other activities are neglected. During every project there comes a point where a company cannot crash anymore. This paper will look at techniques managers can implement before the project even begins to avoid crashing.

A company's reputation can be affected by how efficiently it completes a project. If a project is costly and over deadline the client will be displeased and not use or recommend the company in the future. This can lead to lost business and strained relationships with suppliers. Although crashing is seen as a viable option to execute projects, unrealistic proposed timelines and high costs, pre planning options such as the project buffers, analyzing data and creating a company culture that focuses on the overall company goal rather than individual tasks are more realistic options that will provide great efficiency to companies and help with long term planning and project execution. By logically justifying upfront costs in planning, companies can save more money and time in the long-term and achieve more sustainable results. This shows a critical need for additional options for companies other than crashing.

LITERATURE REVIEW

Project scheduling is one of the most critical functions to project management. The planning process involves goal setting, defining the project, and team organization (Heizer et al., 2017). While project scheduling is concerned with people, costs, limited resources and how they relate to different project activities, the ultimate goal of a project manager is to see the successful and timely completion of a project, and it is through accurate estimations and proper scheduling that managers are able to achieve this goal (Pellerien & Perrier, 2018). In project scheduling, managers analyze networking activity sequences, durations, and resource tradeoffs so that aggregate plans are set in place. While some projects are well-defined in the planning and scheduling processes, others are ill-defined and more sensitive to uncertainty, which leads to the risk of cost overruns and unnecessary delays and, at times, complete project failure (Pellerien & Perrier, 2018; Feylizadeh et al., 2018). In many project scheduling problems, managers have to use different ways to speed up the project in an effort to counter unreliable forecasts and ultimately meet a pressing deadline.

There are two scheduling approaches that can generally be identified in project management literature: reactive and proactive (Pellerien & Perrier, 2018). Reactive scheduling involves revising the baseline schedule when unexpected events occur, either by complete reconstruction of a new schedule or by modifying the existing. When faced with high levels of uncertainty, project managers often find themselves resorting to reactive scheduling strategies such as project crashing. These project crashing techniques may include working overtime, hiring extra resource capacity, changing the mode of activities with other modes, or outsourcing during project implementation

(Moradi & Shadrokh, 2019). While crashing techniques attempt to reduce the duration of a project with the minimum cost, there are some downfalls to this approach. Present research suggests that crashing is generally costly, and there are many studies that explore optimizing solutions among project time, cost, quality, and risk. Feylizadeh et al. (2018) find that, through their fuzzy multi-objective non-linear model, uncertainty can be mitigated in existing projects at a reduced cost. While scholars find solutions to the project scheduling problems, literature also suggests that crashing significantly impacts project quality (Babu & Suresh, 2021).

When faced with uncertainty, project managers should look to proactive scheduling approaches which rely on statistical knowledge. Under a proactive approach, schedules are constructed with the purpose of protecting against project disruption. Goldratt (1997) introduces the project buffer to avoid unanticipated delays during project execution. Buffering strategies such as 'wake up calls' or idle time on materials (Morandi & Shadrokh, 2018) can be added into the initial budget of the project to reduce cost and used to protect critical milestones (Cherkaouri et al., 2017). Furthermore, Mornadi and Shadrokh (2018) find that resource buffers are useful as they decrease the total project duration and help meet the deadline with more assurance. By this logic, project managers may look to account for uncertainty in their scheduling techniques, or have buffering strategies in place (Cherkaouri et al., 2017), in an effort to make activities less sensitive to disruptions during project execution.

Another approach a company should consider is analyzing data from past projects to assist in making estimations and to be better prepared for costs and unforeseen events. By analyzing historical data project managers can better ensure an organized project. "Project organization is developed to make sure existing programs continue to run smoothly on a day-to-day basis while new projects are successfully completed" (Heizer et al., 2017, p. 62). The stronger quality planning a company can do on the front end of a project will result in fewer unforeseen costs, will be completed on time and will have a satisfied customer (Dvir, 2003). Analyzing past projects can help managers determine the accurate amount of time each activity in the project takes. This can eliminate the need for crashing because you will have a better understanding of how much time your team needs to complete each activity, rather than roughly estimating. Looking at past projects of the company, and even those of the competitors, can assist managers in the planning process of projects.

Projects act as small organizations and thus there should be an emphasis on continuous learning. Without improvement at the highest level of project management resulting in maturity, it can be inferred that "without 'discounted' lessons learned, a company can quickly revert from maturity to immaturity in project management" (Williams, 2008). Knowledge is ultimately lost, and past mistakes are repeated. The lessons learned can be implemented into the next project cycle and can be conducted on a trial-error basis. Continuous learning does have its costs. In a survey done by Williams (2008) when asked why their organization was not participating in a lessons-learned process the main reasons were lack of employee time, lack of management support, lack of incentive, and lack of unclear guidelines.

The final task after completing a project is to analyze and evaluate the project. Taking the time to audit the positives and negatives of the project can help future project managers and create a natural cycle of continuous improvement and learning. Learning within a project is a very difficult process to complete. It requires commitment, attention to detail and a continuous investment of resources (Ayas, 1996). However, taking the time to complete this evaluation can lead to less crashing and a better understanding of what went right and wrong in the project. Continuous learning may not be an immediate fix on current projects but can serve as a vital tool for future implementation and therefore should not be overlooked.

Lastly an approach a company should consider in project management to avoid crashing is investing in its people. Failure of a project to meet its deadline may look to be an operational problem but the root cause could be poor personnel management. As Vaníčková (2021) states "one of the main causes of project failure is inappropriate project management methods used, but also failure of human capital" (p. 5). This failure could be a result of a variety of objectives such as but not limited to "closed formal communication between people, between members of the project team/stakeholders in the project, etc. sub-partners… lack of trust, low diversity and involvement of individual members in solving tasks, fears and fears of conflicts/failures in the competence of the assigned roles of the project team, intentional avoidance of responsibility, indifference to project results/outputs, low motivational element, limited involvement, side effects and etc." (Vaníčková, 2021, p.6). By implementing synergy into projects or "the coordination and compatibility among the social resources, cognitive resources, and emotional resources brought about by different identities" (Chen, Jiao, Yang, & Wang, 2021, p.794) project committees are better able to work together as a team and are better able to avoid project lateness that requires crashing.

The human factor in a project is many times overlooked yet is one of the most important parts of a successful project (Vaníčková, 2021). The concept of having a positive organizational culture or "way of life and work in an organization or company" (Majstorovic, V. & Majstorovic, A., 2020, p. 54) is a good practice for companies to not only see more project success but overall company success. Promoting team members to share unique ideas and perspectives will allow a company to have less stagnant problems and can allow for problems to be solved faster (Majstorovic, V. & Majstorovic, A., 2020). Good relations with fellow employees as well as suppliers, distributors and all levels of the supply chain can help foster positive work habits that result in projects being more successful (Vaníčková, 2021). Once again, these relations may mimic synergy factors (Chen, Jiao, Yang, & Wang, 2021). These behaviors are many times established and encouraged at top level management and then the effects trickle down. Top management "determines the purpose of the organization" (Majstorovic, V. & Majstorovic, A., 2020, p. 50). This is crucial "since organizations use projects as a means to achieve strategic goals, it can be logically concluded that a strategic focus on project culture is one of the elements of organizational culture that has a significant impact on the success of management by projects" (Majstorovic, V. & Majstorovic, A., 2020, p. 54). For this reason, a clear company and project goal are important to help establish positive work environments. The project organizational structure should also reflect that of the overall organizational structure of the company to produce the best results (Majstorovic, V. & Majstorovic, A., 2020, p. 50). This shift for an individually task oriented thought process to an interconnected company mission, helps to create greater unity throughout business units. This concentrated focus on personnel management will help companies avoid crashing by increasing project efficiencies.

Although the suggestion of teamwork and synergy may seem to suggest a zero-conflict work environment, this is not the case. The suggestion of order rather than harmony are two vastly different concepts (Butler, 1973). In fact, conflict "may be required to challenge people to perform and to encourage progress" (Butler, 1973, p. 86). Differing opinions and ideas add to the diversity of a project and can reap benefits especially in the planning process. Once again personnel management from the top down is key to helping foster positive environments where order is created to help end in more efficient and timely project results.

INSIGHTS

When evaluating best practices for projects the three most important variables to consider are cost, quality and time (Vaníčková, 2021). Alternatives to crashing therefore must be minimized in at least one of these three areas. Based on research it can be concluded that although alternative options to crashing also involve resources like time and manpower, they produce more cost effectiveness and on time effectiveness. This may suggest that alternatives to crashing are sometimes not feasible for companies who do not have the appropriate resources to implement non

crashing plans. Some companies may have crashing as their only option and therefore is why it is considered a viable option in project management.

Analyzing why projects were on time or late can uncover simple actions that managers and the company can implement to have projects completed on time and contribute to the company's overall strategic focus (Williams, 2008). Small actions, such as paying suppliers in a timely manner can lead to better relationships with suppliers. These relationships are critical when a manager unexpectedly needs resources quickly and can rely on the strong relationship between the supplier to provide the materials on time. This is a sustainable strategy that may not yield results until the far-out future compared to other alternatives that result in quicker results.

Williams (2008) identifies lack of employee time and management support are a leading cause of inefficient projects. Employee engagement is directly related with organizational performance outcomes (Markos & Sridevi, 2010). Managers should focus on involving employees in the planning and preparation process of a project. Employees are a resource, and usually the ones physically doing the work, who have a unique insight into the project process. When employees are more involved in the planning process they feel more of an ownership to the work and are most likely to execute the plan on time if they feel more involved. It gives them an overall sense of self-gratification, accomplishment and ownership. The company's need to focus on creating a lessons-learned environment where sharing past failures and successes can be widely accepted and heard without judgement and looking towards the greater overall success of the company. A company environment where employees are engaged in project management decisions and planning and where employees and management learn from past projects can lead to lower costs due to no crashing and insights on how to create a more efficient project process. Continued research in this specific area could be beneficial to operational effectiveness and should be further pursued. Based on other theories and topics in operations management, organizational behavior in direct relation to projects should be further developed. The majority of the current article showed implicit relationships and are therefore inferred.

CONCLUSIONS

Further research should be done to fully conclude what industries crashing is most applicable in and industries where pre-planning strategies are more useful. The recommendations provided in this paper apply to project operations rather than production operations and therefore should be applied in a similar way. Each project and industry are unique and therefore should be treated as such. As Vaníčková (2021) says "significant projects can be managed in the same ways, but each project will ultimately be unique thanks to a different team of collaborators, other sources of translated text, situations or stakeholders" (p. 5). There are some factors in a project, such as weather, if employees get sick or injured or lack of resources, which are uncontrollable and unpredictable. In these instances, crashing is the only option a manager has to complete the project on time. Throughout the research it was clear that steps can be taken to avoid crashing, however, it may still be necessary to crash an activity in order to complete a project on time to a client's satisfaction. The more satisfied a client the more likely they are to use the company again and refer to others.

There are limitations to our research because we focused on crashing avoidance as the overall topic and did not focus on a certain type of management project or industry. Further research should be conducted and focused on crashing in different industries, such as healthcare, construction and more. Companies should investigate other options to crashing depending on what industry they are in. The main conclusion of our research is that no effort should be spared in the initial pre-planning process of a project. This sets the foundation and tone for the entire duration of the project and involving employees in the initial process contributes to the project's overall success as

well as overall company success. To conclude, investing time and money upfront in predictions and strategies will save the company money in the long run.

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AN ECONOMIC PRODUCTION QUANTITY MODEL WITH BACKORDERS AND GEOMETRICALLY DECREASING PRODUCTION COST

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Abstract

In a recent paper, an improved Economic Order Quantity (EOQ) model was introduced, incorporating backlogging for out-of-stock items and a variable unit procurement cost. This cost decreases geometrically by a factor r ($0 < r \leq 1$) with each increase in lot size. Using this adjustment, the authors formulate a new and more general EOQ model with planned shortages and infinite input rate. Using an approximation technique, they provide explicit expressions for the optimal values of policy variables, lot size, and backorder level. For the special case when $r = 1$, the authors show that the findings drive down to the corresponding results of the conventional EOQ model with backorders and constant unit procurement cost. This paper extends the EOQ paradigm described above by relaxing the implicit infinite input rate assumption which leads to instantaneous replenishment of inventory. Specifically, we develop a modified Economic Production Quantity (EPQ) model with planned shortages and geometrically decreasing unit variable procurement cost in which inventory builds up gradually at a finite production rate. It will be seen that the results of the modified EPQ model in this study reduce to the analogous findings of the previous EOQ model with backorders and variable unit procurement cost when the production rate approaches infinity. Furthermore, for the specific situation when $r = 1$, the explicit expressions for the optimal values of policy variables in this paper become identical to the corresponding results for the case of the conventional EPQ model with backlogging of shortages and constant unit production cost.

Keywords: EPQ Model with Planned Shortages, Variable Production Cost

INTRODUCTION

The well-known Economic Order Quantity (EOQ) model was initially developed by Harris [1913] and subsequently utilized to a great extent by Wilson [1934]. Taking nothing else into account, the model is commonly referred to as Wilson's Square Root formula. The original EOQ model is developed based on a sequence of vastly limiting conjectures among which are deterministic demand, no backlogging of out-of-stock items, instantaneous buildup of inventory, and constant procurement cost per unit. These restrictions impose profound limits on the applicability of the EOQ model to the real-life inventory problems that companies frequently face.

In acknowledgement of this reality, numerous researchers, practitioners, and consultants have developed more reasonable inventory paradigms by loosening one or more of these limitations through a variety of approaches. An early modification relates to an EOQ model with finite input rate which allows for shortages to accumulate when demand for a briefly out-of-stock item arises. The resulting model is frequently referred to as the EOQ model with planned shortages. Another, again early, extension proposed by Taft [1918] involves the development of a lot size model, called the Economic Production Quantity (EPQ) model, in which the replenishment units are produced internally at a finite production rate, P, and, therefore, inventory accumulates gradually. In a recent paper, Paknejad and Affisco [2023] focus on the relaxation of the constant unit procurement (purchase) cost assumption of the EOQ model where shortages are permitted to occur. In the conventional EOQ model with planned shortages, the inclusion of this assumption leads to the total disappearance of the procurement cost parameter from the expressions for the optimal values of policy variables, lot size and backorder level, ensuing the process of typical optimization techniques. However, as Paknejad and Affisco [2023] contend, it is understandably conceivable that the unit procurement cost may not be constant. For example, better quality may be realized through the life cycle of the process by elimination of special causes, operational performance may be enhanced by workers' training and learning effects, routine maintenance of machines and equipment may improve the overall functioning of the production process, and implementation of co-maker concepts may prove beneficial to both vendor and purchaser.

Under these circumstances, it is sensible to presume that the unit cost of procurement will decrease for each additional unit bought or manufactured. Paknejad and Affisco [2023] initiated the study of variable procurement cost in the context of an EOQ model with infinite input rate and backlogging of out-of-stock items by assuming that this cost decreases geometrically with increasing lot size. This paper extends those results to the case where replenishment units are produced internally at a known, constant, and finite production rate and develops an EPQ model with planned shortages and variable unit procurement (production) cost which follows a geometrically declining pattern.

THE MODIFIED EPQ MODEL AND ASSUMPTIONS

The basic model modified by Paknejad and Affisco [2023] for the variable procurement cost factor is the EOQ model with an infinite input rate that permits backlogging of out-of-stock items. This paper extends the idea to the case of the conventional EPQ model with a finite production rate which allows backordering of unsatisfied demand. The total cycle cost and total annual cost of the classic EPQ model with planned backorders, denoted by $C_{Basic-EPQ}(S,Q)$ and $A_{Basic-EPQ}(S,Q)$, respectively, are as follows:

$$C_{Basic-EPQ}(S,Q) = K + CQ + C_h \frac{\left[Q\left(1-\frac{D}{P}\right)-S\right]^2}{2D\left(1-\frac{D}{P}\right)} + C_b \frac{S^2}{2D\left(1-\frac{D}{P}\right)} \qquad (1)$$

$$A_{Basic-EPQ}(S,Q) = \frac{D}{Q}K + CD + C_h \frac{\left[Q\left(1-\frac{D}{P}\right)-S\right]^2}{2Q\left(1-\frac{D}{P}\right)} + C_b \frac{S^2}{2Q\left(1-\frac{D}{P}\right)} \qquad (2)$$

where

D = Demand rate in units per unit of time (year),

P = Production rate in units per unit of time (year),

Q = Lot size per setup,

T = Q/D = Cycle time, the time between placement (or receipt) of replenishment orders,

S = Number of units backordered,

K = Setup cost per setup,

C = Unit variable cost of procurement (production),

C_h = Inventory holding cost per unit per unit of time (year), independent of dollar value,

C_b= Backordering cost per unit short per unit of time (year).

The pursuit of the standard optimization techniques yields the following well-known expressions for the optimal values for the lot size, $Q^*_{Basic-EPQ}$, units backordered, $S^*_{Basic-EPQ}$, and the total annual cost, $A^*_{Basic-EPQ}(S,Q)$:

$$Q^*_{Basic-EPQ} = \sqrt{\left(\frac{2DK}{1-\frac{D}{P}}\right)\left(\frac{1}{C_h}+\frac{1}{C_b}\right)} \tag{3}$$

$$S^*_{Basic-EPQ} = Q^*_{Basic-EPQ}\left(\frac{C_h}{C_h+C_b}\right)\left(1-\frac{D}{P}\right) \tag{4}$$

and

$$A^{*}_{Basic-EPQ}(S,Q)=CD+\sqrt{\left(\frac{2DK}{\frac{1}{C_h}+\frac{1}{C_b}}\right)\left(1-\frac{D}{P}\right)} \qquad (5)$$

One of the implicit assumptions of the above derivations is the assumption that the unit variable cost of procurement, C, is known, constant, and the same for all units in the lot. Paknejad and Affisco (2013), assume that this is not the case. Specifically, in the context of an EOQ model with backorders, the authors assume that starting with a unit variable procurement cost of C (in dollars) for the first unit in the lot, that is $C_1 = C$, for reasons such as the incremental unit price discounts in purchasing or the effects of operator training or learning in production, the unit procurement cost for each of the subsequent units (C_j for j=2, 3, 4, …, Q) drops by a constant factor r, where $0 < r \leq 1$, compared to the unit procurement cost of the preceding unit (C_{j-1} for j= 2, 3, 4, …, Q). Using the same specifications in this paper, but in the context of an EPQ model which permits backordering, we express the unit variable cost of production for the j[th] unit in each lot by $C_j = Cr^{j-1}$ *for* $j = 1,2,3,...,Q$. Accordingly, the total production cost per cycle for Q units is $K + V(Q)$, where K is the setup cost per setup and $V(Q)$ represents the cumulative variable cost of production during one cycle of length $T = \frac{Q}{D}$. Thus

$$V(Q)=\sum_{j=1}^{Q} Cr^{j-1} = C + Cr + Cr^2 + Cr^3 + ... + Cr^{Q-1} \qquad (6)$$

Obviously, when $r = 1$ in (6), then $V(Q) = CQ$, and the results of the traditional EPQ model with planned shortages represented by equations (1) through (5) apply. For 0 < r < 1, $V(Q)$ in (6) is the sum of the first Q terms of a geometric series, up to and including the Cr^{Q-1} term, with a common ratio of any term with the previous one, r, and the coefficient C (the initial variable production cost for the first unit in the lot), representing the first term of the geometric series in expanded form. Therefore,

$$V(Q)=\sum_{j=1}^{Q} Cr^{j-1}=\sum_{k=0}^{Q-1} Cr^{k}=C\left(\frac{1-r^{Q}}{1-r}\right) \qquad (7)$$

Using (7), the total cost per cycle for the modified EPQ model with planned shortages and geometrically decreasing unit production cost is

$$\begin{aligned} C_{Modified-EPQ}(S,Q) &= K+V(Q)+C_h\frac{\left[Q\left(1-\frac{D}{P}\right)-S\right]^2}{2D\left(1-\frac{D}{P}\right)}+C_b\frac{S^2}{2D\left(1-\frac{D}{P}\right)} \\ &= K+C\left(\frac{1-r^{Q}}{1-r}\right)+C_h\frac{\left[Q\left(1-\frac{D}{P}\right)-S\right]^2}{2D\left(1-\frac{D}{P}\right)}+C_b\frac{S^2}{2D\left(1-\frac{D}{P}\right)} \end{aligned} \qquad (8)$$

Dividing equation (8) by the cycle time, $T=\frac{Q}{D}$, yields the total annual cost for the modified EPQ model as follows:

$$A_{Modified-EPQ}(S,Q)=\frac{D}{Q}K+\left(\frac{CD}{Q}\right)\left(\frac{1-r^{Q}}{1-r}\right)+C_h\frac{\left[Q\left(1-\frac{D}{P}\right)-S\right]^2}{2Q\left(1-\frac{D}{P}\right)}+C_b\frac{S^2}{2Q\left(1-\frac{D}{P}\right)} \qquad (9)$$

Assuming that the rate of decline (1-r) in variable production cost per unit from one unit in the lot to the next (from C_j to C_{j+1}, where $j=1,2,3,\ldots,Q$) is low so that the common ratio, r, is close to one, a Taylor series expansion of $r^{Q}=e^{(\ln r)Q}$, similar to the one initially employed by Porteus [1986], and then by Nasri, Paknejad, and Affisco [2006], and finally by Paknejad and Affisco [2023], can be used. Upon using a second order Taylor series expansion and setting $\ln r\cong-\left(\frac{1-r}{r}\right)$, r^{Q} is found as follows:

$$r^{Q}=e^{(\ln r)Q}\cong 1-\left(\frac{1-r}{r}\right)Q+\left(\frac{1}{2}\right)\left[\left(\frac{1-r}{r}\right)Q\right]^2 \qquad (10)$$

Substitution of (10) into (9), after some simplifications, yields the following approximate expression for the total annual cost of the modified EPQ model with backorders and geometrically decreasing variable procurement cost

per unit as follows:

$$A_{Modified-EPQ}(S,Q)=\frac{D}{Q}K+\left(\frac{CD}{r}\right)\left[1-\left(\frac{1-r}{r}\right)\left(\frac{Q}{2}\right)\right]+C_h\frac{\left[Q\left(1-\frac{D}{P}\right)-S\right]^2}{2Q\left(1-\frac{D}{P}\right)}+C_b\frac{S^2}{2Q\left(1-\frac{D}{P}\right)} \quad (11)$$

To minimize $A_{Modified-EPQ}(S,Q)$ in (11), it is necessary to set

$$\frac{\partial A_{Modified-EPQ}(S,Q)}{\partial Q}=-\frac{DK}{Q^2}-\frac{CD}{2r}\left(\frac{1-r}{r}\right)+\frac{C_h}{2}\left(1-\frac{D}{P}\right)-\frac{1}{2\left(1-\frac{D}{P}\right)}\left(C_h+C_b\right)\left(\frac{S^2}{Q^2}\right)=0 \quad (12)$$

and

$$\frac{\partial A_{Modified-EPQ}(S,Q)}{\partial S}=-C_h+\left(\frac{C_h+C_b}{1-\frac{D}{P}}\right)\left(\frac{S}{Q}\right)=0 \quad (13)$$

Solving (12) and (13) simultaneously, yields the following expressions for the optimal values of lot size and backorder level, $Q^*_{Modified-EPQ}$ and $S^*_{Modified-EPQ}$, respectively:

$$Q^*_{Modified-EPQ}=\sqrt{2DK\left(\frac{1}{C_h}+\frac{1}{C_b}\right)\left[\frac{1}{\left(1-\frac{D}{P}\right)-\left(\frac{1-r}{r^2}\right)\beta}\right]}=Q^*_{Basic-EPQ}\sqrt{\frac{\left(1-\frac{D}{P}\right)}{\left(1-\frac{D}{P}\right)-\left(\frac{1-r}{r^2}\right)\beta}} \quad (14)$$

and

$$S^*_{Modified\_EPQ}=Q^*_{Modified-EPQ}\left(\frac{C_h}{C_h+C_b}\right)\left(1-\frac{D}{P}\right)=S^*_{Basic-EPQ}\sqrt{\frac{\left(1-\frac{D}{P}\right)}{\left(1-\frac{D}{P}\right)-\left(\frac{1-r}{r^2}\right)\beta}} \quad (15)$$

where β is given by

$$\beta = CD\left(\frac{1}{C_h} + \frac{1}{C_b}\right) \tag{16}$$

It should be noted that when $0 \le \left(\frac{1-r}{r^2}\right)\beta < 1 - \frac{D}{P}$, finite positive values will be obtained for $Q^*_{Modified-EPQ}$ and $S^*_{Modified-EPQ}$, and the minimum total annual cost will be

$$A^*_{Modified}(S,Q) = \frac{CD}{r} + \sqrt{\frac{2DK\left[\left(1-\frac{D}{P}\right) - \left(\frac{1-r}{r^2}\right)\beta\right]}{\frac{1}{C_h} + \frac{1}{C_b}}} \tag{17}$$

Please note that when the production rate, P, approaches infinity, equations (14), (15), and (17) become the same as those in Paknejad and Affisco (2023) for the adjusted EOQ model with shortages. Furthermore, if $r = 1$, then, $\frac{1-r}{r^2} = 0$, and $Q^*_{Modified-EPQ}$, $S^*_{Modified-EPQ}$, and $A^*_{Modified-EPQ}$ (13) reduce to the comparable results of the basic EPQ model with planned shortages given by equations (3), (4), and (5).

Finally, to prove that the stationary point $\left(Q^*_{Modified-EPQ}, S^*_{Modified-EPQ}\right)$ is a relative minimum point, it is sufficient to show that the first and second principal minors of the Hessian determinant of $A_{\mathrm{mod}ified-EPQ}(S,Q)$ in equation (11) are both strictly positive. The first principal minor is

$$\left|H_{11}\right| = \frac{\partial^2 A_{\mathrm{mod}ified-EPQ}}{\partial Q^2} = \frac{2DK}{Q^3} + \left(\frac{C_h + C_b}{1-\frac{D}{P}}\right)\left(\frac{S^2}{Q^3}\right) \tag{18}$$

Which is strictly positive at $\left(Q^*_{Modified-EPQ}, S^*_{Modified-EPQ}\right)$ since $P > D$, provided, of course, that $0 \le \left(\frac{1-r}{r^2}\right)\beta < 1 - \frac{D}{P}$.

The second principal minor is

$$|H_{22}| = \begin{vmatrix} \frac{\partial^2 A_{\mathrm{modified-EPQ}}}{\partial Q^2} & \frac{\partial^2 A_{\mathrm{modified-EPQ}}}{\partial Q \partial S} \\ \frac{\partial^2 A_{\mathrm{modified-EPQ}}}{\partial Q \partial S} & \frac{\partial^2 A_{\mathrm{modified-EPQ}}}{\partial S^2} \end{vmatrix} = \frac{2DK}{Q^4}\left(\frac{C_h + C_b}{1 - \frac{D}{P}}\right) \qquad (19)$$

Which is again strictly positive at the stationary point $\left(Q^*_{Modified-EPQ}, S^*_{Modified-EPQ}\right)$ given by equations (14) and (15).

Before conclusion, it is helpful to discuss how an admissible range of values for r can be deduced from the restriction $0 \le \left(\frac{1-r}{r^2}\right)\beta < 1 - \frac{D}{P}$ discussed before. Since $0 < r \le 1$, the left-hand side of inequality is always satisfied. Working with the right-hand side, r should satisfy the following inequality

$$\left(1 - \frac{D}{P}\right)r^2 + \beta r - \beta > 0 \qquad (20)$$

The quadratic equation on the left-hand side of inequality (20) has only one positive root as follows:

$$r_{\min} = \left(\frac{\beta}{2\left(1 - \frac{D}{P}\right)}\right)\left(\sqrt{1 + \left(\frac{4}{\beta}\right)\left(1 - \frac{D}{P}\right)} - 1\right) \qquad (21)$$

Hence, the admissible range of values for r in the proposed EPQ model of this paper should satisfy $0 < r_{\min} < r \le 1$, where $r_{\min}$ is given by equation (21).

CONCLUSION

This paper presents an extension of a recently modified version of EOQ model with backlogging and variable unit procurement cost to the case of an EPQ model with planned shortages in which units are produced internally at a finite production rate, P, while variable production cost per unit deceases in a geometric fashion by a constant factor, r, for each unit increase in the lot size. The admissible range of values for r is given for the proposed model. It is shown that the explicit expressions for the optimal values of policy variables for the enhanced EPQ model in this paper reduce to the corresponding results of the counterpart EOQ model when the production rate approaches infinity. Likewise, when r=1, the explicit findings in this study become the same as those for the case of the ordinary EPQ model with constant unit production cost which allows backlogging of out-of-stock units.

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Papers

Public Administration and Policy

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Health Equity Consequences of Prescription Drug Monitoring Programs

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Abstract

Initialized from over-prescribing prescription opioids in the 1990s, the opioid crisis has wrecked millions of lives for the past 30 years and has become deadlier during the pandemic. Tremendous efforts have been made to fight opioids, and these efforts were mainly to reduce societal harm by controlling its supply. From the history of the opioid crisis, we have developed the hypothesis that as the number of multiple provider episodes (a patient who visits more than five prescribers and dispensaries within six months) decreases, the number of opioid-related hospitalizations and overdose deaths decreases. To test the hypothesis, we have acquired datasets from relevant secondary panel databases of the New Jersey state during 2012-2017: Uniform Billing, Vital Statistics, and Prescription Drug Monitoring Program. From the zip code-level fixed-effect analysis, we have found the opposite result; as the number of multiple provider episodes decreases, the number of overdose deaths and hospitalizations increases. Moreover, this effect is moderated by the disparity level of the given zip code area, measured by its education level. The result suggests that controlling the prescription opioid supply displaces its demand toward riskier illicit drugs. Demand management and policy recommendations are provided to prevent further unintended consequences.

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Investigating the Impact of Digital Solutions on the Sustainability of Power Utilities

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ABSTRACT

The power utilities sector faces immense pressure to reduce emissions and adopt sustainable practices. This qualitative study explores how digital solutions are driving improved sustainability in power utilities. The case study employs an interpretivism philosophy using an inductive approach to develop theories grounded in the collected data. Semi-structured interviews with eleven industry experts provided insights into digitization's transformative sustainability impacts. The research offers useful theoretical and practical insights into the complex interplay between digitization, sustainability, and innovation in the power utilities industry. Findings reveal digitization enables enhanced operational efficiency, lower costs, and reduced environmental footprints. Smart meters and predictive maintenance cut waste and emissions. Integrating renewables necessitates digital twin simulations, advanced sensors, and analytics. Decentralized energy resources and storage solutions also support decarbonization. However, digitalization poses cybersecurity, cost, and adaptation risks.

Keywords: Sustainability; power utility; digitalization

1. INTRODUCTION

The Power Utilities sector has undergone a profound transformation due to digitization, impacting operations, customer behavior, competition, and technology integration. Recent advancements have compelled the traditionally slow-moving sector to embrace digitization for competitiveness (Accenture, 2020). This study explores digitization's impact on Power Utilities, analyzing changes in operations, customer behaviour, and technology integration (Accenture, 2020), along with assessing associated challenges and opportunities. Significantly, this research underscores the critical need for Power Utilities companies to comprehend.

The Power Utilities sector, historically perceived as slow in tech adoption, has been compelled by recent digital advancements to embrace digitization for competitiveness (Metcalf, 2020). This integration of digital technologies has notably influenced operations, customer behavior, competition, and technology integration, introducing both opportunities and challenges for industry players. The energy landscape has shifted with the ascent of renewables and smart technologies, fundamentally altering energy generation, distribution, and consumption (IEA, 2020). Digitization has also impacted customer behavior, heightened

energy awareness, fostered demand for smart meters, and enhanced competition among Power Utilities. This study aims to scrutinize digitization's impact on Power Utilities, examining its implications, particularly on sustainability. It offers insights into the sector's transformation, challenges, and opportunities in the digital age with a sustainability focus, which is crucial for maintaining competitiveness and contributing to the UN sustainability development goals (SDGs), particularly Goals 11 and 13. Goal 11 focuses on sustainable cities and communities, digital solutions contribute by enhancing energy efficiency, enabling smart grid management, and promoting sustainable urban development. Goal 13 addresses climate action, digital solutions in the power industry significantly contribute to mitigating climate change.

The current research is based on the key questions below:

- What impact do digital solutions have on the sustainability of Power Utilities in the UAE?
- What are the key disruptive factors currently affecting the Power Utilities in the UAE?

2. Literature Review.

Power utilities systems' resilience, sustainability, and efficiency have all been impacted by digital transformation. Sustainability has gained prominence as organizations seek environmentally and socially responsible practices. The United Nations defines sustainability as meeting present needs without compromising future generations' ability to meet their own (United Nations, 2023). According to Munoz-Garcia (2016), sustainable utilities involve environmentally friendly energy generation, transmission, and distribution that support economic growth while minimizing negative environmental and social impacts.

2.1 Disruptive Factors to the Power Utilities Industry

The Power Utilities industry faces several disruptive factors forcing it to re-think its traditional business model. Industry has traditionally relied on large, centralized power plants to generate electricity and a grid system to distribute it to customers. However, this model is being challenged by various factors, including the rise of renewable energy, advances in digital technology, changing customer preferences, and new regulatory frameworks.

As per a report by Deloitte published in the year 2021, five key disruptive factors impact the Power Utilities sector, i.e., (1) Ageing Assets, (2) Natural disasters, (3) rising physical and cyber threats, (4) shifting of demand due to working-from-home trends, and the (5) increasing regulatory scrutiny and mandates. The digital transformation enhances the sector's resilience through improved response capabilities during disruptions. Technologies like smart grid management, renewable energy integration, and advanced monitoring contribute to sustainable urban development (Goal 11) by promoting energy efficiency and resilient infrastructure (EY, 2020; Alpagut, 2022). Simultaneously, the rapid identification and response to disruptions align with Goal 13, addressing Climate Action, as digital advancements support reducing environmental impact and carbon emissions in the power utilities sector.

2.2 Innovative Digital Solutions for the Power Utilities Sector

The power utilities sector has changed significantly lately, with an increasing emphasis on sustainability and lowering carbon emissions. The industry's ability to accomplish these objectives has been greatly aided by digital transformation. Rahman et al (2022) proposed in their study that sustainable power utilities balance environmental and social responsibility with customer needs. They use clean, renewable sources like wind, solar, and hydropower for electricity generation, whilst reducing greenhouse gas emissions. On the consumer side, they enhance efficiency and reliability through smart grid technologies, reduce energy waste, and promote conservation and efficiency among customers (Munoz-Garcia, 2016).

According to a report by the International Energy Agency (IEA), digitalization can reduce energy consumption by up to 10% and greenhouse gas emissions by up to 20% by 2030 (IEA, 2017). The report also emphasizes the need for Power Utilities to adopt digital solutions for greater efficiency, flexibility, and integration of renewable energy sources into the grid. However, challenges still need to be addressed, such as cybersecurity risks, regulatory barriers, and the need for a skilled workforce (Yang et al., 2020).

A report by Deloitte 2021 has introduced the 3D framework, which presents Decarbonization, Decentralization, and Digitization as drivers of the utility journey and current industry trends while transforming the energy sector globally. Decarbonization is reducing carbon emissions and moving towards renewable energy sources to mitigate the impact of climate change. Decentralization is the shift from a centralized power generation model to a distributed one, with the deployment of renewable energy sources closer to the point of consumption. Digitization involves the integration of digital technologies to optimize and automate processes, improve efficiency, and enable greater visibility and control of energy systems. These trends are interdependent, as integrating renewable energy sources requires digital technologies, and decentralization helps a more flexible and resilient grid to support decarbonization efforts (Deloitte,2022).

The Power Utilities sector has adopted various innovative digital solutions to enhance efficiency, reduce carbon emissions, and optimize operations. Digitalization is a major disruptive factor that has changed how Power Utilities operate, making them more sustainable and customer focused. Another digital solution is energy storage, which integrates intermittent renewable energy sources such as solar and wind. Energy storage systems allow Power Utilities to store excess energy generated during periods of high output and release it when demand is high. This enhances grid stability and helps reduce peak demand, lowering customer electricity costs.

One of the transformative developments of the power utilities sector is the digitalization of the grid through smart grids. The development of a smart grid involves a comprehensive suite of cutting-edge technologies that bring about a transformative shift in traditional power infrastructure. Artificial Intelligence (AI)-powered analytics, driven by machine learning algorithms, assumes a central role in this transformation, analyzing extensive datasets, forecasting demand patterns, and optimizing grid operations (Zameer et al., 2022). Complementing AI, big data technologies manage the vast volume, velocity, and variety of data generated by smart grids, facilitating real-time decision-making and bolstering overall system efficiency (Zameer et al., 2022). The Internet of Things (IoT) emerges as a critical component, establishing a network of interconnected devices and sensors that collect and transmit data, serving monitoring and control functions within the smart grid framework. Advanced communication technologies, such as 5G, further enhance connectivity, ensuring efficient data exchange among grid components (Habibi et al., 2019). Together, these technologies empower smart grids to boost reliability, optimize energy distribution, and advance sustainability within the power sector. Moreover, smart grids facilitate the seamless integration of renewable energy sources and energy storage systems into the grid, resulting in cost reductions and enabling innovative business models that empower customers. This holistic approach to grid management aligns with the overarching goal of promoting sustainability in the power industry. For example, Dewa has developed its first Smart Grid strategy up to 2035, which is a key component of a smart city, ensuring two-way communication between the utility and its consumer and allowing for monitoring along the power and water grids (Dewa.Gov.ae, 2022).

Digital twins, a rising technology in power utilities, involve virtual replicas of physical assets for real-time data collection and simulations . Real-time data obtained through technologies like the Internet of Things (IoT) plays a crucial role in continuously updating the digital representation, ensuring it reflects the current state of the physical object (HU,W. et al, 2022). Artificial intelligence (AI) contributes by analyzing this data, providing valuable insights, facilitating predictive maintenance, and enhancing overall system efficiency (Li et al., 2023). Extended Reality (XR) technologies, encompassing augmented and virtual

reality, enable immersive experiences and simulations, aiding in better visualization and understanding of complex grid structures (Pan,Z et al., 2021). Together, these technologies empower Digital Twins in the smart grid to optimize operations, enhance decision-making, and improve overall grid performance .
They aid in cost reduction, efficiency improvement, and safety enhancement. Additionally, digital twins enhance asset management, predict equipment failures, and optimize maintenance schedules. By integrating data sources and machine learning, they provide insights into asset performance, energy usage, and customer behaviour. Despite challenges, digital twins offer promising solutions to the evolving complexities in the power utilities sector.

Electric vehicle (EV) charging infrastructure is another innovative digital solution gaining traction in the Power Utilities sector. As more consumers adopt EVs, Power Utilities invest in charging infrastructure to meet the growing demand. EV charging infrastructure requires significant charging stations, networks, and software investments. For example, DEWA has managed to triple the EV chargers across Dubai since 2015 to 350 chargers due to the growth of the number of Electric vehicles to 13,500 as of the end of 2022 and has a target to reach 1000 by year 2025 (SDG Action, 2022).

Advanced smart metering using machine learning and data analytics is another digital solution transforming the Power Utilities sector. Smart meters use machine learning and enable Power Utilities to monitor and analyze energy consumption in real-time, reducing the need for manual meter readings. Power utilities increasingly adopt Artificial Intelligence (AI) to improve efficiency and reliability. AI can be used in various areas of the power industry, including power generation, transmission, distribution, and customer service.

2. The Power Utilities Business in UAE Market

The Power Utilities sector in the United Arab Emirates (UAE) is characterized by a modern and advanced infrastructure and a commitment to sustainability and renewable energy (Al Jenaibi & Al Marzooqi, 2018). The country has significantly invested in developing its energy and water systems and has implemented innovative technologies, such as smart meters and desalination plants (Abdelhamid et al., 2016). The government has set ambitious targets for reducing carbon emissions by setting a target of power generation from clean energies to 50 % (44 % from renewables and 6 % from Nuclear) of its total generation by the year 2050 (Al Naqabi, 2019) which is in line with the UN SDG no 11 and 13 to reach achieve Climate change goals and create sustainable smart cities. The major players in the sector include the Abu Dhabi Water and Electricity Authority (ADWEA), Dubai Electricity and Water Authority (DEWA), Etihad WE, and Sharjah Electricity and Water Authority (SEWA), supported by various government agencies and private firms (Abdelhamid et al., 2016). The sector is highly regulated, ensuring is in line with the country’s overall goals and targets and can meet the population and economy's growing demands (Abdelhamid et al., 2016).

The UAE Government sets a role model here; its Energy Strategy of 2050 (Figure 1), a key initiative for sustainable development, aims to triple renewable energy contributions, investing AED 150-200 billion by 2030. Aligned with COP 28 and net-zero commitments, the strategy focuses on balancing supply and demand, adhering to environmental obligations, and fostering economic growth. The updated strategy targets net-zero emissions by 2050, emphasizing renewable and nuclear energies, energy efficiency, R&D, and innovation. Additionally, the National Hydrogen Strategy 2050 positions the UAE as a low-emission hydrogen producer, aligning with global sustainability efforts. It envisions hydrogen production of 1.4 million tons per annum by 2031, fostering local and global collaboration, and supporting the transition to a hydrogen economy (Moei.gov.ae,2023).

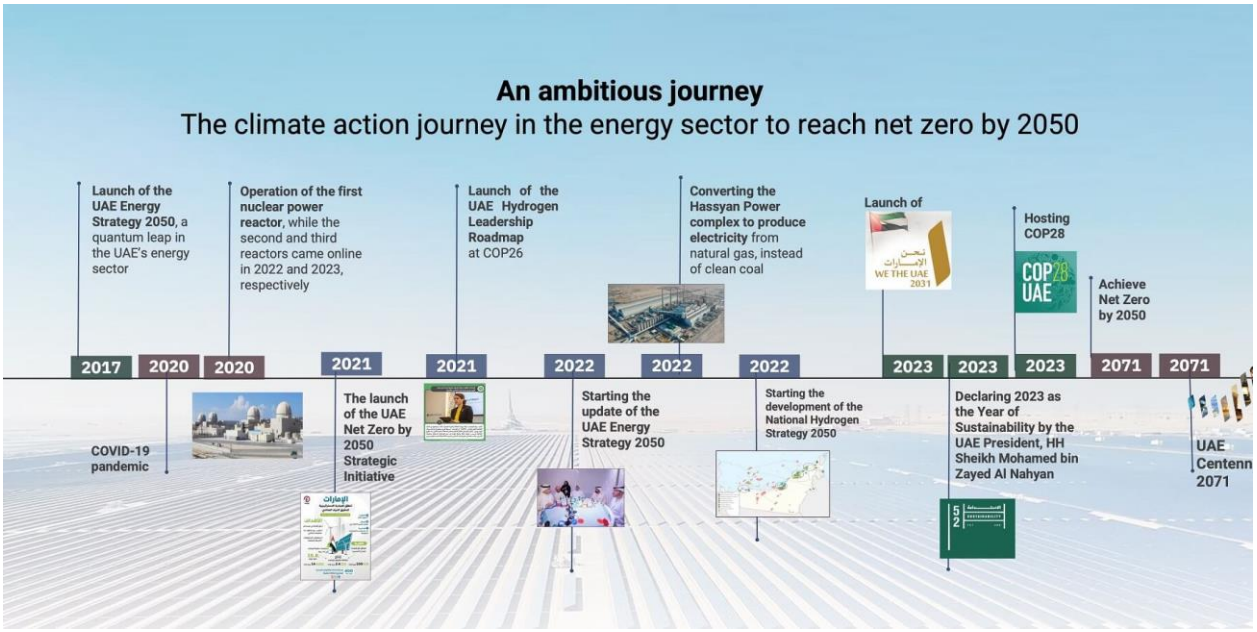

Figure 1: UAE Climate action journey till 2050 (Moei.gov.ae,2023).

3. Research Methodology

3.1 Semi-Structured Interview

This qualitative research study employed semi-structured interviews to delve into the experiences, attitudes, and perceptions of key stakeholders within the Power Utilities industry concerning the adoption of digital solutions for sustainability enhancement. Qualitative research was chosen due to its suitability for exploring intricate and abstract concepts like sustainability and digital solutions, with a focus on understanding individuals' or groups' meanings assigned to these concepts (Creswell and Poth, 2017).
Semi-structured interviews provided flexibility for in-depth exploration of diverse topics and ideas, offering room for follow-up questions and deeper discussions (Babbie, 2017). The participant selection process followed a snowball sampling method, where initial participants referred others knowledgeable about digital solutions in Power Utilities, resulting in a sample size of eleven individuals.

Participants included subject matter experts and business leaders from the UAE Power Utilities and technology providers. The sample size for this study was thirty, out of which nineteen candidates agreed to participate. The researcher has only managed eleven interviews, two of which were conducted with employees of Utilities and nine interviews with employees of major players in technological companies.

The interview questions encompassed various aspects such as the impact of digitization on the sector, integration of renewables, current trends, technology integration, opportunities, challenges, and the role of governments in promoting sustainability within Power Utilities.

The interview structure initiated with participants' backgrounds and experiences in the Power Utilities sector, providing contextual insights. Subsequent sections delved into the effects of digitization, disruptive factors, renewables integration, market trends, and technology. The final section explored opportunities and challenges in adapting to digitization, customer behaviour, and governmental roles in promoting sustainability.
Secondary data will be gathered from academic literature, industry reports, and government publications to examine the impact of digitization on Power Utilities. Academic literature will be reviewed for insights,

industry reports for current sector data, and government publications for policy insights. This approach ensures efficiency and diverse data sources for a comprehensive analysis.

3.5 Thematic Analysis

Data analysis in this study used thematic analysis, a qualitative research method, involving transcription, coding, theme generation, and refinement. Thematic analysis helped identify key concepts and themes within the collected interview data. These themes were rigorously developed, cross-checked, and presented in the findings chapter, providing a comprehensive exploration of factors driving digital solutions adoption in Power Utilities.

4. Research Findings

The findings of this study revealed that the introduction of digital solutions had a significant and positive impact on the sustainability of power utilities. All participants agreed that digitization has allowed Power Utilities to manage their operations more effectively by providing real-time data on all their operations. The availability of such data enables Power Utilities to intervene on time and address issues before they become major problems.

According to Participant one and ten, digitization enables companies, governments, and consumers to monitor their energy consumption in real-time. This data allows Power Utilities to intervene at the right time and monitor performance to reach their preferred efficiency level. AMS reduces the carbon footprint associated with sending personnel to collect readings.

Participant one emphasized that adopting predictive maintenance has allowed Power Utilities to identify potential equipment failures before they occur, reducing the need for costly and environmentally damaging emergency repairs. This is in line with a study by The European Commission, which estimates that deploying advanced digital technologies in the energy sector can lead to a 30% reduction in greenhouse gas emissions by 2030 (European Commission, 2020).

According to Participant 4, digitization has created a "language" between legacy infrastructure and new solutions, enabling a smoother transition to more advanced digital systems. Participant nine identified that technology had impacted not only the generation side of electricity and power but also the consumption side.

These findings align with existing research in the field, which underscores the considerable sustainability benefits of digital solutions within the power sector. Notably, a report by the International Energy Agency (IEA) predicts a potential reduction of 2.5 gigatons in global carbon dioxide emissions by 2025 through the adoption of digital technologies in the power sector (IEA, 2017). Similarly, the World Economic Forum (WEF, 2023) anticipates that integrating digital technologies into the power sector could boost renewable energy generation to 30% of the total energy production by 2025, thereby curbing carbon emissions (WEF, 2023).

4.2. Key Disruptive Factors

The Participants gave different viewpoints on which disrupting factors are currently affecting the Power Utilities industry; however, common answers were provided during most of the interviews: the role of Artificial Intelligence (AI) and cyber security and the role of Electric Vehicles (EV).

New technology is pushing Power Utilities to adapt and change their business model, or in the words of Participant 8, “*the increasing dependence on technologies in the industry is creating cybersecurity risks,*

which must be addressed to protect critical energy infrastructure." As per Participant 1, "*AI, IoT, and Big Data analytics need to be combined in a practical and controlled manner."*

Electric Vehicles (EVs) were highlighted by participants as a significant disruptor in the power industry. Participant 2 emphasized the growing impact of EVs on energy demand and the energy mix as more energy is used for charging. Participant 3 described EVs as both a *risk and an opportunity*, anticipating their potential to act as virtual power plants or grid-supporting batteries in the next five to ten years, although their current impact is limited due to their relatively small numbers. Participant 5 questioned the readiness of the network to handle the increased demand from EVs, pointing out that technology development may not be keeping pace. These insights align with a report by Deloitte (2021) that emphasized the transformative role of EVs in the power and utilities industry.
Participant eight flagged that *"the growth of emerging energy providers in the UAE, such as community energy projects, is disrupting the traditional energy market and increasing competition for power utilities."*

Participant one rightly summarized the above by stating, "*Disruptive factors are forcing Power Utilities to adapt and change how they operate and are leading to the development of new business models that are more sustainable and efficient. As technology evolves, new disruptive factors will likely emerge that will further impact the power industry and drive change*."

According to the participants' viewpoints and in line with the literature discussed and reviewed under section two, various factors disrupt the Power Utilities. Participants emphasized the need to address cyber security risks and to adapt to the growth of EVs in the industry.

4.2. Impact of Digitization on the integration of renewable sources

Participants in the study emphasized the pivotal role of digitization in integrating renewables into the energy mix. They noted that without digitization, such integration would not have been feasible. Digital twin technology, according to Participant 8, has made renewable energy viable and emphasized its growing feasibility. Participants acknowledged that renewable energy's intermittent nature requires precise monitoring and data sharing between generation and consumption sides to predict energy generation accurately, aligning with Deloitte's findings.

Microgrids and decentralization, facilitated by digitization, were also highlighted. Participant 3 stated that digitization enables decarbonization and decentralization and that it's essential for managing systems with significant renewables. Energy storage systems, including batteries, compressed air, and flywheels, were cited by Participant 6 as crucial for storing excess renewable energy, improving integration, and enhancing sustainability. Storage systems, as Participant 3 added, respond rapidly to changing conditions, maintaining grid reliability.

The study's finding aligns with previous research indicating that digitization has played a crucial role in enabling the integration of renewable energy sources into the power grid. Energy storage systems have enabled microgrids, reducing energy waste and improving the reliability and security of the grid. Digitization made integrating renewable energy more economically viable and allowed monitoring of remote grids.

5. Conclusion

In conclusion, digitization has fundamentally transformed the Power Utilities sector, offering benefits like increased efficiency, reliability, and sustainability. Yet, it also presents challenges such as cybersecurity risks, workforce adaptation, grid modernization, and changing consumer behaviour. Recommendations include bolstering cybersecurity, upskilling the workforce, modernizing grids, and engaging customers in

sustainable practices. Governments play a crucial role by setting ambitious sustainability goals and providing regulatory support.

The study relied on subjective responses from semi-structured interviews, introducing the possibility of researcher and participant biases. The study's focus on the UAE Power Utilities sector may limit the generalizability of findings to other industries or countries. Additionally, the limited number of interviews with Utilities personnel suggests the potential for broader external validity through comparative analysis and a larger Utilities sample in future research. The study primarily examined digitization's impact on sustainability and current industry trends, neglecting other factors like geopolitical and economic policies that may influence the sector. Future research should consider these factors for a more comprehensive understanding of the industry.

Power Utilities should embrace digitization to improve operational efficiency, cost savings, and reduce carbon emissions. Technologies like Digital Twin, AI, IoT, and blockchain can optimize grid management, reduce energy waste, and empower consumers with tools like smart meters for informed energy decisions.

References

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Papers

Strategy, Knowledge Management and Organizational Behavior

Leader – Managers in the Robotic Era

By

Dr. Michael Faulkner

May 2021

Introduction

Throughout the history of human civilization there have been individuals who have stood out from the masses by virtue of some exceptional or extraordinary physical, mental, or spiritual capabilities that led to people, willingly or unwillingly, to accept their authority or give allegiance to them.

Political scientist Francis Fukuyama believes the first combat between primitive men was not over food or possessions but the desire of one to dominate the other using power. Fukuyama citing Hegel, wrote, “the desire to be recognized as a human being with dignity drove man at the beginning of history into a bloody battle to the death for prestige. The outcome of this battle was a division of human society into a class of masters, who were willing to risk their lives, and a class of slaves, who gave in to their natural fear of death. But the relationship of lordship and bondage, which took a wide variety of forms in all the unequal, aristocratic societies that have characterized the greater part of human history, failed ultimately to satisfy the desire for recognition of either the masters or the slaves. The slave, of course, was not acknowledged as a human being in any way whatsoever. But the recognition enjoyed by the master was deficient as well, because he was not recognized by other masters, but slaves whose humanity was as yet incomplete. Dissatisfaction with the flawed recognition available in aristocratic societies constituted a “contradiction” that engendered further stages of history”. Fukuyama (1992)

The questions of what leadership is and who are leaders have been studied and posited by philosophers, sociologists, politicians, researchers, business executives, universities, think tanks, the military, and many others. The common thread seems to deal with the reciprocities of groups, tribes, cultures, and nations and the individuals who stand out due to their influence or power over the masses.

Leadership as a universal function of association. “The assumptions with which we start are, first, that leadership is a function common to all the different stages of the social process, from its simplest and most primitive to its most complex and highly developed manifestations; second, that it is a function in the expression of all kinds of social interests, whether the interactions be inter-individual, inter-groupal, or infra-groupal. Leadership is one of the most primary as well as one of the most general forms of association. It arises wherever there are interactions reciprocities of individuals or of groups, no matter what the purposes may be or aims of these interaction” Mumford (1906).

Philosophers such as Hagel, Locke, and others have written and posited ideas however, it has only been since the nineteenth century that research began to examine leadership and leaders beyond the original concepts. In the earlier times, individuals who displayed uncommon courage, bravery, strength, fortitude, intelligence, and wisdom were our role models for leadership.

Generals such as Sun Tuz, Alexander the Great, Caesar, Napoleon, Elizabeth I were the individuals whose exploits exemplified the heroic behavior of leaders and were the focus of initial study of leadership and identification of the Hero Leader.

As the appendix #1 shows, the concept of leadership and leaders is highly subjective. My literature review of 21 sources discovered 395 different words or phrases that authors have used to define leadership.

The idea of conceptualizing and defining leadership began with an examination of specific individuals who were considered heroic. This has evolved to where there are today over two hundred different academic ideas and theories on leadership and how to define this concept (McCleskey, 2014).

The study of leadership is part of a systematic theory of the human social process. The social process is the reciprocal activities of living organisms. These include relationships of the group influence upon the individual and of the individual upon the group in the interactions of individuals. The unifying factor in all the complex diversities of social phenomena is to be found in the social activity itself. In other words, what is done and who does it. The social process, then, is to be considered as the central fact. (Mumford 2014)

The question of what leadership is and who are leaders will be a topic that will continue to evolve and be influenced by the social interrelationships of both the human and robotic civilization era or epoch. In the specific case of Leader - Management in the Robotic Era, I am suggesting an evolution of a new interrelationship. I am referring to the developing relationship between human workers and robots with AI and the inevitable relationship between Leader - Managers of robotic teams, whether the teams are all robotic or comprised of humans and robots.

William James[1], writes, “Emulation is the very nerve of human society”.

From historic times when brave, bigger than life, heroes were our conspicuous models to today’s high-tech executives we typically mimetic, our society tends to emulate models presented to us in life and art.

Because there is still some uncertainty whether AI will be capable of mimicking human behavior and reasoned thought, the relationship between AI robots themselves and the relationship between Robotic AI and human managers and leaders is not undertaken here.

A Brief History Technology from the Last Ice Age to The Robotic Era

Anthropologist Ian Morris, Author of *Why the West Rules – For Now: The Patterns of History and What They Reveal About the Future*, starts tracking human societal and technological progress from 14,000 BCE when the world began to warm after the last Ice Age. Despite the invention of the wheel, creating fire, hunting & fishing, the domestication of animals (the dog and oxen first followed the horse 8,000 years latter), the invention of weapons, the development of agriculture, the creation of the great religions, the invention of writing, and the printing press the progress of society and technology was painfully slow and sporadic. Then, in the 18th century the Industrial revolution was ushered in by the era’s principle technology, the James Watts improved steam engine. This technology and the nearly simultaneous innovations of mechanical, chemical, metallurgical developments gave us the ability to overcome limitations of human and animal muscle – power. For the first time the technological curve moved from a primarily flat line to one beginning to rise vertically. In Morris’s words, “It was the most profound transformation the world has ever seen because it was the first time our progress was driven primarily by technological innovation” (Morris 2010).

Now, we are in the second machine age, the Robotic Era. Computers, AI, and other digital devices are supplementing our mental powers. What the steam engine and the and the ancillary technologies did for

[1] Talks to Teachers on Psychology, Chapter 7

muscle - power, the digital technologies are doing for our mental - powers. This will make the Robotic Era's exponential curve and the resulting technological innovations, as significant, if not more so than the technologies of the industrial Revolution.

The Developments of Leadership and Management Theory and Practice During the Industrial Revolution

While the theory of heroic leaders had been in place for thousands of years before the Industrial Revolution, it had mostly been a way of explaining who became leaders and why, and when. Leadership was not associated with the development of technologies or their application and benefit for people.

Prior to the industrial revolution, management was limited to the owner who handling tasks such as coordination, planning, controlling, rewarding, resource allocation and sales. The exceptions were the church, the military, and a few large trading, construction, and agricultural endeavors, and many of these unfortunately used slave or prison labor. The future of what was to come showed up in the work of thinkers such as Adam Smith, with his insight that the division of labor would increase productivity (McGrath 2014)

The term "management" was a term and practice to emerge from the lead-up and development of the Industrial Revolution.

The Renaissance and its ideals came to England, a backwater power at the time, during the reign of the Tudors (1485–1603) (Bridgen 2001). It was during this time that the word *management* came into the English language from Italy through translations by John Florio, an Anglo-Italian member of Queen Elizabeth's court (Muldoon and Martin 2013).

With the rise of the industrial revolution, that changed. Along with the new means of production, organizations gained economies of scale. the modern corporation, in which work, usually in a factory setting, was specialized Owners needed to depend on others to coordinate, oversee, and direct the work. The focus was wholly on *execution* of mass production, and managerial solutions such as specialization of labor, standardized processes, quality control, workflow planning, and rudimentary accounting came into existence. By the early 1900's, the term "management" was in wide use, and Adam Smith's ideas came into their own. Smith proposed the idea of specialization and coordination within corporations as a source of economic growth. Specialization and division of labor were Smith's major contributions to management thought.

Others – such as Frederick Winslow Taylor, Frank and Lillian Galbreth, Herbert R. Townes, and Henry L. Gantt – developed theories that emphasized efficiency, lack of variation, consistency of production, and predictability. The goal was to optimize the outputs that could be generated from a specific set of inputs (McGrath 2014).

As Adam Smith would write in his 1776 book, *An Inquiry into the Nature and Causes of the Wealth of Nations*, Expansion of global trade will lead to the creation of the marketplace as the most effective and efficient means of organizing and exchanging of goods for the benefit of worker and owners.

The division of labor meant that a worker specialized in performing one task that was part of a larger series of tasks, at the end of which a product would be produced. The idea of specialization of labor had several important outcomes. Firstly, specialization drastically reduced the cost of goods. Secondly, it drastically reduced the need for training. Instead of learning every aspect of a task, workers needed to learn one portion of it. Thirdly, the need to coordinate all these different tasks required a greater emphasis on management.

The Industrial Revolution shifted from England across the globe and eventually found its way into the United States. The United States started seeing several notable industrial revolutions from the 1820s until the 1860s. The transportation revolution included the construction of canals and, later, railroads that connected the different parts of the continent. The emergence of a telegraph system allowed for faster communication between various parts of the United States. Previously, it would take weeks to get information from New York to Boston; with the telegraph, it took minutes (Howe 2008).

As the Industrial Revolution progressed, small factories transformed into larger ones. In 1849, Harvester in Chicago employed 123 workers and was the largest factory in the United States. McCormick plant by the mid-1850s had 250 workers who made 2,500 reapers per year. After the Great Chicago Fire, McCormick built a new plant with 800 workers and sales well above $1 million. In 1913, Henry Ford's plant in Dearborn employed up to 12,000 workers (Lacey 1986).

After the period of the American Civil War, which ended in 1865, society witnessed the emergence of gigantic corporations that spanned the continent and factories that were like small cities (Bendickson, Ligouri and Davis 2016).

Yet, in the factory, it was possible for workers to avoid work or even destroy machines if they disliked management's ideas such as the Luddites who threw their wooden shoes into the machinery in protest of their working conditions. Each worker did the job in a different fashion, workers seemed to be selected without regard to whether they were suited for a specific job, management seemed to be whimsical, and there was little standardization of equipment.

Because production quantity remained an unknown to both management and the worker, management did not explain how they determined what should be produced. Workers believed that management determined what should be produced in haphazard ways (Wren, & Bedeian, 2009).

Workers believed that if too much were produced, management would eliminate workers because they believed that there was a finite amount of work in the world. Workers would control production by punishing those workers who produced too much. For example, if a worker produced too much, his equipment would be damaged, or he would be brutalized by his coworkers. Methods of production were similarly haphazard. For example, if you learned how to shovel coal or cut iron, you learned multiple ways to perform the job, which did little for efficiency. Due to managerial inefficiency, various reformers in engineering urged for the establishment of management as a distinct field of study so that some order and logic could be brought to bear on how work was performed. Although this period witnessed enormous changes in technology, management was still lagging (ibid).

In retrospect, it was clear that management (not leadership) struggled with several worker issues, i.e., satisfaction, productivity, lack of training and unclear skill requirements, pay, and worker safety. Over time, the owners and managers began to acquire more information and knowledge about what did and did not work in various situations. The repository of this knowledge had been exclusively the European universities that saw business management as a discipline. In America the first university to educate and train business managers was the Wharton School founded in 1881.

By the 20th century, the next change was the shift in the management discipline emphasizing *expertise*. The mid-twentieth century was a period of remarkable growth in theories of management, and in the guru-industrial complex. Writers such as Elton Mayo, Mary Parker Follett, Chester Barnard, Max Weber, and Chris Argyris imported theories from other fields (sociology and psychology) to apply to management. Statistical and mathematical insights were imported (often from military uses) forming the basis of the field that would subsequently be known as operations management. Later, attempts to bring science into management, included the development of the theory of constraints, management by objectives, reengineering, Six Sigma, the "waterfall" method of software development, and the like. Peter Drucker, one of the first management specialists to achieve guru status, was representative of this era. His book *Concept of the Corporation*, published in 1946, was a direct response to Alfred P. Sloan's challenge as chairman of General Motors: attempting to get a handle on what managing a far-flung, complex organization was all about (McGrath 2014).

Peter Drucker was among the first to express ideas about "knowledge work." He saw that value created wasn't created simply by having workers produce goods or execute tasks; value was also created by workers' use of information.

As knowledge work grew as a proportion of the US economy, the new reality of managing knowledge and knowledge workers challenged all that organizations knew about the proper relationship between manager and subordinate.

When of all the value in an organization walks out the door each evening, a different managerial contract than the command-and-control mindset prevalent in execution type work is required. Thus, new theories of management arose that put far more emphasis on motivation and engagement of workers. Douglas McGregor's "Theory Y" is representative of the genre. The idea of what executives do changed from a concept of control and authority to a more participative coaching role. As organizational theorists began to explore these ideas (most recently with efforts to understand the "emotional intelligence" factor in management, led by writers such as Daniel Goleman), the emphasis of management was shifting once more" (Ibid)

Today, we are amid another fundamental rethinking of what organizations are and for what purpose they exist. This also changes the roles and values of managers. Businesses are rethinking their role as not only as providers of goods and services but also participants in the social, political and cultural fabric of the society. There is growing sense that we are ready for a new era of business thinking and practice that will require a completely new role which I am calling the Leader-Manager.

As Chart #1 shows, technological innovations such as The Internet of Things (IoT), robotic process automation (RPA), 3D printing, blockchain, augmented reality and virtual reality all promise to do things faster and cheaper. Businesses have little option but to adopt these technologies as quickly as possible as

it has become the essential parts of every business nowadays. Businesses invest in IT to help streamline the flow of information, speed-up decision-making, sustain competitiveness and improve organizational performance

We are in the Robotic Era. This time in our human history could easily be referred to as the second machine age, Internet Era, the Technological Era, the artificial intelligence (AI) Era, or even the Quantum Era. The naming of eras and epochs is better left to philosophers. For the purpose of this article, The Robotic Era, is simply a convenient use of one symbol that can represent this era defined by the point in time in which we have passed the elbow of the exponential growth trend line of accelerating growth in technology.

My purpose in selecting the Robotic Era was to merely find a suitable name for this point in our society that is easily recognizable and representative of the era.

The following chart (Chart #1.) depicts this accelerating trend of technology and demonstrates how quickly technological components are changing our lives, including but not limited to, how and where we communicate, the work we do, how we work, how we learn, how we manage the workforce, and most importantly who and how he or she leads

Exponential Growth in Technology

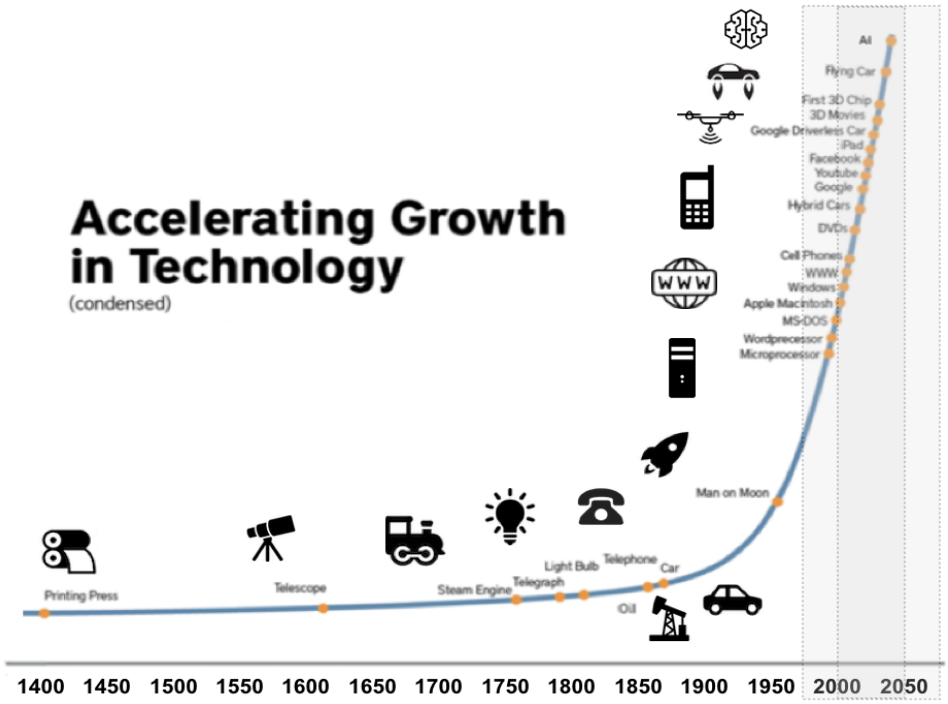

Chart #1

Chart #1 provides a visual depicting the era or epochs humanity has gone through since the enlightenment represented by the invention of movable type printing press. This was an era which followed the dark ages. In the different stages of society, i.e., agricultural, mechanical, industrial, Internet, etc. The social sciences have examined the various stages and epochs of human societal development.

The science has dealt with the stages of human development by examining the phenomena that are expressed through such modal social functions as co-operation, conflict, competition, imitation, invention, obedience, leadership, etc. (Mumford 1906).

The way in which leaders of the past were identified and their leadership characteristics described were based upon human to human interaction. However, the leaders of the Robotic Era will be identified more by their thinking skills and traits and less by their physical actions and deeds.

As the exponential growth in technology accelerates leaders and managers of the Robotic Era will have to continually engage in change management. Constant disruption and innovation will be the order of the day.

The Robotic Era will call upon leaders and managers to act and lead in ways never before required. It would be easy to say that leaders have always been the visionaries that led us form one era to the other. But It isn't that easy. When the recordable technological exponential timeline began around 2400 BC to the invention of the steam engine in the 17th century, it was basically a flat linear progression. There were technological innovations, but they tended to be few and far between. Therefore, the necessary skills and traits of leaders were limited to explaining and making existing technology more available and more useful to the population.

As we know, business, government and societal changes occur with a much slower adaption of technology. Therefore, these have a far longer curve which has yet to reach an exponential shift and Moore's Law isn't even part of the calculation.

This article is not an argument of whether the exponential growth of anything, including technology, is inevitable and will continue stretching Moore's Law[2] unabated forever. That is a debate of the Singularity Movement and not part of the discussion of the role of the Leader-Manager in the Robotic Era.

The act of defining leadership and the qualities that demonstrate leadership have changed and evolved over centuries since the beginning of human civilization. "Researchers have explored leadership traits using various methodologies since the concept of the leader and leadership has arisen in the lexicon. However, a consistent methodology or even consensus of the nature of effective leadership has been the subject of great debate"(Hunt, and Fedynich, 2018).

My purpose is not to discuss or define what makes great leaders or poor leaders – that is the role of history – but to try to examine what the Robotic Era workplace will be like and to identify the traits, characteristics, skills, behavior, and abilities of men and women who will be the Leader - Managers in the Robotic Era. This of course, will create some antagonism of those who continue to think that leaders and managers are separate roles and combining the two into one role is, at best, unorthodox but more like heresy.

If we have learned anything from the disruptive exponential growth of technology, the status quo is deadly.

[2] Moore's Law: the principle that the speed and capability of computers can be expected to double every two years, as a result of increases in the number of transistors a microchip can contain. Even if Moore's Law fails in the future, new methods of computing may again set the industry on breakneck development speeds

Understanding the role of Leader-Managers in the Robotic Era will demand a reexamination of the historical definitions of leadership and manager. The early ideas of leadership were born of an age of expansion and industrial revolution that identified a leader as that one, great individual who had unique skills and abilities. Through this tour of history, the theories surrounding leaders and leadership have evolved and changed with each era.

Intellectual theories and models such as, Trait theory and behavioral models, have given way to ideals such as authentic leadership and environmental influenced leadership. More modern theories invert the traditional paradigm of vertical leadership to a flattened form of dynamic leadership where leaders are interchangeable dependent upon the task.

While the intricacies of each theory cannot be completely and exhaustively examined in this text, a review of the evolution of leadership principals is important in providing a framework to a better understanding of what skills, behaviors, traits, and knowledge will be needed in Leader-Managers in the Robotic Era.

There is an ongoing discussion regarding Leadership and Management. There is a frequently asked question, that too often is considered merely rhetorical, which it is not. It is a practical question and asks, what the difference is between leadership and management. Another question that is often posed in the same vein and it asks, is a good manager automatically a good leader, and vice versa?

I mention this debate, not to settle the question, but to make the point that this paper is about a concept of the Leader - Manager. In this context, leadership is believed to be the creation and actions of a shared vision which individuals will follow. On the other hand, management is about people who work for them and who may or may not share their vision. The question can be left to the circumstance of whether leaders can also be managers and managers can also be leaders.

I realize this is an intentional oversimplification of terms and readers are free to substitute managers for leaders. In business, an entrepreneur or founder is often both a leader and performs some management functions to ensure the vision gets carried out.

Marcus Buckingham and Curt Coffman co-authored the bestselling book, *First Break all the Rules, What the World's Greatest Managers Do Differently.* The book was based upon the Gallup Organizations groundbreaking study in which Gallup interviewed more than 1 million employees and 80,000 managers at all levels and in companies of all sizes.

The survey asked hundreds of questions about countless aspects of the workplace. What the study revealed is there were no demographic characteristics of great managers but there were traits and characteristics of great managers. The bottom line of the survey results is nothing works in an organization without *great managers. This not to say leaders are not important only that managers get the work done that makes the vision work.*

There have been thousands of articles and books written about what makes a leader and a manager. However, as I began to think about the changes in our society brought about by the Robotic Era, It became clear that both leadership and management have changed in past eras because society was changing. Therefore, as we have entered the robotic era, leadership and management need to evolve again.

Originally, I was going to undertake a research project that examined the different definitions of Leadership and try to find the most common characteristics and traits of leaders in business. However, as I got started on the literature review it became apparent that the literature was populated with so many different definitions it was a project that could easily end up with something resembling a dictionary.

In the first 22 pieces of literature, I found 390 different words and phrases describing leadership. A review of the literature titles reveals what the author believes is the key to understanding "leadership" as a concept and then leadership in the Robotic Era. A literature review of the first 22 sources to date, more to come) has uncovered more than 390 unique traits and characterizes of "leadership". A search of Amazon for book titles on Leadership revealed 89,000 titles. Book titles with the words "Leadership Traits" found 4,800 titles. The following table (table #1) Sample of the Literature Titles on Leadership *but this sample is characteristic of the literature. And the state of defining leadership.*

At that point, I put the idea of the research on hold. Gradually, as I begin to understand the enormous impact of technological change on business and our lives, I redirected my interest to how leadership needs to change in the face of the exponential growth and change of technology.

Sample of the Literature Titles on Leadership

Source	Author	Type
10 Most Common Traits of Bad leaders	Jorge Barba	Article
12 Ways to Spot Ineffective Leadership	Mike Mayat	Article
15 Ways to Identify Bad Leaders	Mike Mayatt	Article
18 Characteristics of Poor and Great Leaders	Jeff Voltener	Blog
19 Bad Leadership Traits	M. Rasing	Article
20 Bad Leadership Traits	Qun Trang	Blog
3 Bad Leadership Qualities	Bryan Tracy	Blog
3 Scariest Traits of Bad Leaders	Unknown	Blog
50 Bad Leadership Traits	Todd Nielson	Article
Becoming a Healthy Team: Five Traits of Vital Leadership	Stephen Macchia	Book
Good vs Bad Leadership	Ben Simonton	Blog

Lead like Jesus	Blanchard & Hodges	Book
Lead like Margaret Thatcher	Mathew Bishop	Blog
Leadership Research, Findings, Practices, and Skills	Andrew DuBrin	Book
Leadership Secrets of Attila the Hun	Wes Roberts	Book
Leadership Secrets of Santa Claus	David Cottrell	Book
Leadership the Theory and Practice	Peter Nordhouse	Book
Leadership Traits: the 4 Traits of those who Wield Lasting Influence	Crawford Loritts	Book
Lincoln on Leadership	Donald Phillips	Book
Patton on Leadership	Alen Axelrod	Book
The Leadership Challenge	Kouzes & Posner	Book
Traits and Qualities Exhibited by a Bad Leader	Stan Mack	Book
Transformational Leadership: 92 Tips for Using Different Types of Leadership	Gary Vernum	Book

Table # 1

If one goes to Google and the simple search term, the result is 3 billion, one-Hundred fifty million hits. The term, “Leader” results in 2 billion, nine hundred fifty million hits. And, the term, “lead” finds 2 billion, six hundred forty million hits.

Going through the literature four things stood out.

First, authors seem to be fascinated in the idea that there is some secret number of traits and characteristics that their model of leader possesses. Which leads to the second point.

Secondly, many authors frequently depend upon some extremely small sample usually fewer than ten cases and frequently 3 to five cases in which the author’s found their unique leadership model working.

However, these same authors never seem to get around to explaining that the particular model they are touting never seems to get replicated in another case or written about again.

Thirdly, is probably the reason why this doesn't happen. In the literature I have been able to find any cases in which the authors have quantified or provided empirical measurements of their various traits or characteristics so they could be tested by other researchers or writers.

For example, in one source, the author listed the following characteristics of leaders: tall, devoted, and brave. My questions are simple, how tall? Devotion as based on what devotion scale? And brave as in courageous, or brave as in strong willed, or brave as in willing to take calculated risks, or brave as will kick in the door and save people from a burning building kind of brave?

Finally, the fourth and most significant issue is there isn't a lot of data on the leadership traits or skills that will help lead businesses through the exponential growth trend line of accelerating growth in technology. If ever there was a need for individuals with vision we could follow it is now, in the Robotic Era.

Another issue that confounds the attempt to define leadership is the context and moral issues of what is good and bad behavior and in whose eyes this decision is based. For example, a leader who has been described as "bold", "daring" and "having an incredible memory for detail" would be normally thought of in most instances in a positive light.

These are incidentally the same traits which were used to describe Adolf Hitler. A leadership skill frequently described is having an incredible ability to speak eloquently about political issues and gather mass audiences to a cause. Mahatma Gandhi had this skill but so did Joseph Stalin.

If we can't quantify leadership traits and characterizes how are we ever going to be able to define it or exploit in the Robotic Era? If there are thousands or tens of thousands of traits and characteristics in all sorts of different styles, forms, conditions, applications, meanings of leadership, what is the sense of discussing it unless you have a specific context in which to frame it or otherwise it is meaningless.

The nascent field of leadership study began with what has been coined as the "Great Man Theory" (Malakyan, 2014). This theory presupposes that leaders are born to lead (Malakyan, 2014).

According to early adherents of this theory, certain men (women at the time were not part of the research due to the pervasive gender discrimination and views of the time) were born with innate characteristics that destined them to lead (Johns & Moser, 1989). Researchers examined ancient and past leaders such as Napoleon, Genghis Khan, Alexander the Great, and others (King, 1990). Their leadership assumed a certain born ability to lead (Johns & Moser, 1989). Individuals were counseled that to be a leader, one needs to emulate the historically great leaders of our ancient past (King, 1990).

Obviously, this theory had several problems, not the least of which is any empirical data to prove the validity of the Great Man. Further, a certain bias inherently exists. Who decides out of the sum of human history who is a great leader, and who is not a great leader? Interestingly enough, one can still find the "Art of War" by Sun Tzu on bookshelves.

Business management and leadership styles have evolved over the years sometimes lagging the actual technological and social changes that led to new eras. Universities still teach leadership and management theories that are aging, and many have lost their relevancy. For example, the 1970s Blanchard & Hersey's situational Leadership Model, Dowton's Transformation Leadership Model, Fiedler's Contingency/Stress Model form 1987, Free Reign Theory, 1980, Gold Setting Theory, 1969, Hertzberg's Two Factor Theory, 1950 and others.

However, as a result of the unprecedented exponential growth of technology, leader-managers have to lead and manage change and not merely react to change by more current events and factors. In the past, leaders and managers dealt with machines that were tools, aids to achieving efficiency. The machines and the human teams of the Robotic Era will need to be led and managed as collaborative assets, colleagues and partners and not merely implements of productivity.

The word "robot" entered the English language by way of a 1921 play by the Czech playwriter, Karel Capek. This began a growing interest and fascination with robots. From that point onward, books, movies, articles, research, movements (Singularity) have speculated that robots could do anything form wage war to defeat boxing champions.

The capabilities have been less than what has been imagined. For now, we have Moravec's paradox[3] but for how long we don't know.

In the Robotic Era, the archetypal "great man" who knows best what needs to be done to enhance organizational performance, and who has the necessary personal skills influencer or power to do whatever it takes to get others to play their assigned parts is a thing of the past.

Leader-Managers of the Robotic Era

The Leader-manager of the Robotic Era will be both leader and manager. The Leader-manager will have to a blended compliment of what was formally separate roles. It is not just combining the two roles as they traditionally functioned, and it isn't a hybrid of the best of each role. The Robotic Era Leader-Manager is a role for people with a unique mindset, abilities, skills, knowledge, character, adaptability, and vision and who are comfortable in the era of disruptive technologies. The current *disruptive technologies such as internet of things (IoT), robotic process automation (RPA), and virtual 7reality (VR) are just the* It will be someone who is both visionary and functionally adapt and will be capable of thinking through different options and implementing the best option.

Of course, leadership and management skills and traits will have to evolve to the those that identify and employ the digital assets of the economic concept of comparative advantage. This will be the Robotic

[3] Moravec's Paradox is the discovery by artificial intelligence and robotics researchers that, contrary to traditional assumptions, high-level reasoning requires very little computation, but low-level sensorimotor skills require enormous computational resources. Hard things are easy for robots, the easy things are hard.

Era's new division of labor. The architype "Hero Leader" and the "production line manager" will become part of business history.

Some of the specific roles and responsibilities will remain but will be modified to accommodate teams of robots (AI) and humans. This obviously will be a significant change and, no doubt, will have detractors and opponents as well as supporters. It will positively give new meaning to the idea of "change management".

Predicting the future is futile because history has shown that even the most carefully planned and thought out forecasts and predictions have not been that accurate. No matter how much data, information, and knowledge is put into the effort, the unknowns variables cloud certainty. From Thomas Edison who said in 1889, "Fooling around with alternating current (AC) is just a waste of time. Nobody will use it, ever." to Albert Einstein's 1932 statement, "There is not the slightest indication that nuclear energy will ever be obtainable. It would mean that the atom would have to be shattered at will."

To T.A.M. Craven, Federal Communications Commission (FCC) commissioner comment in 1961, "There is practically no chance communications space satellites will be used to provide better telephone, telegraph, television or radio service inside the United States."
to Bill Gates in 1989 saying, "We will never make a 32-bit operating system." And 7 years earlier he said, "No one will need more than 637KB of memory for a personal computer. 640KB ought to be enough for anybody."

The Leader-Mangers of the Robotic era will face not only the challenges of the changes that they initiate, but also the changes that result from both inside and outside the business, and the shear pace of changes.

These Leader-Managers will need to refrain from focusing on narrowly defined problems, specialized operations or specific issues, and should avoid making changes in any part of the organization without first ascertaining their overall impact (Poblador 2019).

The Robotic Era leader-manager should be knowledgeable and skilled in digital platforms, the collection of cloud-based software and services that allow businesses to form extended networks of interactive product users and providers. Digital platforms exemplify the universal sharing and partnering.

The digital platform business model (DPBM) is a special case of extended value networks (EVNs) consisting of highly interacting players that include customers, owners of physical assets, producers of goods and services, government regulatory agencies, and so on.

These ongoing transactions are overseen by business organizations that serve as network nodes for EVNs. The continuous tracking and sharing of information on ongoing transactions, decisions and processes taking place in these EVNs is facilitated by powerful computer software supported by advanced technologies, such as voice recognition and other sensor applications (ibid).

While a complete list of areas in which the leader-manager will need to be proficient isn't practical, the following list provided here is based just upon our current state of knowledge of digital technology:

- **Blockchain**.
- **Adapt to a robotic AI partner** that will gather and sort data for leader-manager to access information instantaneously for the development of knowledge.
- **Additive Manufacturing** (3D printing)
- **Augmented reality and virtual reality**
- **Assignment of work and supervision of machines** to allow for the maximum capabilities of robots for what they do best and humans for what they do best. Implementing 24/7 operations, security, safety, production, logistics, maintenance. Also manage shorter product runs and to be more responsive to market trends than current methods.
- **Co-opition**, the cooperative operations with non-competitive business partners to better serve common customers.
- **Communication** including standards for both the human and machine members. Robots tend to be non-functional without human direction. With the new Leader-manger, AI leaders will engage in processes that focus on leading the programmers of the AI machine as well as influencing decisions made by AI machines post-programming with greater focus needed on ethical and moral mentoring.
- **10 gigabit networks**, or 10G™ – a powerful, capital-efficient technology platform that will ramp up from the 1 gigabit offerings of today to speeds of 10 gigabits per second and beyond.
- **The acceptance of uncertainty**. We cannot know just how fast exponential change will take place. Digital technology itself may be left behind as Quantum computing develops into business and daily life functions.
- **Manage knowledge base** and be capable of sourcing, within the organization or elsewhere, relevant knowledge and expertise that is needed for improving innovation speed and product performance.
- **Moore's law** is still relevant but for how long we don't know.
- **Panning for disruption**, Black Swan events, that negatively impact robots and AI.
- **Planning for deployment of robots in outer space**.
- **Robotic developments and new technologies.**
- **Recognition of the weakness and strengths of robots** by understanding algorithms.
- **Safety and security** of both humans and robots in the workspace.
- **Thinking and planning** with emphasis on adapting quickly enough to the rapid and unpredictable changes

- **Training for new technology** so that its arrival is done with seamless integration, i.e., voice recognition, facial recognition, mimicking behavior, recognition of subtlety

- **Train and support** replacement staff for all human jobs including leader-manager.

- **Workplace designs** to accommodate limitations of robots but human- centric

- **Understand the cost curve which** allows more lower skill work to be done by robots and fewer humans there must be plans made for how the replaced humans are retrained and redeployed.

- **Lead and manage directive path-goal behavior for interphase**, to create an organizational structure and culture that allows many individual experts both within and outside of the organization to come together in a massive collaborative effort. This role is not to initiate action but to create context.

  The main concern is not to show the way but to set the tone. Organizations must, therefore, be given the utmost opportunity to create their own self-organizing dynamics — with a minimum of administrative control and directions from persons of authority (ibid).

- **Lead and manage organizational goals** of sustainability, green initiatives, relative social engagement initiatives, customer experience functions, gender and race equality initiatives, and government affairs and regulations.

- **Machine Learning**

- **Moore's law,** the difference between an idea and the laws of physics that govern the laws of thermodynamics or Newtonian classical mechanics. Moore's law is not governed by the constraining limits of the laws of physics or Newton's Laws. It is human knowledge, ingenuity, creativity, and flexibility that keeps expanding the capabilities of Moore's Law. Microchip density, processing speed storage capacity, energy efficiency and download speed, and other capabilities have been improving at their own exponential rate.

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Appendix A

Characteristics and Traits of Leaders by the Literature on Leadership

1. Abilities with a malleable quality that that can continuously be augmented through practice and persistence
2. Accurately diagnose the situation
3. Achieve goals
4. Achieve objectives
5. Achieve the highest standards of performance
6. Achievement oriented
7. Act appropriately
8. Act calmly and quickly
9. Acute understanding of cause and effect which is unconscious and automatic over time.
10. Adapt to situation
11. Adapt the world to them
12. Alert
13. Align
14. Ambitious (4)
15. Anticipate
16. Apply organizational values every day
17. Arouse intrinsic motivation
18. Articulate a vision
19. Articulate value
20. Ask questions
21. Assertive
22. Authoritarian
23. Authority (absolute authority over followers)
24. Authority to lead a group of people
25. Autonomous
26. Avoid favoritism
27. Avoid making rash decisions
28. Avoid procrastination
29. Balance the paradox of routines
30. Balls of steel
31. Be fair at all times
32. Be recognized
33. Be unreasonable
34. Behave well
35. Behavior is unconscious and automatic over time
36. Bend reality
37. Benevolent guardian
38. Big dreamer
39. Bold, resourceful and flexible
40. Born to lead
41. Brave
42. Bring out discretionary energy
43. Broad minded
44. Build commitment
45. Build mass organizations
46. Build trust
47. Calm
48. Caring (2)
49. Celebrate team accomplishments (2)
50. Challenge
51. Challenge assumptions
52. Challenge the process
53. Challenge their people to think
54. Change
55. Change agent
56. Change their perspectives
57. Charisma (2)
58. Clarity

59. Coach
60. Coercive power
61. Collaborative
62. Command of situation
63. Committed
64. Communicate expectations
65. Communicates (2)
66. Communication skills
67. Compassion
68. Competent (2)
69. Compulsion
70. Confidence builder
71. Confident (2)
72. Connected to people
73. Conquest and Inclusion
74. Consensus builder
75. Considerate (2)
76. Considers feelings
77. Consistently putting forth best effort
78. Contend with adverse political developments
79. Contend with diverse factions
80. Continuously developing their abilities
81. Control information and the flow of information
82. Control over followers
83. Control over the situation
84. Convert adversity into opportunity
85. Convincing
86. Cooperate with teammates
87. Cooperative
88. Courageous (2)
89. Courteous and cheerful
90. Create alignment
91. Create positive emotions
92. Create value (2)
93. Creative
94. Curiously complicated
95. Customer orientation
96. Decide
97. Decisive (4)
98. Dedicated
99. Deep thinkers
100. Deflect attention away from themselves and encourage others to voice their opinions
101. Delegates authority (2)
102. Demand perfection
103. Democratic
104. Depend strongly upon their “gut-feel” especially in high risk decisions
105. Dependable (2)
106. Desire to improve
107. Determined (2)
108. Determined to preserve in face of difficulties
109. Determines how a group will achieve its goals
110. Develop competence
111. Develops shared vision
112. Devoted to cause
113. Diplomatic
114. Directive
115. Disconnect to connect
116. Dominance
117. Don’t follow standard management practices
118. Don't need to be universally loved
119. Drive and achievement
120. Effective bargainer
121. Embolden
122. Emotional intelligence

123. Emotionally stable
124. Empathy (3)
125. Empower people (2)
126. Enable others (3)
127. Encourage
128. Encourages participation
129. Encourages the heart
130. Endurance
131. Energize
132. Engage employees to carry-out the mission
133. Engage employees to contribute
134. Engage employees to embody company values
135. Engage employees to support vision
136. Engage face to face
137. Engagement
138. Engenders collaboration
139. Engenders fear
140. Engenders partnership
141. Enjoy responsibilities and being in charge
142. Enlist others in a common vision
143. Enthusiasm
144. Entrepreneur
145. Envision an uplifting and ennobling future
146. Experiment, take risks
147. Extroverted
148. Exudes positive energy and attitude
149. Exudes self-confidence
150. Fail up
151. Fair and consistent
152. Farsightedness
153. Fearless
154. Feel for ebb and flow of things
155. Figurehead
156. Find something to fix
157. Flexible (2)
158. Focus (2)
159. Foresight
160. Formal
161. Forward looking
162. Foster collaboration
163. Genuine
164. Get along with a diverse group
165. Get people excited
166. Goal-oriented
167. Good judgment
168. Good memory
169. Great accomplishment
170. Grow the organization
171. Growth mind set
172. Guide
173. Head practices
174. Heart of stone
175. Help achieve goals
176. Help employees see how work contributes
177. Hire people who are competent
178. High energy level
179. High tolerance for frustration
180. Honest (3)
181. Humility (2)
182. Imagination
183. Imaginative
184. Immune to the pressure associated with decision making
185. Improve the quality of life or work or health of followers
186. Improvement-oriented

187. In control
188. Inclusive
189. Incredible memory for detail
190. Independent (2)
191. In-depth knowledge of the organization
192. Industry expertise
193. Infectious optimism
194. Influence-driven
195. Influences others
196. Influencing
197. Informed
198. Initiate action
199. Innovative (3)
200. Insightful
201. Inspirational-oriented
202. Inspire a shared vision
203. Inspire and develops people
204. Inspire commitment (2)
205. Inspire innovative thinking
206. inspire people (5)
207. Inspire something deep within another
208. Inspire vision
209. Instill compassion
210. Instill confidence
211. Instill morale
212. Instill respect
213. Instill trust
214. Instinctual decision maker
215. Integrator
216. Integrity
217. Intellectually stimulating
218. Intelligent (3)
219. Intelligent conservatism
220. Interpersonal skills
221. Interpret
222. Interpret conditions
223. Intuitive
224. Invests in relationships
225. Keep calm
226. Keep everyone calm
227. Keep others motivated
228. Keep yourself motivates
229. Knowledge
230. Known to all
231. Lead by example
232. Lead from everywhere
233. Lead from the front
234. Leans in
235. Learn
236. Learn their behavior
237. Learn what's happening by walking around
238. Learns from experience and adapts to change
239. Leverage attitudes
240. Leverage skills (2)
241. Light passion
242. Loyal (2)
243. Made
244. Made by the events
245. Maintains confidence
246. Maintains morale
247. Make and learn from decisions
248. Make decisions
249. Make good decisions
250. Make it safe for others to speak-up

251. Manages
252. Mass organizer
253. Master the art of politicking and thus don’t waste their time on issues that disrupt momentum
254. Mature
255. Mentors
256. Micromanage
257. Model the way
258. Monitors and helps followers get work done
259. Motivates (4)
260. Move things forward
261. Natured
262. Need to achieve
263. Negotiator
264. Never compromise
265. Never passes buck
266. Never petty
267. Not charismatic
268. Nurtured
269. Open minded
270. Openness to experience
271. Optimistic
272. Participatory management (2)
273. Passion
274. People-focused (2)
275. People-oriented
276. Perception
277. Performance-oriented
278. Persuades others to follow (4)
279. Persuasive
280. Physical stamina
281. Physique
282. Pick themselves up after defeat
283. Political strategists
284. Position power
285. Positive
286. Practice leadership
287. Promote cooperative goals
288. Promotes values and principles
289. Properly allocate and deploy resources
290. Provide continuous feedback
291. Provides a spark
292. Provides choice
293. Punishes failure
294. Punishes (or the threat of punishment) to influence behavior
295. Punishes disloyalty
296. Pushes for protection
297. Puts products before profits
298. Questions the status quo
299. Quick decisions
300. Radiates confidence
301. Rational persuasion
302. Recognize individual contributions
303. Re-evaluate their decisions
304. Resilient
305. Resilient
306. Resolve conflict
307. Respect
308. Responsible for outcomes
309. Revolutionary in thought
310. Rewards loyalty
311. Rewards success
312. Risk taker (2)
313. Role player
314. Rules oriented

315. Ruthless
316. Search out challenging opportunities to grow, innovate, improve
317. Seek advice and counsel
318. Sees and fixes problems
319. Seize opportunities
320. Self-awareness (2)
321. Self-confident (3)
322. Self-controlled
323. Self-disciplined
324. Self-interested
325. Selflessness (2)
326. Self-objective
327. Sends people shopping for ideas
328. Sense of duty
329. Sense of humor
330. Sense of responsibility
331. Sensible
332. Sensitive
333. Sets direction (2)
334. Sets goals
335. Sets priorities
336. Sets purpose
337. Shared vision (2)
338. Simplifies
339. Skills
340. Spokesperson
341. Stand up for what is believed to be right
342. Stands up for something
343. Staying mentally and physically alert
344. Steers organizations to new destinations
345. Steps back and takes in the bigger picture
346. Steps forward
347. Straightforward
348. Strong minded
349. Strong work ethic
350. Supportive (4)
351. Supports search for individual's growth
352. Tactful
353. Take action
354. Take responsibility end to end
355. Takes responsibility
356. Takes responsibility for a group
357. Tall
358. Teaches
359. Team build (3)
360. Team player
361. Technical problem solver
362. Technological savvy (2)
363. Tenacious
364. Think about things clearly, calmly, and in an orderly fashion
365. Thinks out a plan and ensures its success
366. Threatens
367. Tin ear
368. Tolerance for stress
369. Tolerates only A players
370. Touches hearts
371. Touches people emotionally
372. Touches people spiritually
373. Transformational
374. Translates principles into successful mass action
375. Trustworthy
376. Turns bad situations around
377. Understands employees are individuals
378. Understands how external events affect organization

379. Understands limits
380. Understands small group dynamics
381. Understands what it takes to do things right
382. Unique accomplishment
383. Unselfish
384. Use outsight
385. Using resourcefulness to get something done
386. Ventures out
387. Visionary (2)
388. Vitality
389. Warm
390. Withstands pain, fatigue, stress, and hardship
391. Works to accomplish a task

Papers

Supply Chain Management and Logistics

Repair Kit Inventory Policy Creation with Empirical Stochastic Branch-and-Bound

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Abstract

This article explores a methodology for creating a repair kit inventory policy using a simheuristic framework that is supported with an empirical stochastic branch-and-bound (ESB&B) approach. Repair (also known as spare) parts are important in many businesses, although their intermittent demand and the need to have all necessary parts available to do a repair can make their inventory management problematic. The methodology combines a deterministic model that creates periodic review inventory policies for each part in a repair kit independently, with a simulation that accounts for dependencies across parts within a repair kit, and a heuristic model that identifies the highest magnitude improvement in performance along a solution space. The ESB&B approach tries to minimize the number of simulations needed to obtain an effective solution by bounding unpromising branches within the solution space.

1.0 Introduction

This work was motivated by an inventory management challenge existing at the Massachusetts Bay Transportation Authority (MBTA) repair part warehouse. The MBTA, which serves greater Boston, is the 6th largest public transit system in the U.S. Their service routes include buses, subways, commuter rail lines, and ferries. There are many types of vehicles and other equipment that support the operation of the transit system and the vast array of these resources increases every year. The MBTA repair part warehouse stores millions of spare parts (over 10,000 of them are unique parts) worth tens of millions of dollars. Repairs are done at MBTA-operated garages that request parts from the warehouse on a daily basis. The challenge for the warehouse inventory manager is exacerbated by the nature of demand (intermittent), procurement load time (often very long), and coordinating disparate parts that are used in combination to complete a repair.

Although new consumer products are often not repairable, there are many instances where spare parts are required, and their management is a problem faced in many industries. The maintenance of airplanes requires many spare parts (Block et al., 2014), and the U.S. military includes many examples of spare part challenges (Deshpande et al., 2006). The maintenance of legacy telecommunication systems, such as radar, still requires vacuum tubes (Geng, 2021). Other examples are found in 3D printing, where spare parts are needed to maintain printing quantity and reliability (Zhang et al., 2021). The classic repair kit problem occurs when a copier repair technician travels to an office location where they need to carry all necessary repair parts for the repair to take place (Bijvank et al., 2010). The MBTA includes a number of very old facilities making the management of their repair parts especially costly (Arts et al., 2016).

This work concentrates on developing a periodic review inventory policy for repair parts that together form a repair kit, where a repair can only take place when all the parts needed for the repair are available. Parts within the

kit are purchased from a variety of suppliers, each with a different lead time and unit cost. This article is organized as follows. A literature review presents a sample of the previous research regarding repair inventory policies and provides the perspective of how past researchers have integrated simulation, heuristics, and branch-and-bound to solve problems. The article then details the empirical stochastic branch-and-bound (ESB&B) algorithm developed to find effective periodic review policies for parts in a repair kit. A comprehensive example is shown that illustrates the model's potential use. Plans for completing this research are detailed at the conclusion of the article.

2.0 Literature Review

Many researchers have addressed issues associated with the repair part inventory problem, using a variety of analytical approaches in a variety of settings. Zhang et al. (2020) utilized a genetic algorithm for a high-speed railway application. Wen et al. (2018) developed a data envelopment analysis model to address a stochastic spare parts optimization problem. Bisadi et al. (2023) addressed spare part inventory management for maritime preventive maintenance applications. Rappold and Van Roo (2009) focused on a single-item two-echelon spare parts supply chain. Lin et al. (2017) proposed a heuristic policy and applied it to a standard base stock policy. The accuracy of forecasting spare parts for small and medium aerospace forms has also been addressed (Eguasa, 2016). Periodic-review repair parts modeling has been the focus of many researchers' attention, although optimizing these systems remains a challenge (Brunaud et al., 2019). Hence, various heuristic methods have been proposed (Zheng & Federgruen, 1991), and simulations are often employed (Maleyeff et al., 2022). Analytical models for periodic review repair part policies often employ deterministic assumptions for demand and lead times (Tayur et al., 2012).

The repair kit problem has been defined as the determination of inventory policies for each part in a collection of parts that constitute one repair, where the repair cannot take place when all the parts are available. Prak et al. (2017) developed a repair kit replenishment model with one policy for the repair kit that has a constant lead time, while Brumelle and Granot (1993) model the repair kit problem as a cost minimization of holding and shortage penalty cost using fill rate results from Graves (1982). Solutions have been suggested to solve the inventory problems that include replacing each part as their need becomes apparent (Mamer & Smith, 1985), and utilizing a cost minimization or service fulfillment maximization goal (Hu et al., 2018). Teunter (2006) modeled the repair kit problem with the objective of minimizing the sum of holding and poor service costs using two heuristics. More recently, Maleyeff et al. (2022) developed a repair kit model that created periodic review inventory policies for each part repair kit where the kit was integrated by including the cost of holding other parts in the repair kit.

Simheuristics combines a simulation with a heuristics model to find good solutions to complex optimization problems (Juan et al., 2015). Because simulations often take a long time to run, this approach can be effective as long as the time it takes to solve a problem is reasonable (Rabe et al., 2020). In fact, it has been suggested that improving time-based performance is the key to applying simheuristics in unexplored applications (Juan et al., 2015). Michalak and Knowles (2016) describe the use of simheuristic for many operation management and logistics management scenarios. The heuristic model can take many forms; for example, Seiringer et al. (2022) employed a genetic algorithm as a search procedure.

Branch-and-bound, a mainstay of operations research, is an iterative approach that seeks to eliminate the need to explore a large set of potential problem solutions (Visentin et al., 2021). Stochastic branch-and-bound (SB&B) is a modification of the traditional branch-and-bound methodology that accounts for uncertainty in simulation model results (Sölveling & Clarke, 2014). They present a challenge because random effects can cause an SB&B algorithm to discount potential better or even optimal solutions (Norkin et al., 1998). SB&B algorithms can provide optimal solutions for small problems, but often can only provide an approximate solution for computationally intensive problems (Gutjahr et al., 1999). The application of SB&B algorithms usually incorporates a heuristic or meta-heuristic approach (Doerner et al., 2006), and the term Empirical SB&B (ESB&B) has been applied in these cases (Xu & Nelson, 2013). The ESB&B approach has been augmented by establishing a parallel computing environment to reduce computation time (Rosen et al., 2016).

3.0 Methodology

The methodology seeks to determine a period-review policy for each part in a repair kit, denoted as $(s_i, S_i), i = 1, 2 \ldots n$, that minimizes the total of annual part holding, order setup, and repair delay costs. The methodology consists of applying an ESB&B approach to improve the results obtained from the part-by-part deterministic model recommended by Maleyeff et al. (2022) - this model is presented in the Appendix. The simheuristics method combines simulation and heuristics. The simulation does a comprehensive analysis of ordering policies for a repair kit (where each part has a unique cost and lead time). The heuristic model calculates the total cost changes (i.e., slopes) assuming that each part's reorder point or order up to level increases or decreases by one unit. The ESB&B algorithm searches for better solutions in an iterative manner by assuming a tree structure to represents the solution space and applying a boundary condition to eliminate unpromising branches from consideration.

Figure 15 is a simplified solution space assuming that a repair kit consists of three parts, where the initial part ordering parameters $(s_i, S_i), i = 1, 2, 3$, are (4,20), (9,18), and (7,15), respectively. Better solutions are possible for any of the parameter alternatives. The structure consisting of increasing or decreasing each part's ordering parameter by one unit is arranged as a tree.

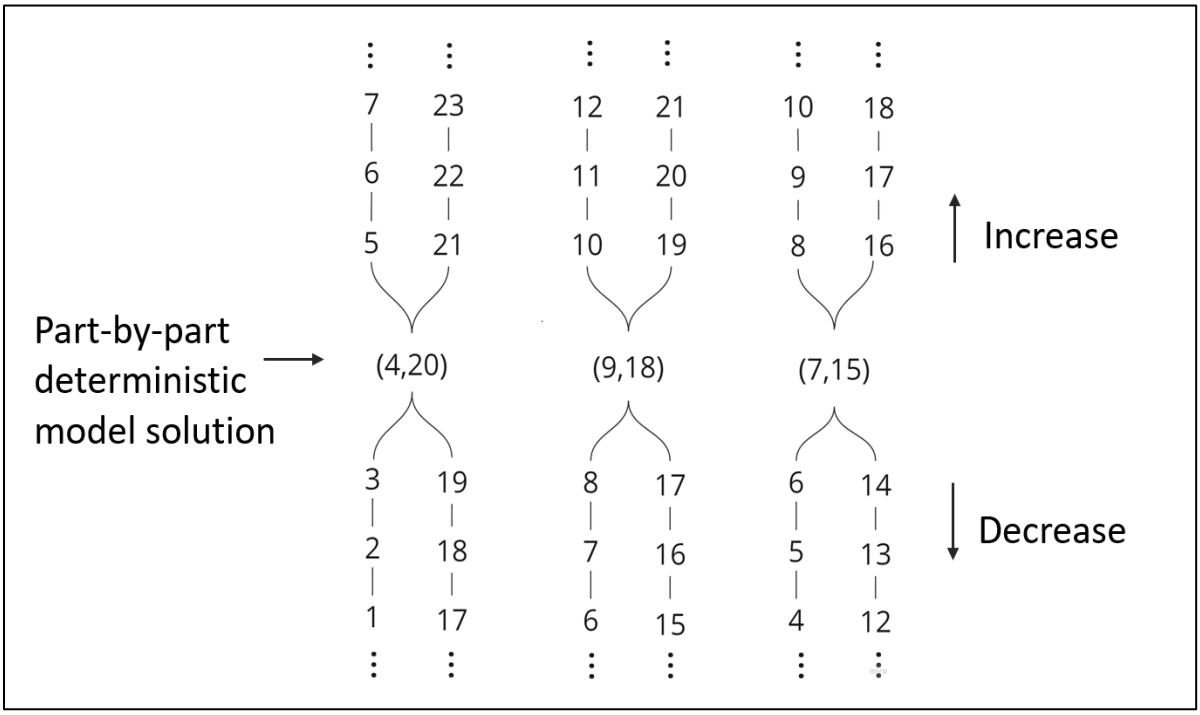

Figure 15: Example Sample Space

3.1 Simulation Model

The simulation is used to mimic the behavior of inventory for a set of parts in a repair kit, where parts are ordered from suppliers having different unit costs and lead times. Repair demand is random and a repair cannot be completed if any part is unavailable. The simulation is described using the five-part STRESS framework (Monks et al., 2019).

Objectives: The simulation model represents a periodic review inventory management system for one repair kit consisting of n parts. It is used to perform a comprehensive analysis to determine the total annual cost (the sum of holding cost, delay cost, and setup cost) for a proposed set of ordering parameters for each part $(s_i, S_i), i = 1, 2 \ldots n$. Repairs follow a Poisson distribution, while parts in the repair kits have deterministic lead time and unit cost that vary by part. Many previous studies have shown the Poisson assumption to be valid for repair parts (e.g., Silver et al., 2016, p. 275).

Logic**:** Simulation inputs include the lead times, the unit costs for each of the n parts, the (s_i, S_i) values for each part i, and the repair demand rate. Constant terms include the annual holding cost rate, the fixed setup cost, and the repair delay cost per week. The outputs of the simulation include the 95% confidence interval for the total annual cost, as well as each of the three cost components. The simulation was written in Python 3.9.13 using packages panda, numpy, matplotlib, and scipy.stats. The numpy random model is used to generate random numbers.

Data: The range of repair part demand, part lead times, and part costs are consistent with the values in the MBTA repair part warehouse.

Experimentation**:** The simulation is run for a specified numbers of trials and iterations (i.e., weeks) per trial, and includes a warm-up period that was determined using Welch's method (Welch, 1983, pp. 268-328). For the results included here, the warm-up period was 120 weeks, the number of iterations per trial was 5000, and the number of trials was 100. These parameters resulted a less than 10% ratio of the standard error of annual cost to the mean annual cost.

Implementation & Code Access: The running environment is MacBook Pro (Apple M1 Pro CPU, 16 GB memory, and 512 GB storage), with a Ventura 13.2.1 OS. The simulations of an eight-part repair kit with 100 trials and 5000 weeks took 2.1 hours to simulation 55 scenarios (i.e., an average of 2.3 minutes per simulation scenario). Referring back to the solution space shown in Figure 15- the number of possible solutions shown is 46656, which would require 2.5 months of simulation time to completely enumerate.

3.2 Heuristic Model

A heuristic model was developed to calculate branching directions iteratively based on making a one-unit change (up or down) to each of the inventory policy parameters (i.e., 40 slopes would be calculated when determining reorder points and order up to levels for a 10-part repair kit). The heuristic model estimates slopes for each of the following:

1. Decreasing each part's reorder point by one unit $(s - 1)$
2. Increasing each part's reorder point by one unit $(s + 1)$
3. Decreasing each part's order-up-to level by one unit $(S - 1)$
4. Increasing each part's order-up-to level by one unit $(S + 1)$

The branching direction with the lowest slope (i.e., largest total cost decrease) would constitute the next simulation run. These total cost slope estimates are based on independent part-by-part effects, which are evaluated in the simulation for the entire repair kit that accounts for the dependencies across parts. The following notation is used to display the heuristic slope models (including the model shown in the Appendix):

d = Demand during one ordering cycle

μ = Mean demand per week

L = Deterministic lead time in weeks

I = Beginning cycle inventory

T = Cycle duration (weeks)

C_S = Fixed ordering (i.e., setup) cost

C_D = Delay cost per week

C_P = Part purchase cost

C_T = Total repair kit part cost

h = Annual carrying cost rate

50 = Number of weeks per year

3.2.1 Delay Cost Slope Model

Equation 1 shows the estimated delay cost associated with one part for the current best solution, while Equations 2-5 show the same cost category if two inventory policy parameters are increased or decreased by one unit for that part. Delay cost is a function of the cost per week and the expected number of repairs that will be delayed due to the part being unavailable. Although the Poisson distribution is assumed, other discreet probability mass functions can be employed within the framework presented. It is assumed that, when a delay occurs, the demand is uniformly distributed within an ordering cycle. The associated slopes are the difference between the estimated delay cost (e.g., DC_{S+1}) and the current estimated delay cost (e.g., DC_0). In total, four slopes are calculated for each part in the repair kit.

$$DC_0 = 50C_D \sum_{d=I+1}^{\infty} \frac{P(X = d|\lambda = \mu T)}{2d} \sum_{t=1}^{d-I} (2t-1) \tag{1}$$

$$DC_{S+1} = 50C_D \sum_{d=I+2}^{\infty} \frac{P(X = d|\lambda = \mu T+1)}{2d} \sum_{t=1}^{d-I-1} (2t-1) \tag{2}$$

$$DC_{S-1} = 50C_D \sum_{d=I}^{\infty} \frac{P(X = d|\lambda = \mu T-1)}{2d} \sum_{t=1}^{d-I+1} (2t-1) \tag{3}$$

$$DC_{s+1} = 50C_D \sum_{d=I+1}^{\infty} \frac{P(X = d|\lambda = \mu T-1)}{2d} \sum_{t=1}^{d-I} (2t-1) \tag{4}$$

$$DC_{s-1} = 50C_D \sum_{d=I+1}^{\infty} \frac{P(X = d|\lambda = \mu T+1)}{2d} \sum_{t=1}^{d-I} (2t-1) \tag{5}$$

3.2.2 Holding Cost Slope Model

Equation 6 shows the estimated holding cost associated with one part for the current best solution, while Equations 7-10 show the same cost category if two inventory policy parameters are increased or decreased by one unit for that part. Holding cost is based on the average inventory during a cycle, which depends on the status of the expected ending inventory (i.e., when the expected inventory is negative, inventory is zero for a portion of the ordering cycle).

$$HC_0 = \begin{cases} \frac{hC_P(2I-\mu T)}{2}, & I \geq \mu T \\ \frac{hC_P I^2}{2\mu T}, & I < \mu T \end{cases} \tag{6}$$

$$HC_{S+1} = \begin{cases} \frac{hC_P[2(I+1)-(\mu T+1)]}{2}, & I \geq \mu T \\ \frac{hC_P(I+1)^2}{2(\mu T+1)}, & I < \mu T \end{cases} \tag{7}$$

$$HC_{S-1} = \begin{cases} \frac{hC_P[2(I-1)-(\mu T-1)]}{2}, & I \geq \mu T \\ \frac{hC_P(I-1)^2}{2(\mu T-1)}, & I < \mu T \end{cases} \quad (8)$$

$$HC_{s+1} = \begin{cases} \frac{hC_P[2I-(\mu T-1)]}{2}, & I \geq \mu T \\ \frac{hC_P I^2}{2(\mu T-1)}, & I < \mu T \end{cases} \quad (9)$$

$$HC_{s-1} = \begin{cases} \frac{hC_P[2I-(\mu T+1)]}{2}, & I \geq \mu T \\ \frac{hC_P I^2}{2(\mu T+1)}, & I < \mu T \end{cases} \quad (10)$$

3.2.3 Setup Cost Slope Model

Equation 11 shows the estimated setup cost associated with one part for the current best solution, while Equations 12-15 show the same cost category if two inventory policy parameters are increased or decreased by one unit for that part.

$$SC_0 = \frac{50C_S}{T} \quad (11)$$

$$SC_{S+1} = \frac{50\mu C_S}{\mu T+1} \quad (12)$$

$$SC_{S-1} = \frac{50\mu C_S}{\mu T-1} \quad (13)$$

$$SC_{s+1} = \frac{50\mu C_S}{\mu T-1} \quad (14)$$

$$SC_{s-1} = \frac{50\mu C_S}{\mu T+1} \quad (15)$$

3.3 ESB&B Algorithm

Figure 16 shows the ESB&B algorithm that uses the simheuristic framework while incorporating a branch-and-bound method to search for effective period-review inventory policies for all parts in one repair kit.

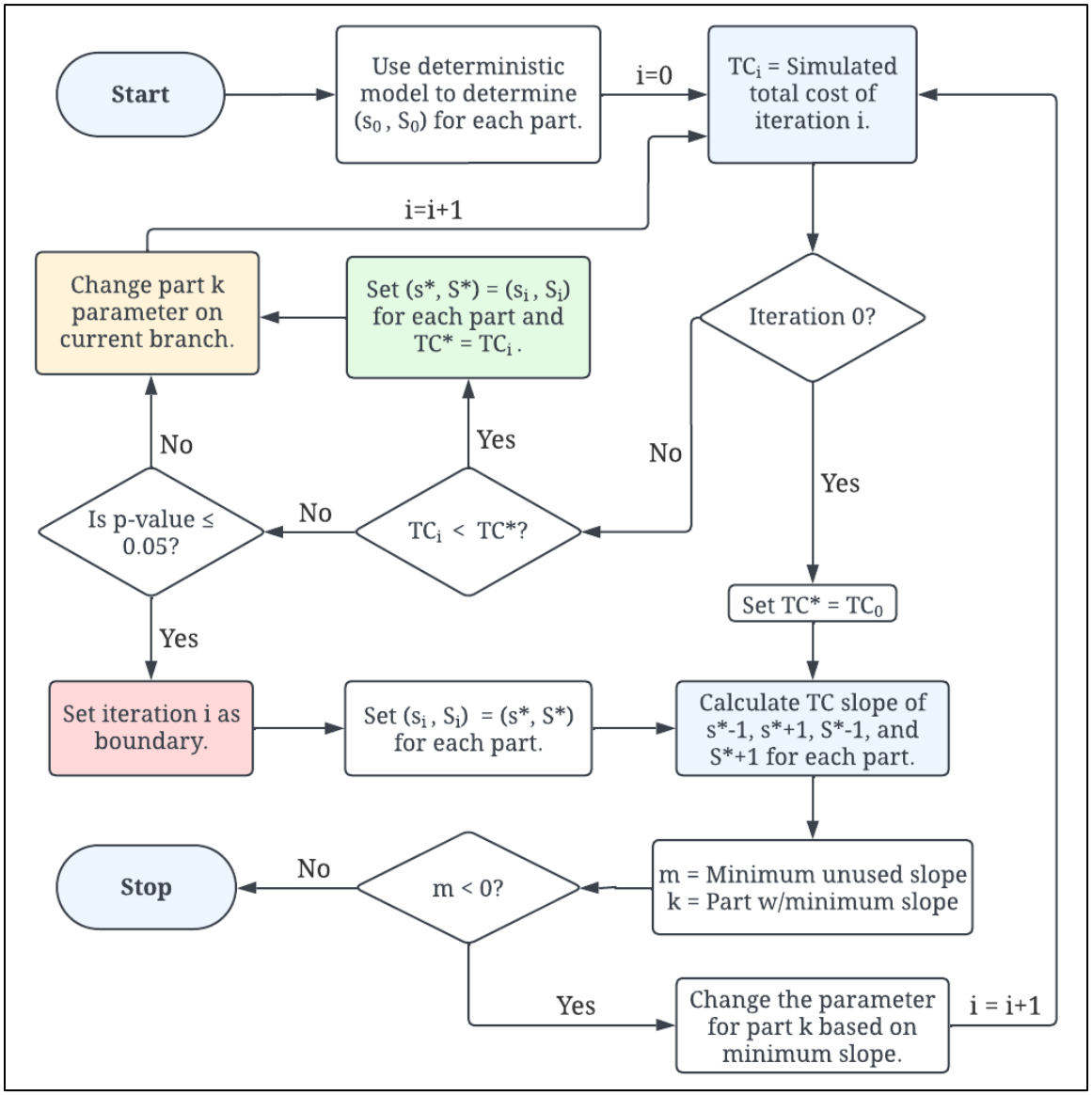

Figure 16: ESB&B Algorithm

The ESB&B algorithm starts by simulating the repair kit inventory process using the parameters resulting from the part-by-part deterministic model. This initial iteration (iteration 0) is set as the best solution, which is referred to as the anchor. Then, the heuristic slopes are calculated to suggest the parameter change that most lowers the total cost. Only one change will be made in one iteration. This change in the parameters is simulated to estimate the total cost, and this result is compared to the anchor. If the total cost is lower than the anchor, the updated parameter constitutes the new anchor. In this case, the minimum slope parameter is again changed by one (i.e., the current branching continues) and the result is simulated. If the total cost is worse than the anchor, a two-sample t-test compares the current result to the anchor result. If the difference is statistically significant, the current solution constitutes the boundary for this branch. In this case, the slopes are recalculated to identify the parameter change that is projected to most lower total cost. This parameter is changed accordingly, and the result is simulated. If the difference in the total cost between the current solution and the anchor is not statistically significant, the minimum slope parameter is again changed by one (i.e., the current branching continues) and the result is simulated. The ESB&B algorithm will be applied until all the slope calculations are positive, which would mean that the heuristic model cannot find a better solution.

4.0 Illustrative Example

The following example illustrates how the ESB&B algorithm identifies an effective periodic review inventory policies for eight parts in a repair kit. The part's unit costs range from $5 to $240, and the total repair kit part cost is $360. If there were multiple units of a part included in the repair kit, the methodology would handle them as a single part with the unit cost set as the total cost of the multiple identical parts (e.g., part A could represent 5 identical parts that cost $1 each). The highest cost part represents 67% of the total $360 cost of all parts in the repair kit. The lead times in weeks range from 2 weeks to 40 weeks. Table 10 shows 8 parts labeled from A to H. The other assumptions for this example are as follows. Average demand (μ) is assumed to be 0.4 parts per week, and demand varies according to a Poisson process. The annual holding cost rate (h) is assumed to be 0.36, the setup cost to place an order (C_S) is assumed to be $50, and the weekly repair delay cost (C_D) is assumed to be $5 per week delayed.

Table 10: Repair Kit Costs and Lead Times

Part	A	B	C	D	E	F	G	H
C_P	5	5	8	15	22	30	35	240
L	40	30	20	10	8	5	4	2

The ESB&B algorithm started by determining the optimal solution for the part-by-part deterministic model by enumerating through all potential solutions. The simulated total cost for this result was $1322.6. Table 11 displays the slopes for iteration 1 branching. The most negative slope occurs when s_E is increased by one (from 4 to 5), which becomes the simulation iteration 1 (with all other part parameters unchanged). As a result, the total cost of iteration 1 was $1320.7 which has a lower cost than iteration 0. Therefore, iteration 1 is labeled as a new anchor, and the exploration of this branch continues. A record of the simulated iterations is shown in Table 12.

Table 11: Iteration 0 Slopes

TC Slopes	A	B	C	D	E	F	G	H
$\mathbf{s+1}$	-11.1	-11.1	-11.1	-10.2	-14.6	-6.6	-12.7	47.0
$\mathbf{s-1}$	14.0	14.0	14.7	15.1	21.1	13.8	21.2	-2.3
$\mathbf{S+1}$	0.2	0.2	0.3	0.6	0.4	1.0	1.2	6.9
$\mathbf{S-1}$	-0.2	-0.2	-0.2	-0.3	0.0	-0.3	-0.4	11.2

Table 12: Iteration Record (Green=Anchor, Red=Boundary, Yellow=Continue)

Iteration	A	B	C	D	E	F	G	H	**TC**
0	(17,50)	(13,46)	(9,35)	(5,24)	(4,20)	(3,16)	(2,15)	(1,5)	1322.6
1					(5,20)				1320.7
2					(6,20)				1321.9
3					(7,20)				1337.6
4							(3,15)		1329.5
5			(10,35)						1313.7
6			(11,35)						1313.4
7			(12,35)						1316.1
8			(13,35)						1316.5
9			(14,35)						1314.2
10			(15,35)						1322.2
11							(3,15)		1323.0
12		(14,46)							1305.7
13		(15,46)							1302.8
14		(16,46)							1302.8

15		(17,46)							1303.7
16		(18,46)							1304.0
17		(19,46)							1301.3
⋮									
26	(22,50)								1276.9
⋮									
37								(0,5)	1263.4
⋮									
41					(6,20)				1261.4
⋮									
55		(20,46)							1268.2
Best	**(22,50)**	**(19,46)**	**(11,35)**	**(5,24)**	**(6,20)**	**(3,16)**	**(2,15)**	**(0,5)**	**1261.4**

In iteration 2, s_E is increased to 6 and the simulation is run resulting in a total cost of $1321.9. Because this result is worse than the anchor but not statistically significant, the exploration of this branch continues. The simulation for iteration 3 results in a higher total cost that is statistically significant. Hence, the branch followed by of increasing s_E is bounded. New heuristic slopes are then calculated using the parameters from the current anchor (i.e., iteration 1). According to the lowest slope suggestion, s_G should be increased by one unit. After simulating this set of parameters (iteration 4), the total cost is shown to be statistically worse than the anchor. The branch followed by increasing s_G is bounded, and the next lowest slope is identified as increasing s_C by one unit. The simulated result for iteration 5 yielded a better solution (i.e., a new anchor). The simulation continued along the same branch, and so on.

After 55 iterations of the ESB&B algorithm, the final result shows a cost of $1261.4, using the parameters shown at the bottom of Table 12. The scatter plot in Figure 17 illustrates how the algorithm operates. The anchors improved in an approximate linear trend across the 55 iterations. For this example, initial improvements are frequent then the number of bounds increases over time.

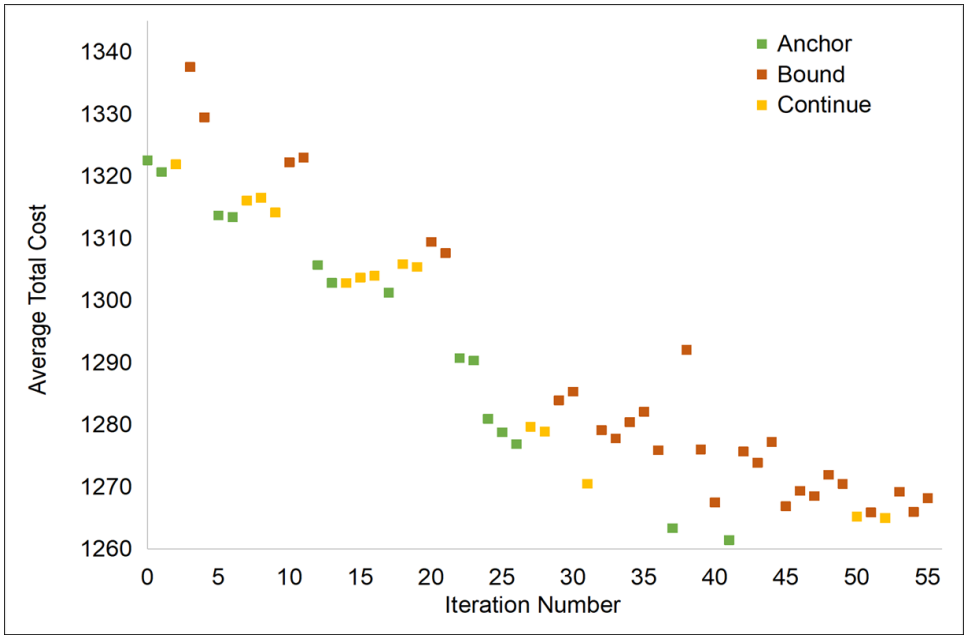

Figure 17: Iteration Record

When comparing the part-by-part deterministic result ($1322.6) to the result of the ESB&B algorithm ($1261.4), which is a 4.6% cost decrease. At this point in the research, it is unclear whether this relatively small decrease is due to the effectiveness of the part-by-part deterministic model or the ineffectiveness of the ESB&B algorithm. The reconciliation of this question will be the subject of future work.

5.0 Future Work

Evaluating the effectiveness of the ESB&B approach to the repair kit problem is ongoing. The authors will be engaged in four areas. First, the ESB&B approach's efficacy will be evaluated to determine how well it performs in a robust set of applications. These applications include a variety of repair kit sizes, lead times, and parts cost distribution within a repair kit. Second, the ESB&B approach will be tested under high-demand scenarios to determine its ability to handle increased operational demands. Third, an evaluation of the ESB&B convergence will be undertaken to ensure its reliability and consistency across various scenarios. Careful attention will be devoted to avoiding returning to an already-evaluated solution or loop infinitely. Fourth, the ESB&B approach will be compared to other published approaches.

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Appendix

Equation A1 shows the total annual cost equation that determines the optimal solution for the periodic review (s, S) inventory model for one part in a repair kit. It is used as the initial solution in the ESB&B algorithm. It considers the annual holding cost (for the part being planned), annual shortage cost (based on the cost of holding other parts in the repair kit), and the annual setup cost. The notation was defined in Section 3.2. More details regarding this model can be found in Maleyeff et al. (2022).

$$TC = \begin{cases} \dfrac{hC_P(S-\mu L)^2 + 2L\mu(C_T - C_P)(1+\mu L - s) + 100\mu C_S}{2(S-s+1)}, & s < 1+\mu L \\ \dfrac{hC_P(S-s-2\mu L-1)}{2} + \dfrac{50\mu C_S}{S-s+1}, & s \geq 1+\mu L \end{cases} \quad \text{(A1)}$$

Distribution Contracts for Digital Content Supply Chains in the Presence of Piracy

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NOTE: At the request of the authors, this manuscript is not included in these proceedings

Abstract

Content manufacturers often face the issue of piracy while distributing digital content (e.g., books, music, games, etc.) through online platforms such as Amazon, Apple iOS, and Google Play. Common distribution contracts, especially the wholesale contract and the agency contract, adopted by online platforms and content creators or manufacturers affect both the spread and the impact of digital piracy. While it has been well-established in the supply chain coordination literature that in the absence of digital piracy, the agency contract coordinates the distribution channel and can lead to a win-win-win outcome when compared to the wholesale contract for the content manufacturer, the platform, and the consumers, these results do not necessarily hold in the presence of piracy. The digital piracy literature has focused on the wholesale price contract, while not addressing the agency contract. In this paper, we develop a game-theoretic model with a content manufacturer and an online platform through which the manufacturer distributes its content to consumers. Unlike physical supply chains, in the presence of pirated content, an increase in the platform's commission rate in the agency model may benefit the digital content manufacturer. Furthermore, we investigate how the distribution contract choice affects the platform's anti-piracy protection level and the content manufacturer's quality decisions to deter digital piracy. As a result of the interplay of these two efforts, we find that under certain circumstances, the wholesale contract can outperform the agency contract, offer better deterrence to piracy, and a win-win-win outcome for the content manufacturer, the platform, and the consumers.

A Real World Application of Transportation Network Optimization in Supply Chain Design

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Abstract:

This study focuses on developing an optimal transportation routing solution for a large scale manufacturer aimed at reducing the transportation cost that represented a significant portion of their annual expenditure. A step by step methodology, using simulation and what-if analysis, is presented to find an optimal solution. The solution consists of finding the optimal means of transportation and the corresponding load from a source to a destination. Production capacity, labor constraints, facility throughput, transportation speed and distance limits all must be factored into the optimization model in order to produce realistic, implementable solutions.

1. Introduction

This study focuses on developing an optimized transportation routing solution for a large scale manufacturer whose transportation cost represented a significant portion of their annual expenditure. The primary function of Supply Chain Solutions is to bring cutting edge industry solutions that enhance performance and drive competitive advantage. The company studied is a prominent international company with its headquarters located in the USA. For privacy reasons, we are going to use a pseudo name for the real company, Supply Chain Logistics (SCL).

SCL has over 15,000 employees around the world and nearly 500 warehouse and office locations. It delivers fully integrated logistics solutions tailored to the needs of our customers and is recognized as one of the leading logistics providers in the market. The organization's full range of logistics services include warehousing & distribution, air and ocean freight forwarding, ground and intermodal transportation, optimized international logistics solutions, supply chain consulting, and IT solutions.

SCL's Vision is to be a leading global logistics enterprise, differentiated by the quality of its services and its mission is to deliver measurable benefits to customers by providing world-class logistics services built on:

- An in-depth understanding of its customers and their businesses
- An outstanding focus on consistent quality, operational excellence and advanced information management
- A superior global network that integrates the diverse assets, operating reach and expertise of its global workforce
- A flexible, agile and innovative organization, and
- A highly trained and professional workforce

The remainder of the paper is organized as follows: Section 2 contains a brief review of the literature related to supply chain design optimization; Section 3 describes the problem, and the solution approach used in this study; Section 4 illustrates how a solution is developed using the real data from SCL; and, finally, Section 5 concludes the paper.

2. Literature Review

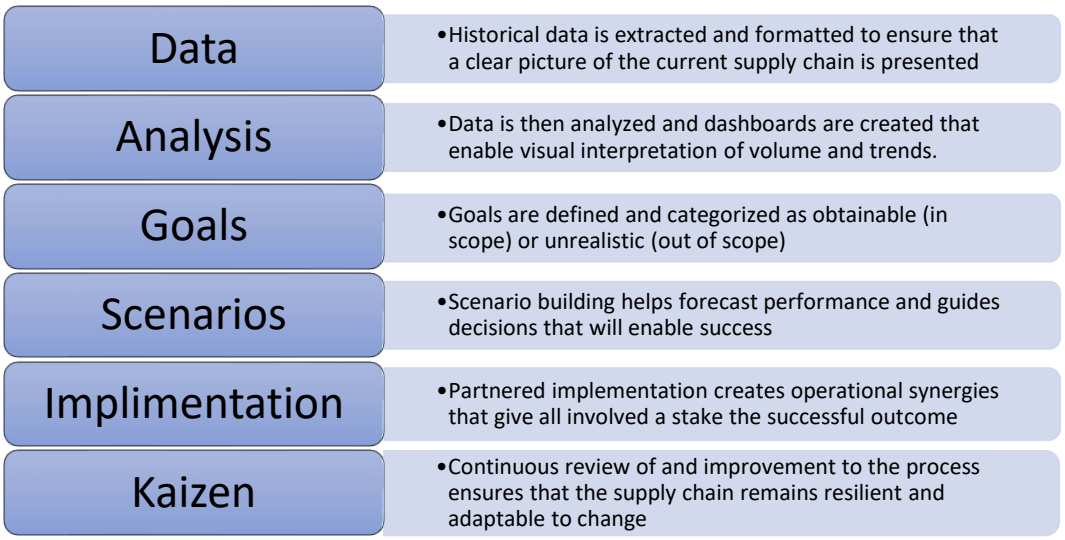
Supply Chain transportation network optimization problem has been around for a long time. An exhaustive literature search is out of the scope of this paper. We will cite some recent work in order to get a good idea of what other methods are being tried to solve such problems.

Tsao and Lu (2012) presented heuristic algorithms to solve supply chain network design optimization problem considering transportation cost discounts. Li, Zhu, and Zhang (2013) investigated the competitive relationship among different warehouses & ports in the same company using Game Theory. Bagloee, Tavana, Ceder, Bozic, and Asadi (2013) applied the network design problem (NDP) to develop a hybrid meta-heuristic algorithm to design a network of links (roads, optical fibers, etc.) enabling the flow of commodities (drivers, data packets, etc.) to satisfy various requirements. Bravo, and Vidal (2013) investigated the inclusion of the freight transportation function in supply chain optimization models (i.e., mathematical programming models), addressing aspects not yet considered.

Eskandarpour, Dejax, Miemczyk, and Péton (2015) presented how to achieve sustainable supply chain network design and discussed the need for inter-disciplinary work involving disciplines such as management, strategy, logistics, etc. Zhen, Zhuge, and Lei (2016) discussed supply chain design optimization in the context of production flow network. Gong, Chen, and Lu (2017) considered both cost and environmental protection to design a multi-objective optimization model aimed at selecting transportation modes. Mejjaouli, and Babiceanu (2018) proposed a cold supply chain model consisting of an integrated RFID-WSN monitoring system architecture that combines the technological and coordination aspects of its logistics operations. Zheng, Yin, Zhang (2019) presented an integrated optimization model of location, inventory and routing in supply chain network design. Sherif, Asokan, and Sasikumar (2021) investigated an integrated optimization of transportation, inventory and vehicle routing with simultaneous pickup and delivery in two-echelon green supply chain network.

3. Problem Statement, Challenges and Approach to Find Solutions

Leadership of SCL was tasked to reduce the annual transportation cost by 10%. The organization sought to use the network optimization module of a software system, Transportation Management System (TMS), but had no in house experience in supply chain solutions engineering or design. This brings to focus the fact that solutions engineering is not a function of software. Software is the tool that allows the engineer to configure the stage for evaluating the dynamic interaction of time and cost in a transportation network and to interpret the results of variation as the result of testing and simulating various network scenarios. C. H. Robinson (2013; "Competing Globally: Combine Global TMS Technology with Expertise") reviews the correlation between a successful network solution and the expertise required to create, analyze and implement a strategy. Even the most sophisticated software system is ineffective without professional involvement. The value of any system is directly proportional to the expertise of the people who are working with it. Systems are highly expensive and it is important to maximize the return on investment. The best solutions are derived from the interaction of technical expertise and operational knowhow. The foundation of any solution is built on information and how it is handled. A well-defined approach to solutions engineering involves clearly defined process flow with logical, sequential phases that produce consistent results.



A modeled solution is only as good as the data that was used to build the network optimization scenario. Great care must be taken in evaluating and preparing the information that will be used to build the model. Data is evaluated and standardized to ensure that locations, volumes, distances and rates are properly interpreted during the analysis phases. Invalid or missing records need to be repaired or removed, zip codes normalized, city state fields validated and rates benchmarked against actual expense and current tariffs.

Analysis can reveal any number of opportunities for efficiency and cost reduction as well as reductions in fuel consumption and carbon footprint. The creation of dashboards around supply chain metrics can create visual aids that help to tell the story of how the network is performing. Patterns and fluctuations show seasonality and periods of congestion. Equipment utilization and variations around average distances can provide insight into opportunities for efficiencies.

4. Optimal Network Solution Development: Data Analysis, Customer Focused Goal Setting

It should be stated that the software uses simulation methodology to develop an optimal solution. It uses various operational parameters, choices, objectives to develop a solution. It uses supply chain data as follows:

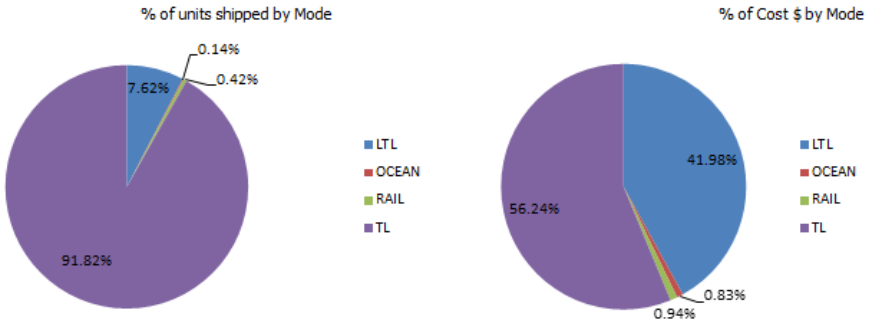
a. Origin and destination location
b. Transit direction (inbound, outbound, intra)

c. Mode of transportation and equipment type
d. Total and average number of shipments, miles, weight
e. Total and average costs, weighted average cost per mile as well as Payment terms
f. number of customers served
g. number of unique 5 and 3 digit zips served (gives a sense of how many customers are in close proximity to each other)
h. Breakout of truckload (TL) vs. less than truckload (LTL)

A typical table of data descriptors for analysis will appear as below.

Summary of Data Post Scrub	Total	TL	LTL	Rail	Ocean
total # of shipments	5,011	3,484	1,504	16	6
total # of units shipped	194,333	178,431	14,816	810	276
Total miles	2,568,200	1,743,793	766,804	42,272	15,331
Average miles	513	501	510	2,642	2,555
Total weight	83,300,234	76,859,751	6,011,147	336,317	93,018
Average weight	16,623	22,061	3,997	21,020	15,503
Total Linehaul charge	$5,501,985	$3,094,584	$2,309,762	$51,980	$45,659
Average Linehaul Charge	$1,097.98	$888	$1,536	$3,249	$7,610
Average cost/mile	$2.14	$1.77	$3.01	$1.23	$2.98

All the averages (miles, weight, linehaul charge) are per shipment. This analysis shows the key measures across a range of transportation modes. Totals provide a broad view of the project scope while averages provide insight into how individual shipments behave for each mode. The formulation of the broad data array into a workable dashboard leads the project naturally into the analysis phase. Dashboards enable visual interpretation of volumes and trends in very large quantities of seemingly random data. **Analysis** for this customer revealed that the manufacturer had US based production with 2 facilities serving the eastern and western United States respectively. Allocation of cargo was plotted with less than truckload (LTL) at 8% of total volume vs. truckload (TL), but almost 42% of total cost by transportation mode. (Note: The numbers on the left dashboard are slightly off from the table caused by a slight change in the numbers when the pie chart was created.)



Transport Mode	Ship QTY	% of Total	LineHaul $	% Total	Shpmnt Weight	% Total
LTL	15,816	8.02%	$2,309,762	41.98%	7,148,147	7.90%
OCEAN	276	0.14%	$45,659	0.83%	93,018	0.10%
RAIL	810	0.41%	$51,980	0.94%	336,317	0.37%
TL	180,413	91.43%	$3,094,585	56.24%	82,859,751	91.62%
Grand Total	**197,315**	**100.00%**	**$5,501,985**	**100.00%**	**90,437,234**	**100.00%**

This visual tool easily leads us to inquire as to how such a small percentage of the customer's volume is responsible for such a large allocation of transportation cost. Such indicators point to inefficiency in the transportation network and bear further scrutiny. Separating and analyzing the various transportation modes individually is often necessary in order to evaluate performance. Isolating underperforming modes or products can direct the project towards achievable goals.

Goal setting and defining operational parameters are key factors in achieving positive results. It is at this point that a second meeting with the customer is scheduled to review the results of the analysis and ensure that goals are aligned. It is often at this point in the discussion that the "scope" of the project can be more accurately focused so that the goals are clear, well defined and obtainable.

During the goal setting meeting with the customer it was determined that the truckload (TL) volume was being consistently optimized with regard to loaded volume and routing but that less than truckload (LTL) volume could provide significant opportunities for

optimization through consolidation. Hence, it was decided to focus specifically on reducing the LTL expense for the organization. A simulation was run that produced the following output.

Customer data - TL and LTL Direct Ship from MFG only

Origin Name	Origin City	Or State	Trans Mode	Cost	Weight
West Coast	Los Angeles	CA	LTL	$1,731,040	12,601,464
West Coast	Los Angeles	CA	Truckload	$7,955,456	128,979,536
East Coast	Pittsburgh	PA	LTL	$1,350,172	10,391,246
East Coast	Pittsburgh	PA	Truckload	$8,864,901	154,437,718
Grand Total				**$19,901,568**	**306,409,965**

Model Output

Origin Name	Origin City	Or State		Cost	Weight
West Coast	Los Angeles	CA		$10,414,040	141,488,083
East Coast	Pittsburgh	PA		$9,464,319	163,834,029
Grand Total				**$19,878,359**	**305,322,112**
Model Variance from actual data				23,209	1,087,853
Percent Variance				0.12%	0.36%
	Customer data		TL	$16,820,357	
			LTL	$3,081,211	
			Total	**$19,901,568**	
	Model Sim		TL	$16,226,428	
			LTL	$3,651,931	
			Total	**$19,878,359**	
				0.12%	
	Accuracy			**99.88%**	**99.64%**

Table 1: Checking the Accuracy of the Model

Functional integrity is critical to extracting quality results with regard to network modeling. The network model must be configured to perform as close as possible to the customer's actual transportation network with regard to cost and capacity. It makes little sense to create a solution that cannot be implemented in the real world.

The table above shows that the model is outputting transportation cost and product throughput within 1% accuracy of the real world distribution network. Once this level of confidence has been achieved the engineers can feel confident that the modeled solutions will be accurate and implementable in an actual distribution and transportation network.

Production capacity, labor constraints, facility throughput, transportation speed and distance limits all must be factored into the optimization model in order to produce realistic, implementable solutions. Attention to detail is required before data can be loaded into a supply chain analysis and optimization software platform. For our modeling we employed Logix 5.0, distributed by Logistics Solutions and Cox Industries.

Accurate supply chain modeling allows the solutions engineers to use the customers historical data to create a model of the customers distribution network including manufacturing sites, consolidation and distribution centers, cross docks, ports, ramps and final delivery locations. The customer's shipment volume can be run through the model to provide an accurate representation of the current network and measures of time, cost and volume as products flow through the supply chain. Linking the model output to a mapping software platform allows for a visual representation of the actual production and distribution network. Advanced software applications have the capacity to easily calculate large volumes of individual transportation moves with relative ease, but it is necessary for our purposes to explain how the software decides which customer to serve from which distribution center. All of the decisions made by the software are based on the best "cost to serve" so let us demonstrate the mathematics that supports those decisions.

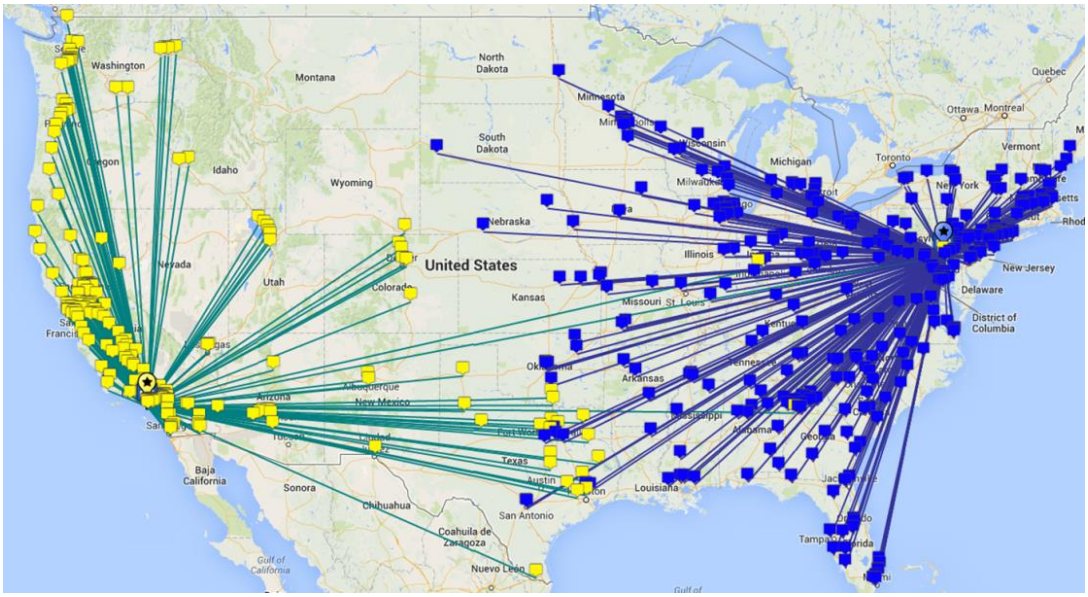
In the table below, we see that each variation within the model has multiple factors that determine the cost. The first leg of any move is the movement of finished product from the manufacturing site to the distribution center. Next is the move from Distribution to customer demand. The product is defined by the average TL and LTL shipment outlined in the earlier data section. For LTL (product B) the unit is 3,997 Lbs. Each shipment of 3,997 Lbs. is treated as a single unit by the model. The model calculates the cost of the total transportation lane using a standard State to

From MFG to Distribution				
LOCATION Kansas City_KS	Product			
MFG2	*B*	*Distance*	*Quantity*	*Trans $*
TOTAL	**(Inbound)**	**1,154**	**181,258**	**$18,101.00**
From distribution to customer demand				
Site Name	*Product*	*Distance*	*Quantity*	*Trans $*
MO-BRIDGETON	B	275	39,510	$3,462
AR-Clarksville	B	308	2,497	$245
MO-Fulton	B	175	15,393	$1,702
KS-Junction City	B	138	26,207	$2,285
OK-OCHELATA	B	228	2,791	$203
OK-Oklahoma City	B	362	17,882	$2,062
NE-OMAHA	B	197	19,908	$2,478
MO-Riverside	B	5	54,919	$1,838
KS-Topeka	B	68	2,151	$92
TOTAL	**(Outbound)**	**1,756**	**181,258**	**$14,367**

Table 2: Transportation Costs Distribution

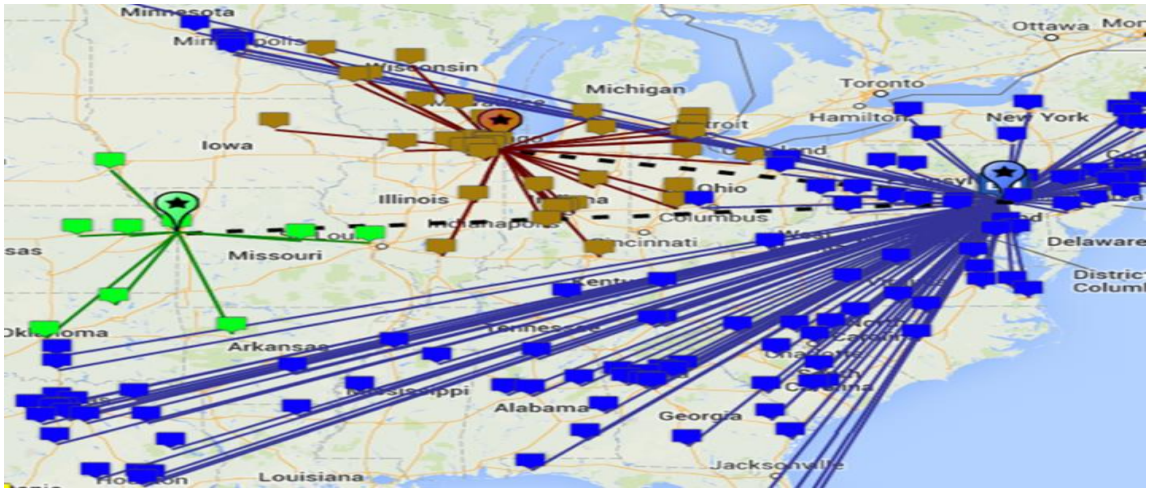
State tariff rate matrix as dictated by competition in the transportation market. For example; the move from Kansas City KS to Bridgeton MO is calculated as total ship quantity of 39,510 / 3,997 = 9.88 shipments. The rate per mile from Kansas City KS to Bridgeton MO is $1.27 X 276 miles = $350.40 X 9.88 shipments = $3,462

The mapped output below shows the east west production locations and the transit lanes that carry the goods from production, through distribution all the way to the customer's receiving facilities based on the calculations outlined above.



It is at this stage that the engineers can begin to create "what if" **Scenarios** that will measure strategic changes to the network and accurately determine if those changes result in increased efficiencies. For example, the centers of customer demand can be measured to determine if the distribution facilities are properly positioned. Can positioning distribution closer to customer demand reduce overall transportation cost? Will demand positioning result in more efficient service times to serve Just In Time and Just in Sequence production and delivery requirements? Any number of scenarios can be modeled and analyzed so the best possible network design that yields the highest performance can be virtually evaluated.

For this customer it was determined that a large number of individual less than truckload shipments were traveling



long distances at high cost. The engineering team asked "what if" we built optimized, consolidated inbound full truckload shipments that would move volume closer to customer demand and then utilize less than truckload cross docks for final deconsolidation and delivery to the end customer. The network model allows the engineers to identify areas of concentrated demand that will yield results.

In order to identify these optimal consolidation points it is necessary to calculate the density of demand within a given proximity. The software uses Geo-coding derived from the US Zip codes to identify each demand point with latitude and longitude coordinates. The quantity demanded in weight within a given distribution radius must be sufficient enough to build consolidated shipments that serve a given density of demand. From the table to the right we can see that the range of **distance** from zip code 752 to zip code 778 is less than 800 miles. This is our maximum distribution range for LTL distribution. From the **Demand by Weight** column we can see that we have demand of 181,360 Lbs. When divided by our specified truckload value of 22,061 we see that we can build multiple (8.2) shipments into this demand point. If there is not enough density or weekly demand based on the constraints of geographic 800 mile radius and minimum truckload of 22,061 to build optimized shipments within the distance points then the shipments for those locations will be served by individual direct shipment as the multi leg shipment required to serve the demand would be a higher cost and as such would not be optimized.

Once identified, the hypothetical distribution points are added to the model and the volume is run and measured to determine the cost, adding both the cost of the inbound consolidation runs (represented by the dashed lines) and the LTL distribution (solid lines) to the final customer. In order for the model to execute these consolidated LTL deliveries it must be able to isolate the customer locations around a selected distribution point that would be most effectively served by these forward located distribution points. The way that the model identifies and isolates these areas of service around the distribution center is by calculating cost to serve based on mileage bands.

Dest 3 Zip	Loaded Miles	Distance	Demand by Weight
752	1442	6	6,405
754	1532	90	35,156
757	1540	8	39,250
759	1625	85	23,631
760	1382	243	3,833
761	1417	35	43,392
762	1429	12	12,884
767	1455	26	16,809

For example, the program is given a mileage based range of rates that it must apply to the identified center of demand. The center of demand is identified with a wildcard entry of X_*. The logic executed in the optimization software will apply this range of rates to any location that begins with X_.

FROM	TO City	Distance	Range	ShipUnit B	Trans Var	Trans Fixed	Flag B
X_*	Mileage	0	200	3735	2.36	125	2
X_*	Mileage	200.1	400	3735	1.19	125	2
X_*	Mileage	400.1	800	3735	1.08	125	2
X_*	Mileage	800.1	5599	3735	9999	125	2

From the above rate table imbedded in the optimization software we can see how for any location within 0 to 200 miles from the origin X_* location a rate of 2.36 per mile will apply. A slightly lower rate applies to each larger mileage band as per widely accepted LTL pricing tariffs. The "Trans Fixed" column gives us a default charge for any shipment that would fall below $125 because if we had a shipment that was only delivering a few miles away from the distribution point the cost would be ridiculously low and would not be worth executing so this constraint of minimum charge must be applied. The engineers are able to constrain the distribution radius in the system to 800 miles by setting a rate that is so high (in this case$9999) that the system will not select any destinations beyond 800 miles.

Once we identify Chicago as a center of demand we apply this rate structure to all of the demand volume that is centered on this location. The way that each individual shipment is calculated is demonstrated below. If we have a demand point that is located 285 miles from Chicago, it falls within the 200.1 to 400 mile band and the rate of 1.19 per mile is applied and the total cost for the distribution leg of the move is calculated as per below.

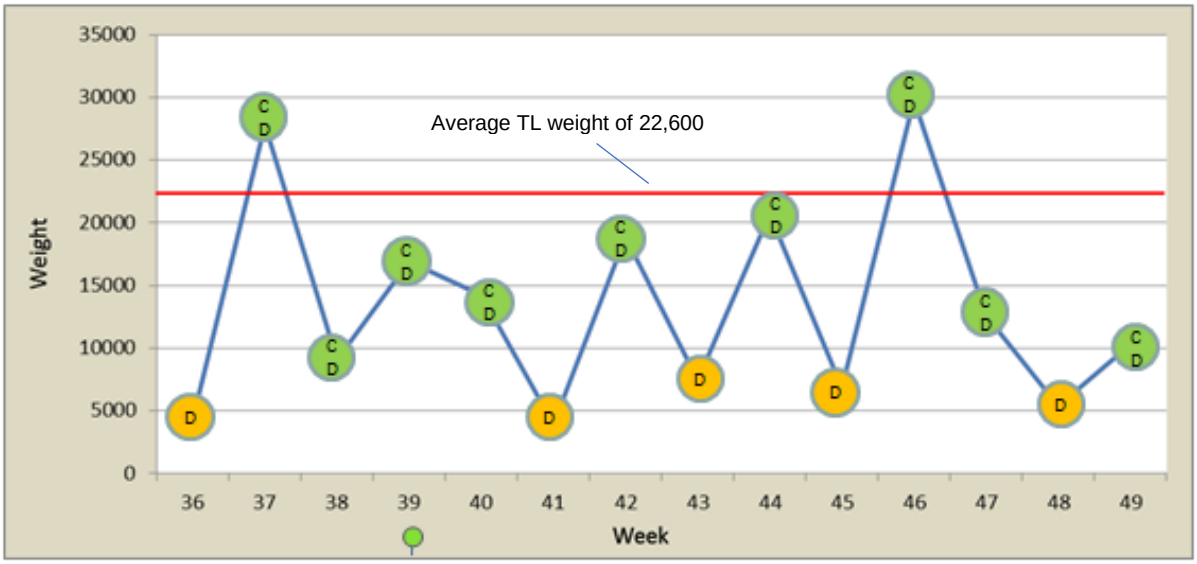
Example	Miles	Range		Ship unit Lbs	Rate	Calculation
X_Chicago	285	200.1	400	3375	1.19	285 X 1.19 = 339.15

The model is subjected to variations in weekly product flows, peaks and seasonality in order to realistically test the new network for capacity and sustainability.

Week #	Weight for Wk	CD to Dest	LineHaul	Total CD	Direct	Managed
36	4320	$903.39	$1,722.18	$2,625.57	$1,247.59	$1,247.59
37	27804	$4,441.20	$1,722.18	$6,163.38	$3,061.29	$3,061.29
38	9120	$1,920.36	$1,722.18	$3,642.54	$4,975.99	$3,642.54
39	16896	$2,299.47	$1,722.18	$4,021.65	$4,975.99	$4,021.65
40	14194	$2,212.22	$1,722.18	$3,934.40	$4,465.32	$3,934.40
41	3923	$612.11	$1,722.18	$2,334.29	$1,421.06	$1,421.06
42	18898	$2,963.47	$1,722.18	$4,685.65	$5,143.59	$4,685.65
43	7437	$1,528.67	$1,722.18	$3,250.85	$2,284.95	$2,284.95
44	20683	$2,519.02	$1,722.18	$4,241.20	$5,742.65	$4,241.20
45	6857	$1,592.46	$1,722.18	$3,314.64	$2,415.75	$2,415.75
46	29771	$4,521.49	$1,722.18	$6,243.67	$9,580.40	$6,243.67
47	12570	$1,629.40	$1,722.18	$3,351.58	$3,504.44	$3,351.58
48	5413	$824.75	$1,722.18	$2,546.93	$1,556.17	$1,556.17
49	10269	$1,132.11	$1,722.18	$2,854.29	$3,199.81	$2,854.29
Grand Total	**354318.73**	**$29,100.12**	**$24,110.52**	**$53,210.64**	**$53,574.99**	**$44,961.78**

Decisions must be made regarding weekly flows and when consolidation or direct shipment will yield the greatest benefit. Fluctuations in shipment volumes over time will impact the cost to serve a region. If there are not enough shipments in a week to build a consolidated shipment to a regional distribution center then it is more cost effective to ship directly to the customer location than to run the cargo through the distribution point. The table above shows the volume of LTL cargo by weight delivering within a specific region over the course of 14 weeks. The question that must be answered on a weekly basis is weather to run the cargo through the cross dock or ship direct. The determining factor is cost of transportation. Cost is calculated by multiplying the cost per total shipment weight by the distance traveled. The "CD to Dest" column is the cost to move from the distribution hub to the final delivery (solid line) and the "LineHaul" column is the cost to deliver the consolidated truckloads to the distribution point (dashed line). These two amounts are combined to create the "Total Cross Dock column in green. The cost to ship the cargo directly to the customer from the production facility is the "Direct column in yellow. It then becomes clear that some weeks should be consolidated into Cross Dock moves and some weeks should be shipped direct. The outcome of the table is depicted in the run chart below.

The chart shows that 9 out of the 14 weeks the cargo should be consolidated and that 5 of the 14 weeks the cargo should ship direct. Evaluating the flow of product over time is critical to maximizing efficiency and optimizing the distribution network.



It is at this point that the modeling outputs are measured against the baseline cost to determine the effect of the network change with regard to key metrics. In our model we considered two distribution points of Kansas and Illinois. In the below table we show the cost output for each individual location optimization scenario and then the combined effect of both locations. The results are then projected across a full year to determine the annualized savings. In the modeled scenarios tested we show a reduction in transportation cost of over 10%.

Transport Mode	Projected Quarterly Spend	Cost Reduction	% Δ	Annualized Savings
LTL Direct (baseline)	$1,000,231			
LTL W KS Cross Dock	$929,437	$70,794	**7.6%**	**$283,176**
LTL W IL Cross Dock	$926,981	$73,250	**7.9%**	**$293,000**
LTL W KS & IL Cross Dock	$907,445	$92,786	**10.2%**	**$371,144**

The optimized volume, when annualized resulted in a savings of over $370,000 for just these two locations. Concentrations of demand density can then be further modeled for additional consolidation points. Any distribution scenario should be tested prior to implementation in order to ensure that the distribution would yield positive results prior to initiating any operational changes to the existing network.

5. Concluding Remarks

The modern supply chain is dynamic and ever changing. Supply chain performance should be subjected to routine checkups to ensure that optimal performance is being achieved in the face of shifting demands and market trends. T Production capacity, labor constraints, facility throughput, transportation speed and distance limits all must be factored into the optimization model in order to produce realistic, implementable solutions. The preceding optimization study resulted in a successful implementation of pool distribution modeling in a dynamic LTL network. The reason that the implementation was successful is directly related to the methodology supporting the implementation. Each step in the process, from interpreting and analyzing the original raw data to the actual hands on implementation of the network strategy must go through its own complete phase in sequence and with the proper oversight in order to produce successful results. Just as goods and services flow through the supply chain in a logical order, the optimization process must do the same. Each step must be evaluated and successfully concluded before the next phase can begin. Experience and expertise are critical during every step of the process, as are communication and collaboration.

A

Acknowledgment

The work reported here was done as part of an independent study by a student of mine, Mike Pedersen, under my guidance. Mike worked for SCL and brought the knowledge of the subject matter that was necessary for using the Logix software to develop solutions under various transportation scenarios. I wish to recognize his contribution to this paper.

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Decision Support Approach for Ranking Response Options in Reaction to Climate Change

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Abstract

This article concerns the development of a decision support application to assist supply chain managers who make risk response choices in the presence of increasing climate change risks. The approach addresses three challenges faced in these settings. First, it uses indifference analysis to quantify climate event impacts that include intangible costs. Second, it uses color-coded decision aids to help decision makers account for uncertainty. Third, it uses the Analytical Hierarchy Process to rank multi-criteria options using pairwise comparisons. The decision methodology is detailed, and a decision support application is demonstrated. The choice of response options is presented using an example derived from future flooding concerns in Boston.

1.0 Introduction

Climate change has significantly impacted many global supply chains due to increases in the occurrence of intense weather-related events. The 2017 wildfire outbreak in British Columbia disrupted transport systems that cost at least 137 million USD to recover (Tymstra, 2020). The 2011 floods in Thailand disrupted automobile and electronics supply chains resulting in 32 billion USD loss for manufacturing industries (Haraguchi & Upmanu, 2015). The 2014-2015 extreme drought in Brazil affected raw material production of many crops, especially orange and sugarcane (Martins de Sá, 2019). Finally, Hurricane Ida in 2021 disrupted supply chains by necessitating the closure of roads that delayed trucks, railroads, and air transport (Shultz, 2022). Studies that detail future climate changes around the world is extensive; however, less attention has been paid to how future climate events will impact businesses and how effective response decisions should be made.

An important responsibility of a supply chain manager is to identify, assess, and act in response to various risks that can affect their supply chain operations. Identifying or understanding a risk factor is only useful if it motivates the development of the effective response. Traditionally, there are four categories of risk responses (Lam, 2017, pp. 425-426). Risk acceptance occurs when no action is taken in response to the risk. Risk transfer occurs when the risk is contractually transferred from one party to another, usually with insurance. Risk avoidance entails eliminating the possibility that a hazard will affect the business or its assets. Risk mitigation concerns reducing the harm caused by a certain risk or reducing the risk likelihood. Table 13 gives an example of how these options would apply in the case of concern over a potential wildfire near a supply chain facility.

Normal risks for supply chain managers include factors such as demand fluctuations, price volatility, supplier disruptions, and economic downturns (Chopra & Sodhi, 2004). These risks are inherent in traditional supply chain management and are part of regular business operations. They usually have short or moderate time horizons, and they are often associated with immediate impacts on business operations and financial performance. Recently, supply chain risks have increased with the effects of climate change, such as extreme weather events, temperature changes, and sea-level rise (Ghadge et al., 2020). These risks are often more complex and can have longer-term consequences on supply chain operations. Supply chain managers are challenged to evaluate alternative responses for each potential climate-related risk. In particular, they need to consider the following:

1. How do I calculate the cost of a climate event impact?
2. How do I make a rational decision in the presence of uncertainty?

3. How do I rank many multi-criteria options simultaneously?

Table 13: Risk Response Options for Wildfire

Options	Example Actions
Acceptance	Do nothing
Avoidance	Move facilities to a less risky location
Transfer	Buy wildfire insurance
Mitigation	Create a defensible space
	Convert to noncombustible materials
	Improve site access for firefighters
	Install fire suppression system

The article is organized as follows. A literature review discusses relevant research on risk-related decision making, including tools such as decision trees, the Analytical Hierarchy Process (AHP), and visual decision aids. The methodology is then described, which details how the three challenges faced by a supply chain risk analyst could be overcome. Next, a decision support system (DSS) application is detailed and demonstrated with a comprehensive example. Finally, future work is discussed.

2.0 Literature Review

Many weather events that have traditionally been low probability risks are increasing in frequency and intensity (Rising et al., 2022). Although rising, the occurrence of especially intensive weather events remains infrequent. Humans often struggle to interpret probabilities, especially when they are low (Cosmides & Tooby, 1996). To address this difficulty, researchers have explored strategies such as the use of color-coded matrices and probability visualizations (Lipkus & Hollands, 1999). Maleyeff and Chen (2021) considered the effectiveness of uncertainty visualizations to assist in patient-centered medical decision making for treatments that include low probability but high impact side effects.

Bonner et al (2021) present an overview concerning the use of various decision aids in patient-centered decision making, with an emphasis on bias associated with various icon shapes. In these cases, simple formats can minimize bias in probability interpretation (Trevena et al., 2021). When practical, humanlike icons may minimize differences between perceived and actual risk compared to more generic icons (Zikmund-Fisher et al., 2014). However, according to Lipkus and Hollands (1999), no single graphical format will perform well in all situations. Various display characteristics, presentation conditions, data complexity, user characteristics, and the purpose of the display can play crucial roles in the effectiveness of visual decision aids (Meyer et al., 1997).

Decision trees have been used in diverse fields to enhance the intuitive understanding of a decision model (Myles et al., 2004). Their ease of comprehension is improved by using flow-chart-like structures that are applicable to a variety of settings (Yadav & Pal, 2012). For example, ElAshmawy et al (2023) demonstrated their use in agricultural risk analysis for decisions in farming. Similarly, Pitros et al. (2020) applied decision tree methodologies for medical treatment planning. Quinlan (1996) illustrated their versatility as a tool for comprehensive data analysis across diverse applications.

The quantification of climate impacts presents a challenge to risk managers because it includes both quantifiable and intangible factors, such as business disruption and reputation damage. Their economic cost is difficult to quantify, which can result in irrational decision making (Tversky & Kahneman, 1974). Risk management decision making is a combination of objective and subjective elements (Tesfamariam et al., 2010), and decisions can be dominated by the recent experiences and anecdotal events (Loewenstein et al., 2001). Quantification of difficult-to-quantify impacts can include indifference analysis where decision makers estimate the event likelihood that would equate two decision options (Maleyeff & Chen, 2020).

The AHP is a decision-making framework that translate the ranking of alternatives to a series of pairwise comparisons (Saaty, 1980). According to Yalcin (2008), the AHP enables the inclusion of both subjective and objective elements in the decision process. Pande et al (2021) used the AHP to assign specific weights to each factor that played a distinct role in influencing groundwater occurrence. Kazakis and Patsialis (2015) used the AHP to do a pairwise comparison for the importance of flow accumulation. Maleyeff and Webster (1994) used the AHP to help users make a choice among alternative software products.

3.0 Methodology

The methodology employed seeks to overcome the three application challenges by using the methods described below. They include indifference analysis to determine differences between the economic utility of each pair of response options, color-coded matrices to make uncertainty more understandable to supply chain decision makers, and the AHP to enhance multi-criteria options ranking by creating a series of pairwise comparisons.

3.1 Calculating the cost of a climate change impact

In response to the challenge posed by estimating supply chain impacts, a mechanism is created to estimate the economic utility associated with the differences between pairs of impacts. Consider the decision tree that shows a set of risk response options (Figure 18). It includes factors that influence decision making, including the implementation cost for option i (C_i), probability of a disruptive event (p), and economic utility (i.e., impact) for option i should the event occur (U_i).

The implementation cost for each risk response option (e.g., building a flood barrier) is usually known to the decision maker, and the probability of the climate event can be estimated from official websites or government agencies. However, the impact of the climate event is difficult to quantify in a precise manner. This impact consists of quantifiable responses and recovery costs (e.g., equipment repairs), along with difficult-to-quantify business disruption impacts (e.g., finding a new supplier), and intangible impacts (e.g., reduced confidence among customers). The inability to quantify these impacts precludes a straightforward choice among the decision tree options.

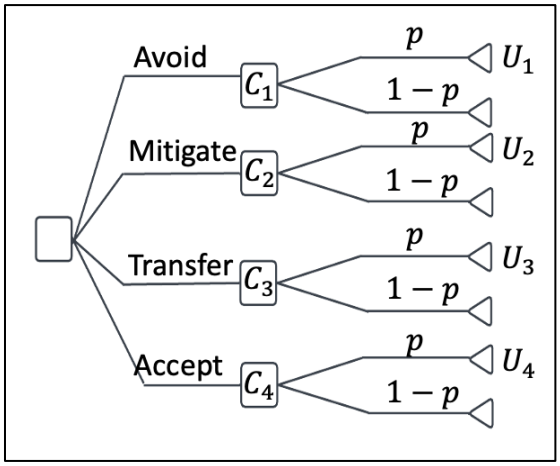

Figure 18: Generic Decision Tree Model for Risk Response Options

Equation 1 shows the expected cost of option i (where E_i is the expected total cost for option i). The quantification of the economic cost utilities is done in a pairwise fashion. Equation 2 shows the difference in expected cost between a pair of options, which is based on the unknown difference in their economic utilities.

$$E_i = C_i + pU_i, i = 1,2,3,4 \quad (1)$$

$$E_j - E_i = (C_j - C_i) + p(U_j - U_i), j = 2,3,4; i = 1, \dots, j-1 \quad (2)$$

By setting the difference between a pair of expected costs to zero (i.e., their indifference point), it follows that the difference in economic utilities between option i and option j can be calculated by finding the decision maker's indifference probability when comparing option i to option j. This relationship is shown in Equation 3, where q_{ij} is the indifference climate event probability that would equate utilities i and j.

$$U_j - U_i = \frac{(C_i - C_j)}{q_{ij}}, j = 2,3,4; i = 1, \dots, j-1 \quad (3)$$

3.2 Making a rational decision in the presence of uncertainty

To respond to the challenge of making a decision in the presence of uncertainty, indifference probabilities for each pair of utilities are estimated using a color-coded matrix. A color choice survey was created to determine an effective color combination. Figure 19 shows the alternatives that were included in the survey after a preliminary analysis of potential color schemes based on recommendations by Zhang et al (2022). The darker color represents an event probability. The survey

asked each participant to estimate the event probability for each of 32 different matrices (i.e., there were two probabilities and two replicates for each color combination). Fifty-four participants completed the survey with the 16 deviations from their pairs of predictions for the identical color and probability used as the response. The small sample size allowed only for rejection of certain color combinations. As a result, it appears that a decision maker can judge probability precisely when the color combination is dark pink and light pink. Accuracy is less important in these determinations, since the method will be effective as long as the decision maker is consistent with their prediction bias.

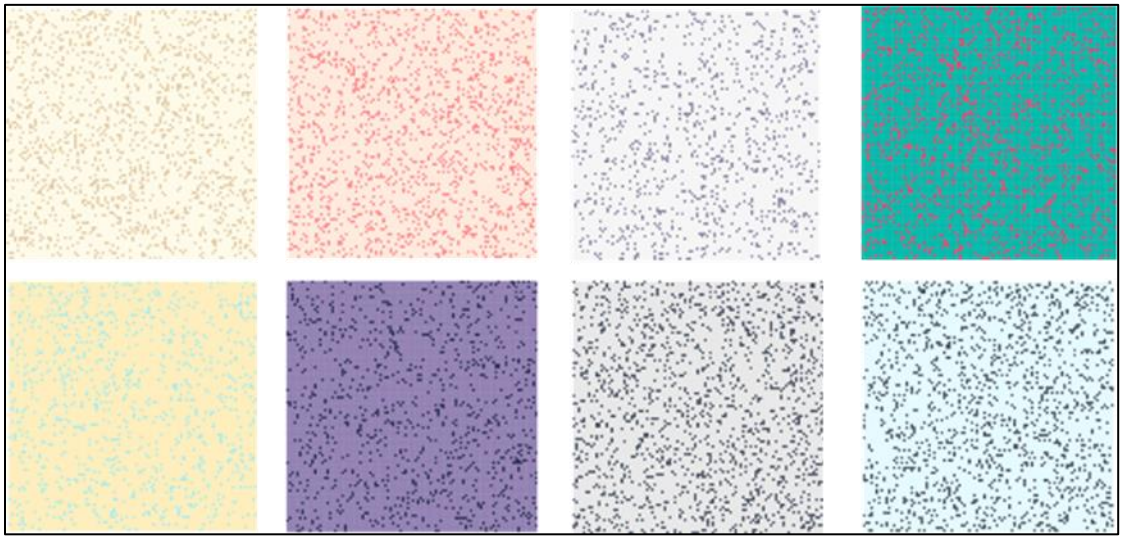

Figure 19: Color Combination Tests

A binary search method is used to obtain indifference probabilities for each pair of response options. Initially, the visualization shows a climate event probability of 50%. The decision maker is asked to choose which of the two options would be preferred given this likelihood. If they choose the more expensive option, the next visualization changes the event probability to 25%, which places the range of the indifference probability from 0% to 50% (the event probability is changed to 75% if they choose the less expensive option). Again, the decision maker is asked to choose the preferred option. Based on their choice, the visualization's event probability is changed to either 12.5% (a range of indifference probability from 0% to 25%) or 37.5% (a range of indifference probability from 25% to 50%). At any point the decision maker can choose "indifferent" when presented with the pair of options. The binary search continues for a maximum of 7 iterations, which will result in an indifference probability with precision of 1%.

3.3 Helping decision makers rank alternative options

The AHP will be used to solve the third challenge of ranking many alternative options in a multi-criteria setting. The effectiveness of the AHP to rank alternatives derives from the reduction of many risk option comparisons to a set of pairwise comparisons, which is especially effective when a multi-criteria evaluation is required. As shown in Table 14, a decision maker indicates preference using a 1-9 scale with 1 indicating equal preference and 9 indicating very strong preference (e.g., here, option A is considered moderately better than option C). In the AHP matrix, cell (i,i) equals 1, and cell (i,j) is equal to the inverse of cell (j,i).

Table 14: AHP Table (Example)

	A	B	C	D
A	1	3	5	1/7
B	1/3	1	4	2
C	1/5	1/4	1	5
D	7	1/2	1/5	1

The overall score for option i is calculated by Equation 4, with the result of the example shown in Table 15. The scores will sum to 1, and each score represents the relative difference among the decision options. In this way, both the ranking of the response options and their relative differences are evident.

$$S_i = \frac{1}{n}\sum_{j=1}^{n}\frac{a_{ij}}{a_{\cdot i}}; i = 1,2,\ldots,n \quad (4)$$

Table 15: AHP Results (Example)

Option	A	B	C	D
Score	0.31	0.22	0.20	0.27

4.0 Decision Support Application

A DSS was developed to implement the integrated methodology. The application is written using the R Shiny package, which allows a developer to build interactive web applications using the R programming language (www.rstudio.com/products/shiny/). The system can easily be made available on a public website; it will not require the user to install an R compiler. No programming expertise is required to an R Shiny the application. The decision support system employs the following procedure:

1. Define the climate event (e.g., flood, wind, heat, storm).
2. Identify potential response options and reduce the list to 3-5 choices (using expert opinions).
3. Enter the application and list each response option with its implementation cost.
4. The application guides the user to identify the indifference probability for each pair of response options using a color-coded matrix and binary search.
5. The differences between expected overall cost for each pair of options based on the actual climate event probability are calculated.
6. The expected cost differences are translated to the 1-9 AHP scale and the response options are ranked.

4.1 Example

The procedure is illustrated using a relevant comprehensive example. It concerns a large bus storage and repair facility that is operated by the Massachusetts Bay Transportation Authority (MBTA) in Boston. The garage chosen is located in an area of Boston that constitutes a known flood plain. This example is especially relevant because a World Bank study showed that Boston will be the 8th most flood prone city worldwide (Hallegatte et al., 2013). Many impacts can be expected at the MBTA garage if a major flood were to occur, such as repair equipment damage, bus vehicle damage, increased workplace hazards, harm to MBTA reputation, and bus vehicle relocation, among others.

Consider the four response options and their implementation costs shown in Table 16. For this example, it is assumed that the decision will not be reevaluated for three years. The permanent modification option involves installing a set of 36-inch-tall ABS flood barriers. In conjunction with this option, the land surrounding the facility will be compacted and sloped away from the facility. The infrastructure modification option involves the installation of industrial pumps to drain floodwaters away from the facility in real time, while also relocating critical infrastructure such as electrical equipment or utilities to flood-proof locations. The temporary modification option includes placing deployable barriers or sandbags that can be installed quickly before an expected flood event. They provide temporary protection to specific areas and can be removed and stored after the floodwaters recedes. The garage manager would take no action to mitigate flood impacts were they to choose the acceptance option.

Table 16: Risk Response Options for Flood Event

No.	Response Option	Cost	Description
1	Permanent Modification	$510,000	Add flood barriers & regrade land
2	Infrastructure Modification	$255,000	Install pumps & relocate equipment
3	Temporary Modification	$95,000	Add reusable water dams
4	Accept Risk	n/a	Take no action

The user accesses the application's interface as shown in Figure 20, where they enter the name of the climate event and the number of response options they will be comparing. For this example, the climate event is flood and there are four response options. The application generates input boxes corresponding to each option and the user enters its name and implementation cost.

After the user selects "Generate Plots," the application generates one pairwise comparison matrix for each pair of response options (in this example, the system will generate six visualizations). For each of the sets of color-coded matrices, the binary search algorithm is implemented, which terminates when either the user indicates “indifferent” or seven iterations are completed.

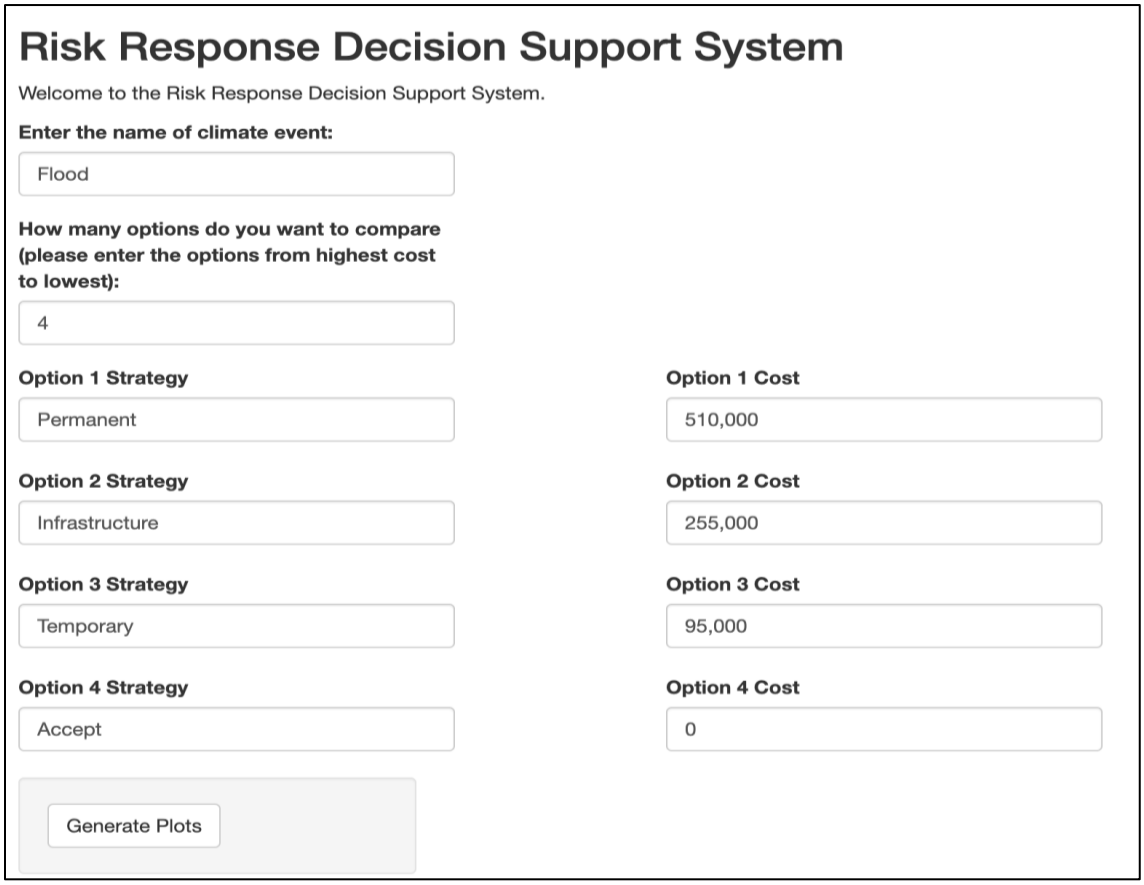

Figure 20: User Interface

To illustrate a user’s experience, consider the pair of options “permanent modification vs acceptance.” The user is asked to make their choice based on the flood likelihood (darker color) that is initially set at 50% (Figure 21a). Assuming the user chooses permanent modification, the flood likelihood will decrease to 25%, and they again indicate their choice (Figure 21b). Assuming they again choose permanent modification, the flood likelihood will drop to 12.5% (Figure 21c). If the user again chooses permanent modification, the flood likelihood decreases to 6.25% (Figure 21d). Assuming they choose acceptance for this iteration, the flood likelihood will increase to 9.375% (Figure 21e). Here, if the user chooses “indifferent,” their indifference probability is 9.375%. Using this procedure, the user will complete the other five comparisons to obtain indifference probabilities for each pair of response options.

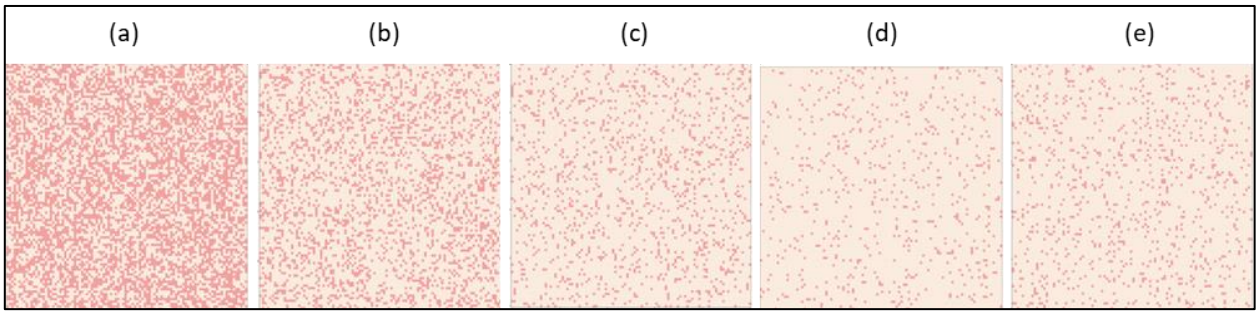

Figure 21: User Choices (Permanent Modification vs. Acceptance)

Table 17 shows the results that could occur after all six pairwise comparisons are completed. Also shown are the differences in each pair of utilities (from Equation 3). It is assumed that the likelihood of a major flood for the next three

years is 12% (i.e., $p = 0.12$). This likelihood is used to calculate the differences in the expected overall cost of each option (using Equation 2).

Table 17: Example Results

i vs. j	q_{ij}	$U_j - U_i$	$E_j - E_i$
1 vs. 2	0.188	1,356,383	-92,234
1 vs. 3	0.156	2,660,256	-95,769
1 vs. 4	0.094	5,425,532	141,063
2 vs. 3	0.086	1,862,631	63,516
2 vs. 4	0.070	3,627,312	180,277
3 vs. 4	0.031	3,035,144	269,217

The differences in expected costs among the pairs of response options are translated to a scale suitable for AHP numerical manipulation. The pairwise difference with the largest magnitude is denoted as 9.0 in the AHP table. Other AHP scores are calculated in proportion to the highest magnitude difference. The values in Table 18 represent the AHP scores associated with the garage manager's indifference probabilities.

Table 18: Example AHP Scores

	[1]	[2]	[3]	[4]
[1]	1	0.32	0.31	6.77
[2]	3.08	1	1.48	6.03
[3]	3.17	0.68	1	9.0
[4]	0.15	0.17	0.11	1

The application ranks each response option (using Equation 4), with the results shown in Table 19. For the MBTA storage and repair garage, the infrastructure modification is the highest-ranking option, followed by the temporary modification option.

Table 19: Example Results

Option	[1]	[2]	[3]	[4]
Score	0.17	0.41	0.37	0.04

Figure 22 shows a sensitivity analysis of how the best option changes depending on the flood likelihood. A user may wish to choose an alternative response option based on this display. For example, they may have conflicting information regarding the climate event probability or they may want to pursue a somewhat riskier option or a somewhat more conservative option.

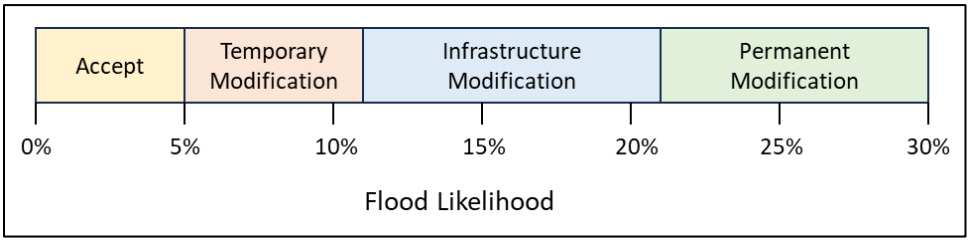

Figure 22: Sensitive Analysis of Preferred Option

5.0 Limitations & Future Work

Two important limitations exist in the approach developed thus far. First, it assumes that the risk response options will not impact the event probability (just its impact). Future work will overcome this limitation by considering the handling of response options that modify the climate impact likelihood. Second, the translation of the pairwise expected cost comparisons to the 1-9 AHP ranking scale should be made more robust. Future work will create a translation scheme that considers choices whose effectiveness are closely aligned, precluding the necessity to assign a score of 9 to the highest magnitude cost difference.

6.0 Acknowledgements

This work constitutes an ongoing project undertaken by the Boston University Metropolitan College Decision Science Research Laboratory (https://sites.bu.edu/met-dslab/). We acknowledge the contribution of Jingyi Wu who developed an earlier version of the RShiny code. The authors also thank Michael Pieroni who gave us valuable insights that helped us understand climate challenges facing facility planners and various risk mitigation strategies.

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Beyond Robustness: Exploring Supply Chain Fragility and Stability

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NOTE: At the request of the author, this manuscript is not included in these proceedings

Abstract

This paper explores the paradox of fragility and robustness within supply chain networks, exploring how strategies to enhance robustness, agility, and resilience may inadvertently contribute to greater organized complexity and systemic risk, resulting in fragility. The phenomenon, termed the "robust-yet-fragile" spiral, is identified in diverse systems such as financial systems, power grids, the internet, and ecological systems. This spiral emphasizes the inherent presence of failure in complex systems, where stability and failure are interconnected. The study demonstrates that supply chain networks exhibit key characteristics of the robust yet fragile framework. Robust yet fragile systems excel at managing anticipated threats but struggle when faced with unanticipated disruptions. Interconnected supply chains, while resilient to small disturbances, become fragile in the face of widespread disruptions. As system complexity increases, both the sources and severity of disruptions grow. Addressing the robust yet fragile paradox may necessitate new tools for managing systemic risk, enhancing supply chain visibility, and refining design. Creating greater supply chain visibility and developing early warning systems to contain local disruptions can prevent cascading effects.

COMPARING SUPPLY CHAIN PUBLICATIONS IN ACADEMIC JOURNALS AND NEWS PAPERS DURING THE PANDEMIC

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Abstract

The covid-19 pandemic has led to significant disruption to the global supply chain, especially to the food and medical supply chain. Numerous articles were published in academic journals and newspapers during the pandemic to discuss the impact of covid-19 on supply chain and the strategies to address these disruptions. This study compares the supply chain articles published in both academic journals and newspapers (Wall Street Journal and New York Times). Articles with the phrase "supply chain" in the title and published from 2020 to 2022 were chosen from the ProQuest database. 3,663 academic articles were obtained from ABI/INFORM Global, 4,777 articles were obtained from Wall Street Journal and 222 were from New York Times. Emotion analysis shows that academic papers exhibit fewer emotional expressions compared to newspaper articles, with fear being the dominant negative emotion in both. Newspapers experience more dramatic monthly emotional shifts. In addition, topic modelling using Latent Dirichlet Allocation (LDA) shows different topics were discussed in each source. Green Supply Chain and Sustainability are common themes in academic papers. The articles in Wall Street Journal focus more on the impact of current economic situation, federal reserve policy, and foreign relations/conflict on supply chain and business, while the articles in New York Times focus more on international trade and government policy in manufacturing and trade. In addition, electric vehicles are a popular topic in both Wall Street Journal and New York Times and however they do not appear as a dominant topic in academic papers.

Introduction

The COVID-19 pandemic caused widespread disruptions to global supply chains when many manufacturers in China were shut down due to the virus In January 2020. China is a major supplier of raw materials and intermediate goods to countries around the world, so this disruption had significant consequences. On March 11, 2020, The WHO characterized COVID-19 as a pandemic. California also becomes the first state to order all residents to stay home with the exceptions of going to an essential job or shopping for essential needs. As cases grow, hospitals become overwhelmed, and there is a nationwide shortage of personal protective equipment (PPE). Many food manufacturers were forced to destroy their products due to a lack of buyers, causing disruptions to the food supply chain. The COVID-19 pandemic also caused disruptions to the normal operation of businesses leading to a significant imbalance between supply and demand. This has increased the uncertainty and unpredictability faced by companies and their supply chains (Iftikhar et al., 2021; Tarigan et al., 2021).

The pandemic has catalyzed a critical reassessment of supply chain dynamics, highlighting vulnerabilities in what was previously perceived as a robust and resilient system. The pandemic's impact has been multifaceted, affecting various aspects of supply chains including manufacturing shutdowns, transportation delays, labor shortages, and fluctuating demand patterns. Particularly noteworthy is the disruption in the global distribution of raw materials and finished goods, which has underscored the interconnectedness and interdependency of modern supply chains. This disruption has not only affected the availability of products but also had a ripple effect on economic stability and business operations across industries. The ensuing challenges have prompted a reevaluation of supply chain strategies, emphasizing the need for greater agility, risk management, and a shift towards more localized and sustainable practices. The pandemic has thus served as a catalyst for a paradigm shift in supply chain management, underscoring the necessity for adaptability and resilience in the face of unforeseen global crises.

Numerous articles and academic papers have delved into the effects of supply chain disruptions during the pandemic, particularly focusing on strategies to mitigate these challenges. Cariappa et al. (2022) conducted a survey with 729 consumers and 225 farmers in India, revealing that pandemic-induced lockdowns have obstructed access to food markets. This disruption led to widespread food loss along the supply chain and increased wastage at the consumer level, coupled with a spike in prices. Similarly, Alan and Khatun (2021) observed that in Bangladesh, lockdowns severely restricted vegetable farmers' market access, adversely affecting their production

and sales capabilities. In the United States, Statacreu and LaBelle (2022) identified that global supply chain disruptions significantly contributed to cross-industry Producer Price Index (PPI) inflation from January to November 2021. Additionally, Nguemgaing & Sant'Anna (2021) found that announcements of supply chain disruption events, such as lockdowns and COVID-19 outbreaks, negatively impacted the stock market prices of meat processing companies. Sharma et al. (2022) explored the role of supplier visibility in adopting sustainable practices and enhancing supply chain performance during the pandemic. Their findings suggest that supply chain traceability and effective information sharing with customers positively influence visibility, offering a potential pathway to mitigate pandemic-related supply chain challenges.

Given the substantial volume of supply chain-related publications during the pandemic, comprehensively grasping the themes and content of these papers, as well as tracking the evolution of discussions over time, presents a significant challenge. This study aims to provide a holistic overview of the research and topics addressed in supply chain literature, encompassing both academic journals and newspapers, during the pandemic period. To achieve this, this study will employ Natural Language Processing (NLP) methodologies to explore the following key questions:

- What are the most popular subjects discussed in academic journals and newspapers (Wall Street Journal and New York Times) respectively?
- What words appear most frequently in the title of academic journals and newspapers (Wall Street Journal and New York Times)?
- What range of emotions (anger, disgust, fear, happiness, love, sadness and surprise) are prevalent in the content of academic journals and newspapers (Wall Street Journal and New York Times) respectively? How do those emotions vary on a monthly basis throughout the pandemic?
- What are the dominant supply chain topics covered in academic journals and newspapers (Wall Street Journal and New York Times) respectively? How do those topics evolve over the course of the pandemic?

Research Methodology

The data was obtained from ProQuest TDM studio, which provides licensed users to access many contents including newspapers, dissertations/theses, journals and many other sources in ProQuest Database, the dominant database used for academic research around the world. The user can search content on a particular topic and use built-in visualization to analyze the articles without coding. In addition, this platform also provided a Python Jupyter Notebook interface that allows a user to write his/her own code to analyze the data. Since it is copyright protected information, users can not export full paper out and they are allowed to export the output of the analysis with certain size restrictions.

For this study, three databases (ABI/INFORM Global, The Wall Street Journal and New York Times) were selected. For each database, all articles with a phrase "supply chain" in the title that were published between 2020 and 2022 were chosen. In addition, articles in ABI/INFORM Global were further filtered to "Scholarly Journals" using the Source Type field. In sum, 3,663 journal articles were obtained from ABI/INFORM Global (ABI/INFORM), 4,777 articles were obtained from Wall Street Journal (WSJ), and 222 were from New York Times (NYT).

Analysis and Discussion

This session will first discuss the number of supply chain articles, prevalent subject terms, and most frequently occurring words in the title of articles by each type of publications (Scholarly Journals, WSJ and NYT) between the years 2020 and 2022, followed by emotion analysis of the article by publication type. This session will then employ Latent Dirichlet Allocation (LDA), a widely recognized methodology in topic modelling to identify the dominant topics discussed in each type of publications.

Number of Supply Chain Articles by Publication Type

From Figure 1, It can be seen there is a big jump for academic papers in supply chain at the end of each year. The supply chain papers published in WSJ jumped at the start of the pandemic (March 2020) and has increased steadily in 2022 compared to the previous two years. There are few papers published in NYT compared to academic journals and WSJ. The big jump of academic journals may be related to the publication cycle of academic journals.

Table 1 shows the top 10 academic journals based on number of papers with the phrase "supply chain" appearing in the title. International Journal of Production Research, Annals of Operations Research, Supply Chain Management, International Journal of Logistic Management, and Benchmarking have published the most papers with a supply chain title.

Figure 1 Number of Supply Chain Publications between 2020 and 2022

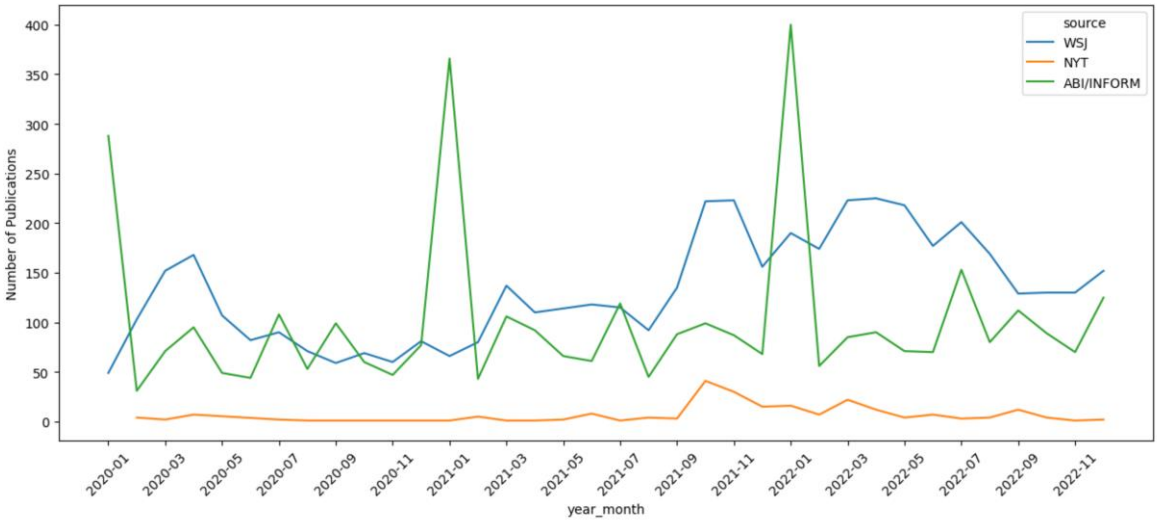


Table 1. Top 10 Academic Journals based on Number of Supply Chain Papers Published

Publication Title	**Number of Articles**
International Journal of Production Research	209
Annals of Operations Research	109
Supply Chain Management	98
International Journal of Logistics Management	91
Benchmarking	88
International Journal of Operations & Production Management	84
Production and Operations Management	80
Production Planning & Control	71
Environmental Science and Pollution Research	70
Logistics	65

Top Subject Terms by Publication Type

Table 2 shows top 20 subject teams by publication type. Supply Chains, Covid-19 and Manufacturing appear in all three types. Literature reviews, supply chain management, decision making, sustainability and logistics are top subject teams that only appear in academic journals; inflation, factories, interest rates, prices and consumers are the

subject terms that only appear in WSJ while ports, semiconductors and shortage only appear in NYT. It appears that each publication type has different focus when discussing supply chain during the pandemic.

Word Cloud based on Article Titles by Publication Type

Figure 2.1-2.3 show word cloud based on article title for each type. For academic journal papers, the most frequent words are management, resilience, network, performance, green, strategy, model, impact, analysis and risk. For WSJ articles, news, business, inflation, exchange, world, stock, and China are most frequent words. The most frequently occurring words in NYT includes problem, crisis, global, Biden and global among others. It seems that academic journal papers focus more on green/sustainable supply chain, and supply chain strategy and performance, WSJ focuses more on the impact of covid on both supply chain and business, while NYT focuses more on crisis and government policy on pandemic.

Table 2. Top 20 Subject Teams by Source

subject	ABI/INFORM	NYT	WSJ	Total
Supply chains	4538	188	667	**5393**
COVID-19	536	50	1639	**2225**
Pandemics		108	1617	**1725**
Coronaviruses		41	1225	**1266**
Supply chain management	1208			**1208**
Manufacturing	498	45	526	**1069**
Suppliers	891	29		**920**
Literature reviews	838			**838**
Decision making	722			**722**
Sustainability	704			**704**
Logistics	496			**496**
Inflation			439	**439**
Collaboration	417			**417**
Factories		52	341	**393**
Interest rates			392	**392**
Prices			332	**332**
Consumers			303	**303**
Ports		41		**41**
Semiconductors		34		**34**
Shortages		32		**32**
Total	**10848**	**620**	**7481**	**18949**

Figure 2.1 Word Cloud for Article Titles in ABI/INFORM

Figure 2.2 Word Cloud for Article Titles in WSJ

Figure 2.3 Word Cloud for Article Titles in NYT

Emotion Analysis

Emotion analysis was performed using pre-trained sentence-transformer (nli-mpnet-base-v2) to first map sentences & paragraphs to a 768 dimensional dense vector space and then Sentence-BERT model (SBERT) was use to evaluate each tweet and assign a raw probability for each label (anger, disgust, fear, happiness, love, sadness and

surprise). This analysis was carried out using Jupyter Notebook within the TDM Studio website. The results were shown in Figure 3.1-3.3.

For the academic papers in ABI/INFORM, the top emotions are surprise, happiness, disgust, followed by fear. There are dramatic changes in fear during the pandemic. October in 2022 has the highest fear score followed by May in 2021 and October in 2021.

For the supply chain articles in WSJ, fear becomes the second highest emotion following by surprise. Fear has the highest score in February in 2020 at the start of the pandemic, followed by December 2020 and December 2021 and March 2022.

For the NYT articles, the overall emotion is more dynamic. There is a big jump in fear in a few months. In addition, anger became the highest emotion in March 2021 and November 2022.

Figures 4.1 to 4.3 compare the three negative emotions (anger, sadness, and fear) across the three publication types. The data reveals that, in general, academic papers exhibit lower scores for anger and sadness compared to those in the WSJ and the NYJ across all months. As for the fear score, the pattern is less distinct; each source alternates in registering the highest score in different months, indicating a more variable expression of fear across these publications.

In sum, academic papers typically exhibit fewer emotional expressions compared to newspaper articles. In both types of publications, fear emerges as the most prominent negative emotion. The emotional tone can vary monthly, with newspapers showing more dramatic fluctuations in emotional expression than academic papers.

Figure 3.1 Emotion over Time for Academic Papers in ABI/INFORM

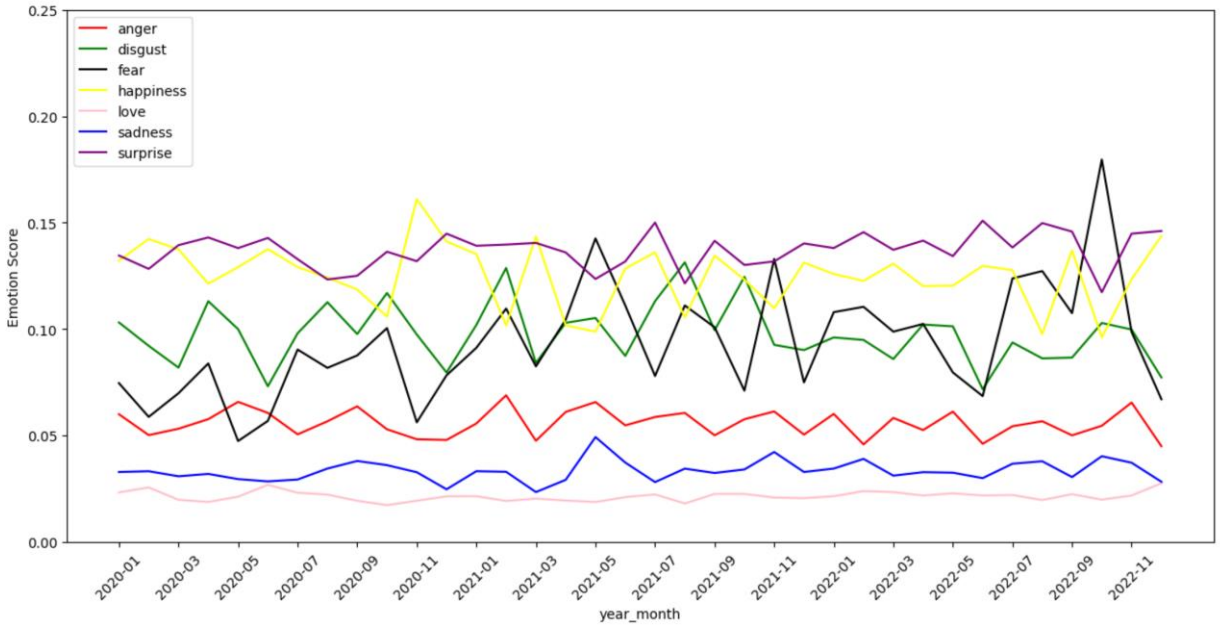


Figure 3.2 Emotion over Time for Wall Street Journal Articles

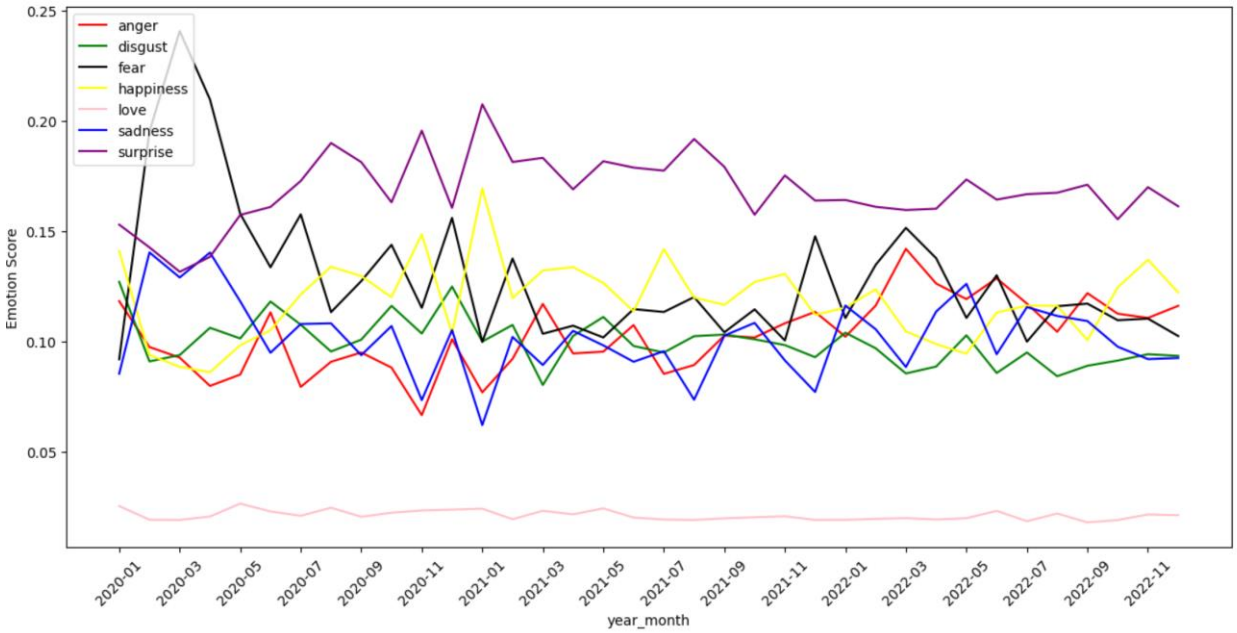


Figure 3.3 Emotion over Time for New York Times Articles

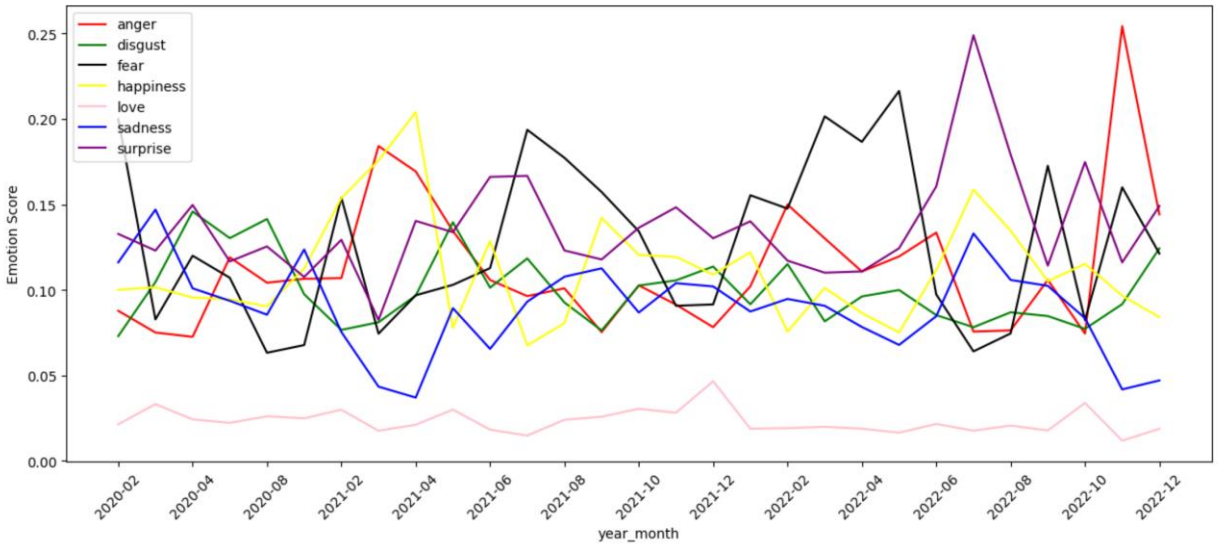


Figure 4.1 Anger Score Over Time by Source

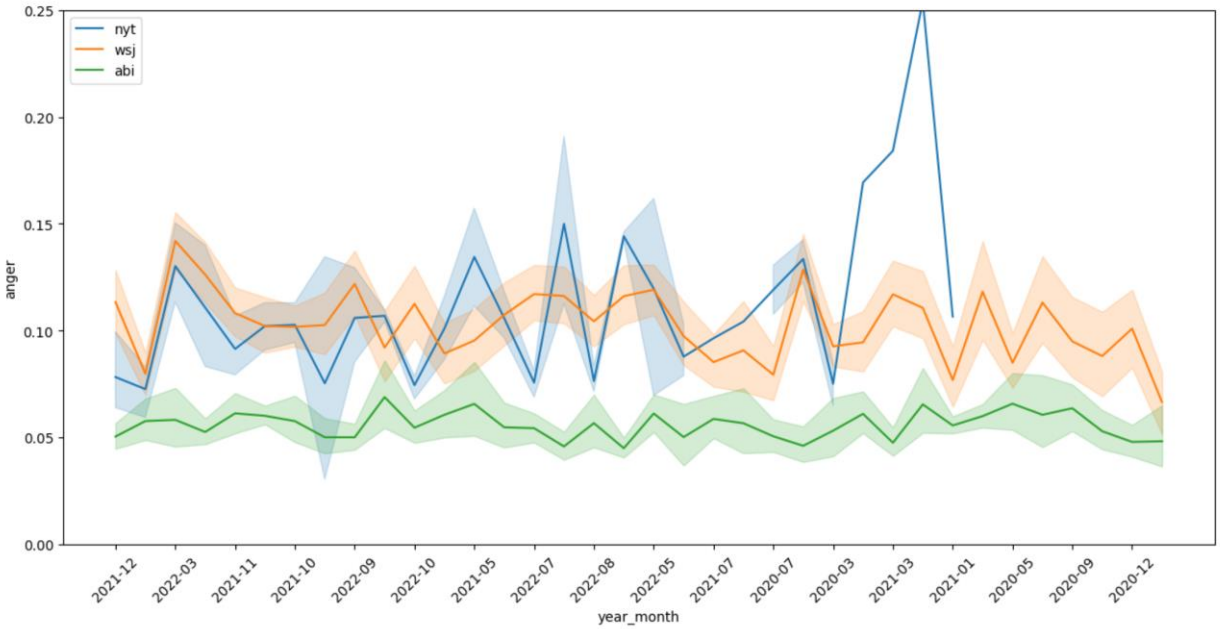


Figure 4.2 Sadness Score Over Time by Source

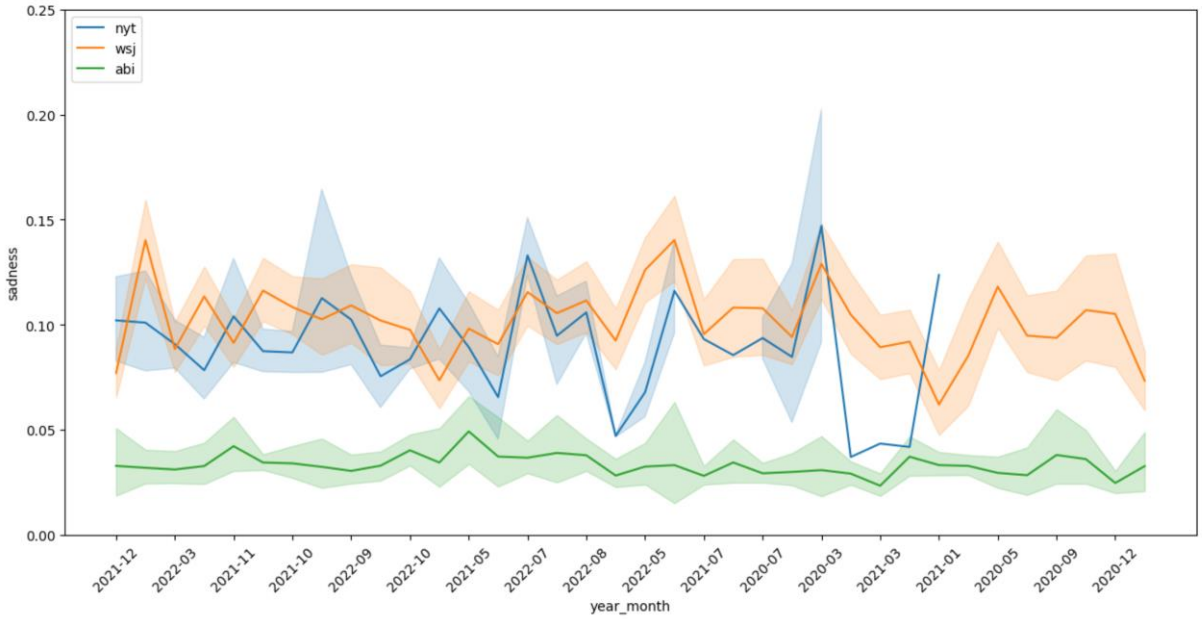
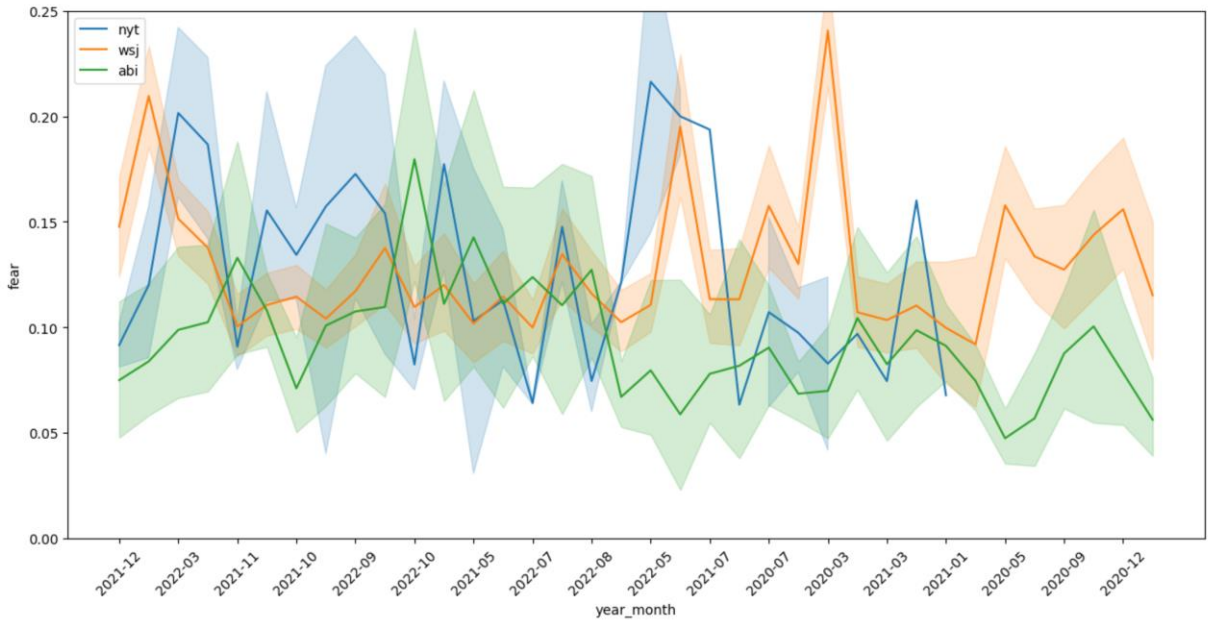


Figure 4.3 Fear Score Over Time by Source



Topic Modelling by Publication Type

Topic modeling is an unsupervised machine learning technique that can scan a set of documents to detect words and phrase patterns within them and then cluster word groups and similar expressions that best characterize a set of documents. One popular methodology in topic modeling is Latent Dirichlet Allocation (LDA), a generative probabilistic model that assumes each topic is a matrix over an underlying set of words, and each document is a mixture of a set of topic probabilities.

LDA is used to identify dominant topics in each publication type, the results are shown in Table 3 and Figure 5.1-5.3. Table 3 shows the type, top 30 most relevant terms for each topic. Based on the top 30 most relevant terms and a name was given to each topic.

For the academic papers, the five emerging topics are Blockchain and Internet of Things (IOT), Retailer and Closed Loop Supply Chain, Green Supply Chain, Supply Chain Resilience and Risk Management, and Sustainable Food Supply Chain. Those topics primarily center on strategies for managing supply chain disruption encountered during the pandemic.

For WSJ, the dominant topics are Electric Vehicles, Inflation and Federal Reserve Policies, Retailers and online stores, US-China Relations and Russia-Ukraine Conflict. The articles in WSJ focus more on the impact of the covid-19 pandemic on current economic situation, Federal Reserve policy, and foreign relations/conflict on supply chain and business.

For NYT, the emerging topics are Logistics and Shipping Industry, Electric Vehicles, Forced Labor and International Trade Issues, Report from Peter Goodman in Global Economy, and Biden Administration's Policy on Manufacturing and Trade. It seems that the articles in NYT concentrate predominantly on international trade and government policies related to manufacturing and trade. Furthermore, the topic of electric vehicles is a popular topic in both WSJ and NYT, and however it does not appear as a dominant topic in academic papers.

Figure 6.1-6.3 show how each topic has shifted from month to month between 2020 and 2022 for each publication type. The average probability of top 30 words in each month for each topic was used to represent the probability of that topic.

Figure 6.1 shows that the topics of Retailers and Closed Loop Supply Chain, Green Supply Chain and Supply Chain Resilience and Risk Management received more discussion than the other two topics (Blockchain and IOT, and Sustainable food Supply Chain). In addition, there are big shifts of these topics over the months. The dominant theme in the academic papers during the pandemic is supply chain sustainability since both green supply chain and

closed-loop supply chain are centered around environmental sustainability and resource efficiency in supply chain operations.

For the WSJ articles in Figure 6.2, Retailers and Online Store and US-China Relations received more discussion at the year 2020, the start year of the pandemic, the topics then switched to Inflation and Federal Reserve Policies and Electric Vehicles in the years of 2021 and 2022. For the NYT articles, Electric Vehicles and Forced Labor/International Trade Issues are dominant topics during the pandemic.

Table 3. Topic Modelling by Publication Type

Publication Type	Top 30 words	Topic Name
Academic Papers in ABI/INFORMS	doi, blockchain, https, org, journal, doi org, https doi, digital, international journal, resilience, agility, scm, big, lean, big data, analytics, scf, adoption, doi https, iot, papers, articles, smart, vol, blockchain technology, applications, security, management https, engineering, visibility	Blockchain and IOT
	retailer, manufacturer, profit, optimal, channel, carbon, contract, green, unit, quantity, fig, emission, retail, scenario, parameters, game, optimization, retailers, pricing, profits, wholesale, closed, loop, closed loop, journal, operations research, center, revenue, algorithm, loop supply	Retailer and closed loop supply chain
	green, scm, gscm, trust, sci, dimensions, constructs, governance, test, measurement, employees, validity, items, sample, smes, respondents, structural, positively, capability, journal, learning, reliability, culture, variable, relational, buyer, fit, construct, corporate, information sharing	Green supply chain
	covid, resilience, pandemic, disruptions, disruption, health, crisis, risk management, local, china, que, covid pandemic, humanitarian, events, sourcing, disaster, global supply, workers, interviews, com, stock, people, public, port, transport, country, event, actors, scrm, para	Supply Chain Resilience and Risk Management
	food, https, doi, org, doi org, https doi, fuzzy, waste, energy, farmers, food supply, journal, agricultural, green, barriers, consumers, consumption, sustainable supply, matrix, halal, circular, producers, safety, packaging, local, china, water, agri, agriculture, traceability	Sustainable Food Supply chain
WSJ	billion, sales, quarter, production, car, electric, vehicles, auto, industry, demand, million, chip, makers, tesla, market, maker, chief, energy, revenue, vehicle, power, profit, battery, analysts, prices, share, cars, earlier, costs, executive	Electric vehicles
	inflation, prices, fed, economy, rates, rate, growth, market, investors, higher, bank, economic, spending, month, price, rose, labor, consumer, stocks, demand, high, quarter, rising, policy, central, federal, markets, index, fell, week	Inflation and Federal Reserve Policies
	sales, people, business, stores, home, million, like, says, chief, workers, products, customers, online, food, billion, employees, retailers, store, amazon, executive, demand,	Retailers and online stores

	market, including, walmart, just, consumers, firm, items, brands, make	
	china, government, biden, chinese, world, people, covid, president, trade, administration, health, state, officials, economic, american, countries, trump, country, vaccine, global, including, national, public, make, house, federal, security, policy, technology, manufacturing	US-China Relations
	prices, russia, oil, ukraine, global, world, gas, russian, goods, energy, shipping, china, europe, demand, trade, production, ports, food, costs, country, war, freight, port, ships, higher, container, long, imports, european, countries	Russia-Ukraine Conflict
NYT	ports, port, drivers, food, shipping, rail, containers, truck, biden, factories, trucks, container, trade, los, los angeles, angeles, trucking, administration, house, president, american, freight, long, help, california, ships, going, consumers, industry, transportation	Logistics and Shipping Industry
	ford, percent, quarter, tesla, sales, billion, workers, inflation, shipping, market, factories, business, vehicles, factory, electric, chief, price, cars, chips, costs, problems, expected, million, wednesday, higher, industry, businesses, apple, york times, american	Electric Vehicles
	xinjiang, chinese, labor, workers, ports, forced, government, russia, union, work, industry, materials, shipping, forced labor, trade, ukraine, lockdowns, factories, emissions, including, economy, long, high, according, report, shanghai, auto, officials, international, contract	Forced Labor and International Trade Issues
	peter, city, businesses, goodman, peter goodman, countries, workers, manufacturers, right, trade, brooklyn, factory, report, work, manufacturing, yard, government, local, need, economic, long, governments, international, organization, labor, ships, things, navy, navy yard, crisis	Report from Peter Goodman in Global Economy
	american, trade, biden, chips, administration, critical, manufacturing, america, president, economic, masks, policy, materials, executive, manufacturers, costs, capacity, domestic, robots, workers, semiconductor, semiconductors, need, long, supplies, making, dps, farrell, industry, going	Biden Administration's Policy on Manufacturing and Trade

Figure 5.1 Topic Modelling for Academic Papers in ABI/INFORMS

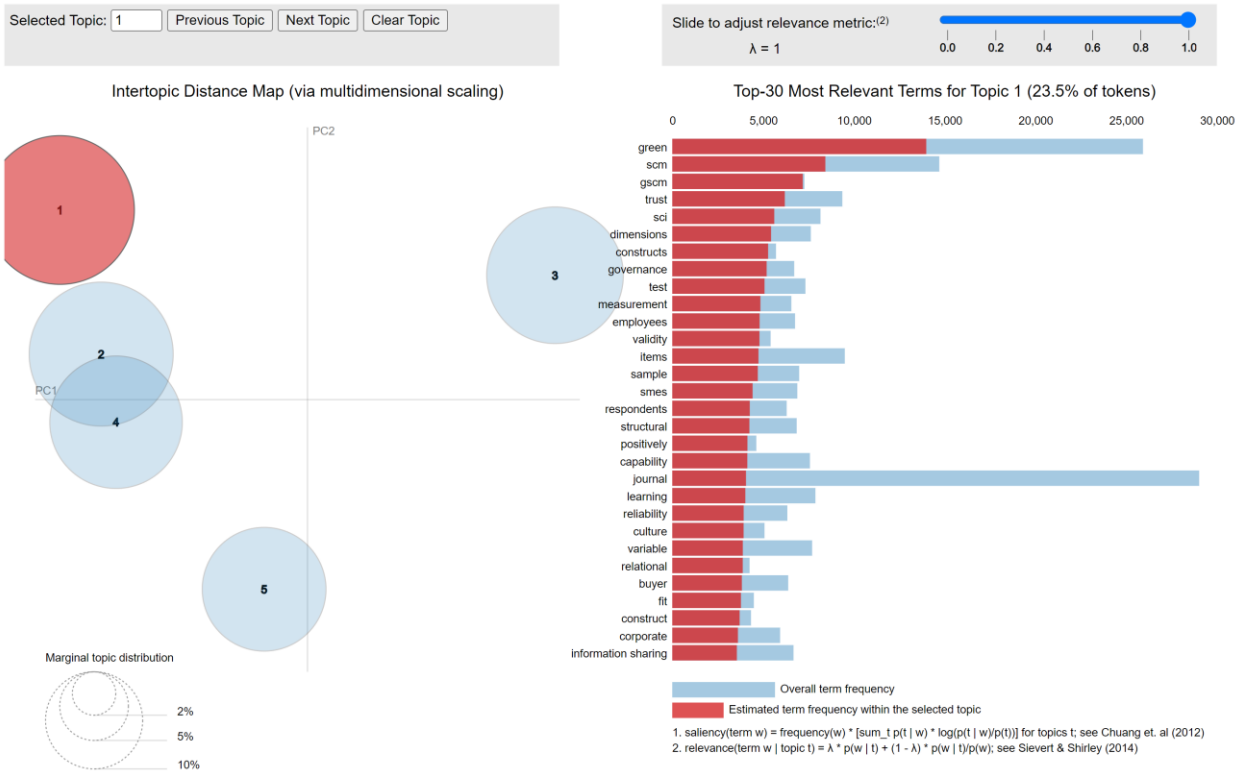

Selected Topic: 1
Previous Topic
Next Topic
Clear Topic
Slide to adjust relevance metric:(2)
λ = 1
0.0
0.2
0.4
0.6
0.8
1.0
Intertopic Distance Map (via multidimensional scaling)
PC2
PC1
1
2
3
4
5
Marginal topic distribution
2%
5%
10%
Top-30 Most Relevant Terms for Topic 1 (23.5% of tokens)
0
5,000
10,000
15,000
20,000
25,000
30,000
green
scm
gscm
trust
sci
dimensions
constructs
governance
test
measurement
employees
validity
items
sample
smes
respondents
structural
positively
capability
journal
learning
reliability
culture
variable
relational
buyer
fit
construct
corporate
information sharing
Overall term frequency
Estimated term frequency within the selected topic
1. saliency(term w) = frequency(w) * [sum_t p(t | w) * log(p(t | w)/p(t))] for topics t; see Chuang et. al (2012)
2. relevance(term w | topic t) = λ * p(w | t) + (1 - λ) * p(w | t)/p(w); see Sievert & Shirley (2014)

Figure 5.2 Topic Modelling for Supply Chain Articles in WSJ

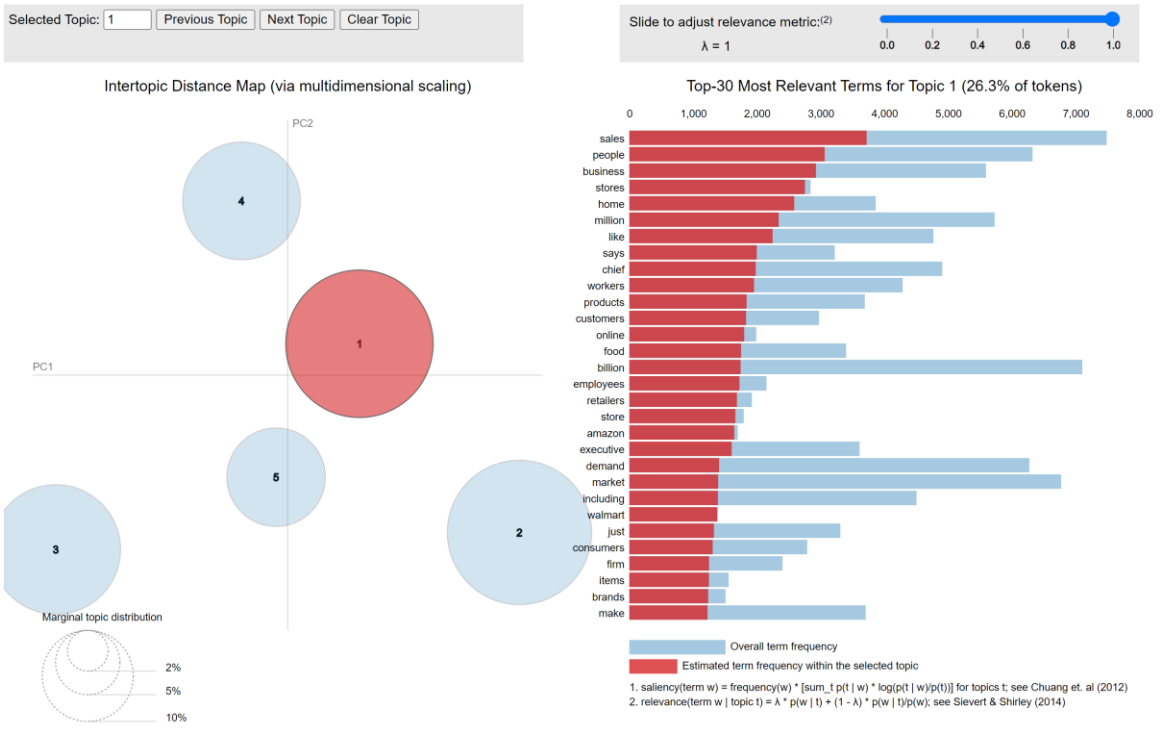


Figure 5.3 Topic Modelling for Supply Chain Articles in NYT

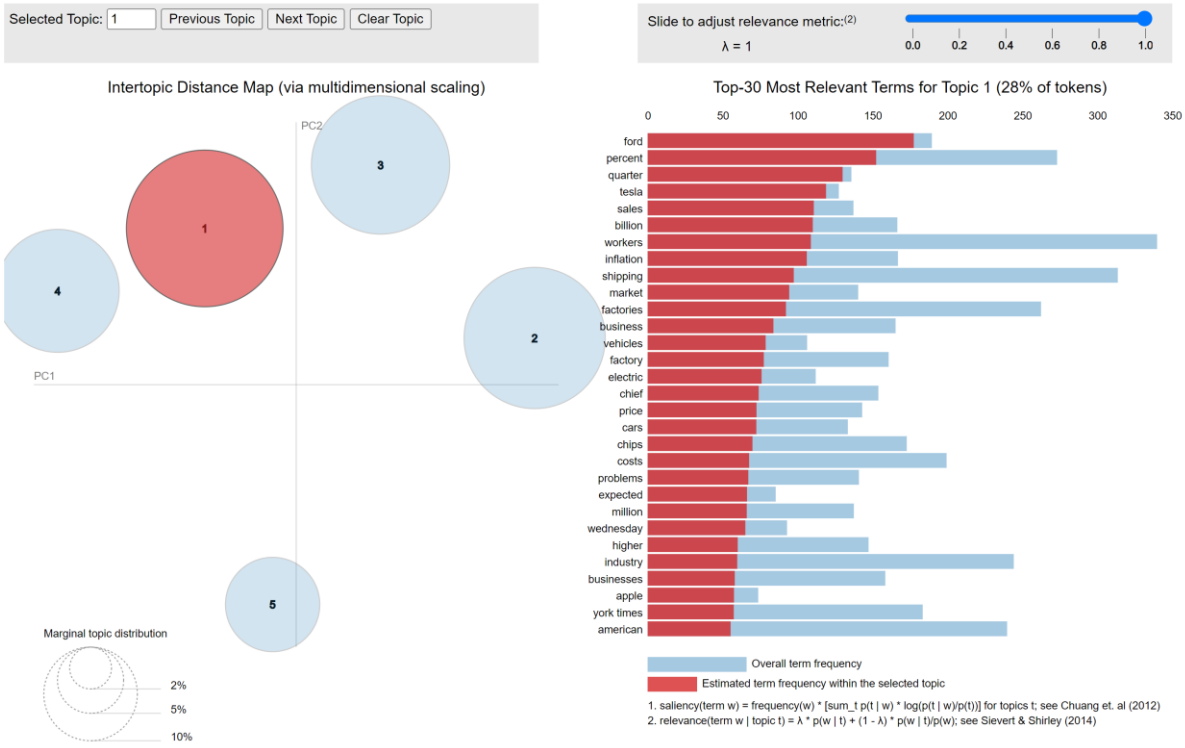


Figure 6.1 Time Line of Topic Didscussion between 2020 and 2022 for Academic Journal Papers

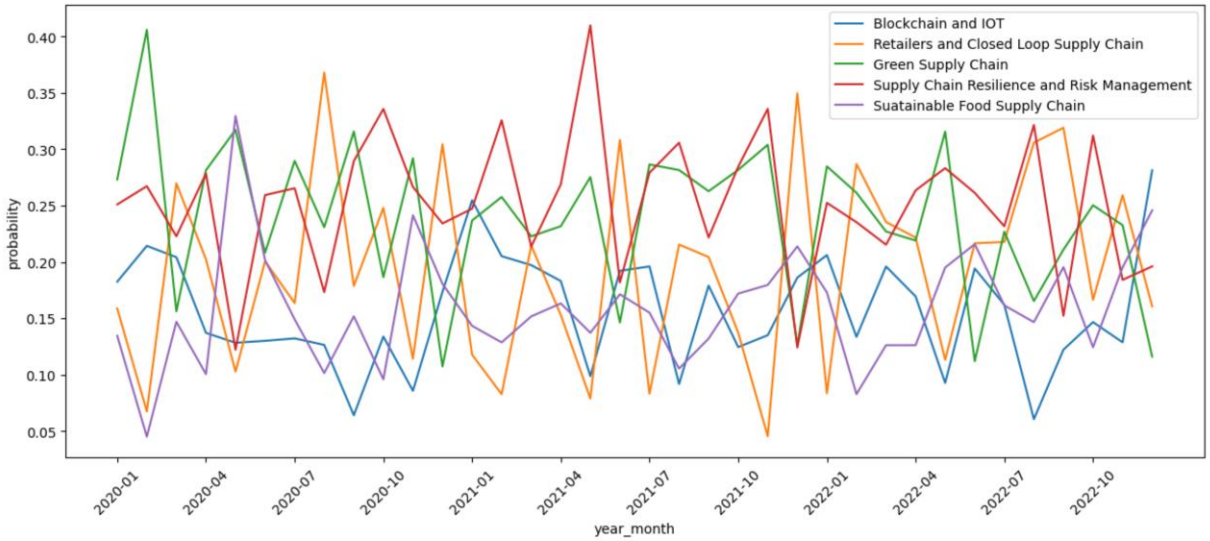


Figure 6.2 Time Line of Topic Didscussion between 2020 and 2022 for Wall Street Journal Articles

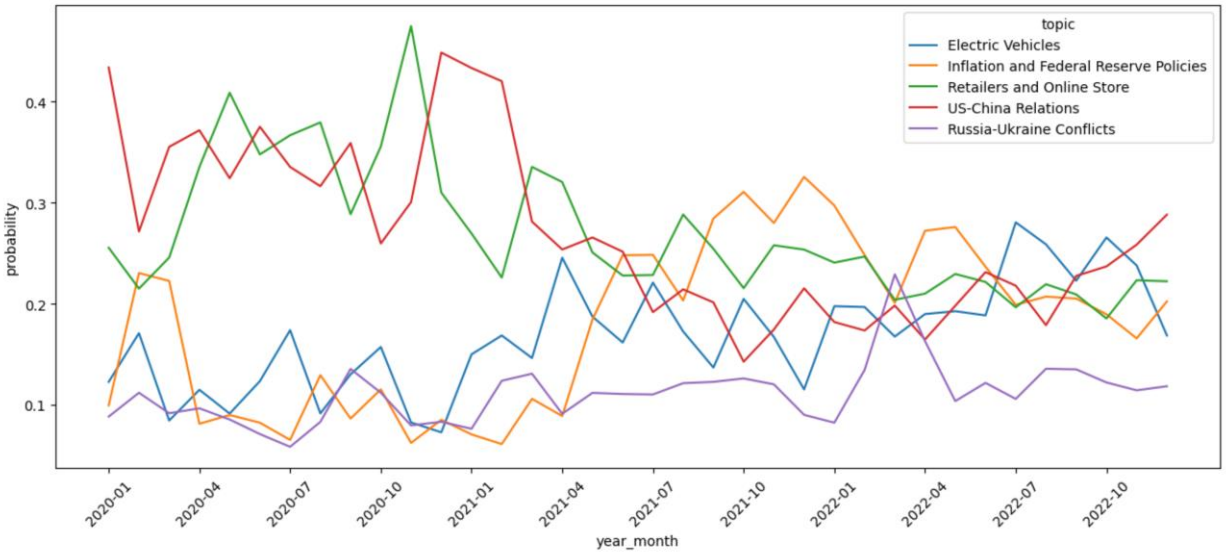
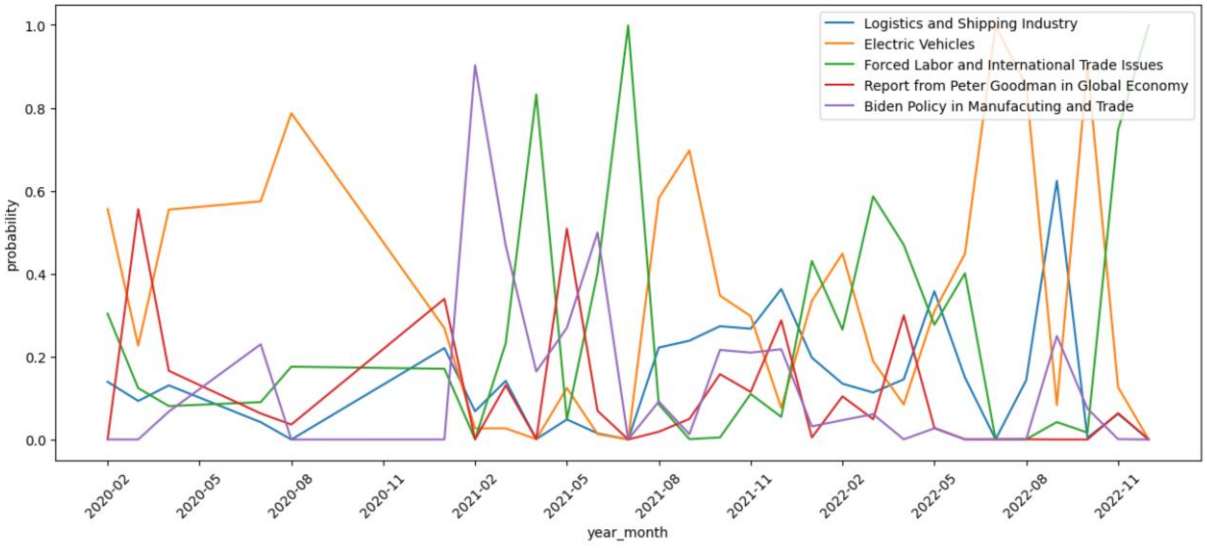


Figure 6.3 Time Line of Topic Didscussion between 2020 and 2022 for New York Times Articles



Conclusion and Implication

This research conducts a comparative analysis of supply chain-related articles from academic journals and newspapers, specifically the Wall Street Journal and the New York Times. Emotion analysis revealed that academic articles generally contain fewer emotional expressions than their newspaper counterparts, with fear being the most prominent negative emotion in both mediums. Newspapers, however, exhibit more pronounced monthly fluctuations in emotional tone. Furthermore, topic modeling using Latent Dirichlet Allocation (LDA) highlighted distinct discussion themes in each source. Academic papers frequently addressed Green Supply Chain and Sustainability. Wall Street Journal articles tended to focus on the effects of the current economic climate, Federal Reserve policies, and international conflicts on supply chains and business. In contrast, New York Times pieces were more oriented towards international trade and government policies in manufacturing and trade. Additionally, the topic of electric vehicles was notably popular in both the Wall Street Journal and the New York Times, but this was not the case in academic publications.

This research offers insightful implications for both academic and industry professionals. The finding that academic articles contain fewer emotional expressions than newspaper articles suggests a more objective and analytical approach in academic discourse. This could influence how supply chain issues are communicated and understood by different audiences. The prominence of fear as a negative emotion in both mediums highlights the pervasive concern about supply chain disruptions, which could guide policymakers and business leaders in addressing these anxieties. The distinct thematic focus of each source – sustainability in academia, economic and geopolitical impacts in the Wall Street Journal, and international trade and government policies in the New York Times – underscores the multifaceted nature of supply chain discussions. This diversity suggests that a comprehensive understanding of supply chain issues requires integrating perspectives from various sources. The notable interest in electric vehicles in mainstream newspapers, but not in academic journals, points to a potential gap in academic research, which could be crucial for understanding future trends in supply chain management and sustainability.

The study, while comprehensive, has certain limitations that open avenues for future research. One limitation is the focus on only two newspapers and academic journals, which may not fully represent the media and academic landscape. Future research could include a broader range of sources to capture a more diverse range of perspectives. Additionally, the emotion analysis, while revealing, is based on textual analysis and may not fully capture the nuances of emotional expression in different types of publications. Future studies could incorporate qualitative methods, such as interviews or content analysis, to gain deeper insights into the emotional undertones of supply chain discussions. The discrepancy in the coverage of topics like electric vehicles between newspapers and academic journals also suggests an area for further investigation. Future research could explore why certain topics gain traction in popular media but not in academic discourse, potentially leading to a more integrated approach to supply chain research that bridges the gap between academic and public interests.

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Sustainability

University of Bridgeport

College of Engineering, Business, and Education

Ph.D. Dissertation Prospectus

CT's BIL: Preparing Techs for EV Transition

By: Saddam Alkhamaiesh

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November 2023

1.Abstract

This dissertation addresses the critical demand for qualified electric vehicle (EV) technicians within the United States, specifically during the pivotal transition from conventional fossil fuel-powered vehicles to EVs. Concentrating on Connecticut, the study meticulously examines the state's strategic planning initiatives to facilitate a seamless transition for prospective technicians entering the burgeoning EV industry. The primary objective is to evaluate the preparedness of educational institutions within the state, scrutinizing state-level support mechanisms to meet the escalating demand for adept EV technicians effectively. Expanding beyond the confines of Connecticut, the research comprehensively delves into the application of change management models to incentivize the nationwide adaptation of EV-centric training paradigms among educational institutions and incumbent mechanics. The study delves into the intricate motivations propelling mechanics to acquire essential skills for EV maintenance at the national level. Aligned with overarching national initiatives, including White House financial allocations dedicated to EV infrastructure development, this research covers the temporal span from 2022 to 2026. Offering invaluable insights for Connecticut, educational institutions, and prospective EV technicians nationally, this dissertation provides a nuanced and exhaustive guide for navigating the dynamic terrain of electric vehicle technology training programs within the evolving context of national policies and industry demands.

2. Table of Contents

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5.0 Chapter One: Introduction

Embracing Change: The Automotive Industry's Shift Toward Electric Power

In transformative endeavors, the adage "Change requires risk" is a poignant reminder that evolution is often synonymous with risk-taking. The transformation is especially pertinent in societal and industrial shifts necessitated by looming risks and potential adverse outcomes. Addressing specific risks or negative consequences compels individuals and industries to embark on transformative journeys. A vivid illustration of this imperative is evident in the contemporary challenges faced by the automotive industry, which is currently navigating a profound transition catalyzed by the exigencies of climate change.

Various intergovernmental organizations have ardently advocated for decisive decarbonization measures in response to the multifaceted challenges of climate change. These measures are essential to mitigate the risk of surpassing critical global temperature thresholds, notably 1.5°C or two °C (Llopis-Albert et al., 2021). The automotive sector is particularly significant, the third-largest contributor to energy consumption and carbon emissions (Guo et al., 2023). As the industry grapples with the imperative to align with sustainability goals, electric vehicles (EVs) have emerged as a pivotal technological frontier.

Distinguished by their capacity to produce zero direct emissions, electric vehicles have garnered attention as a potent means to significantly reduce carbon emissions, ranging from 30% to 50% (Mohammadzadeh et al.,2022). The societal resonance of EVs extends beyond environmental considerations, encompassing heightened anticipation due to their potential to enhance energy security, reduce emissions, and achieve unprecedented fuel efficiency (Guo et al., 2023). Thus, the transition towards electric vehicles transcends a mere shift in propulsion technology; it represents a strategic realignment of the entire automotive landscape.

The strategic transition from fossil fuel dependence to electricity as a primary power source is not merely an industry trend but a pivotal response to the imperative of sustainability. This metamorphosis is emblematic of the industry's commitment to confronting risks associated with climate change, underscoring a profound paradigm shift towards responsible and forward-thinking practices. As the automotive industry navigates this transformative trajectory, it is poised to redefine its role in the global energy landscape, contributing to a more sustainable and resilient future.

From Humble Beginnings to Global Revolution: The Story of Electric Vehicles

The annals of electric vehicles (EVs) unfold a narrative that extends back to the 19th century, marking the inaugural venture into automotive electrification. Nevertheless, the ascendancy of internal combustion engines throughout the 20th century gradually eclipsed the prominence of electric cars, as illustrated in Table 1 (Climent et al., 2021). The tumultuous backdrop of the oil crisis in the 1960s spurred governmental initiatives to investigate alternative fuel modalities for automobiles, leading General Motors to spearhead advancements in battery-powered vehicles. The ensuing epochs witnessed profound strides in battery technology, precipitating cost reductions and heightened performance metrics. A transformative juncture materialized in 2008 with the advent of Tesla Motors, introducing a luxury sedan distinguished by an unprecedented battery range. By the temporal vantage point 2020, the global electric vehicle fleet had transcended the symbolic threshold of two million units (Hossain et al., 2022). These milestones underscore the intricate trajectory of electric vehicles, elucidating their potential to orchestrate a paradigmatic upheaval within the automotive industry. An exhaustive comprehension of the historical continuum and technological progressions within this domain assumes paramount significance for policymakers, researchers, and industry stakeholders actively engaged in sculpting a sustainable and electrified future of transportation.

Table 20:The History of Electric Vehicle.

Year	Milestone
1832	Robert Anderson built the first electric carriage.
1859	Gaston Planté invents the lead-acid battery.
1884	Thomas Parker built the first practical electric car.

1891	William Morrison patents the first successful EV.
1900	Electric vehicles comprise about one-third of all cars.
1912	Charles Kettering invents the electric starter motor.
1960s	Electric vehicles regain popularity during the oil crisis.
1996	General Motors released the EV1 electric car.
2008	Tesla Motors introduces the Tesla Roadster.
2010	Nissan released the Nissan Leaf, a mass-market EV.
2012	Tesla releases the Model S, an all-electric luxury sedan.
2020	Electric vehicles account for over 2 million sales globally.

Governments Initiatives Driving the Global Transition to Electric Vehicles

Governments are formulating and implementing strategic policies to expedite the paradigm shift from traditional internal combustion engine vehicles to electric vehicles (EVs). In the People's Republic of China, for instance, the government has deftly devised a subsidy framework, demonstrating a notable efficacy in incentivizing the widespread adoption of EVs (Yang et al., 2022). Simultaneously, in Thailand, governmental initiatives extend beyond mere subsidies, encompassing preferential pricing structures for electric vehicle batteries and comprehensive support mechanisms targeting the overall cost of ownership, indicative of a multifaceted approach to catalyze EV integration into the automotive landscape (Suttakul et al., 2022).

Within the United States, the Internal Revenue Service (IRS) has introduced a pivotal fiscal instrument: a $7,500 tax credit applicable across the spectrum of electric vehicles strategically tailored to stimulate consumer proclivity towards EV acquisition (IRS, 2023). The year 2022 witnessed the legislative enactment of the Bipartisan Infrastructure Law (BIL) in the United States, a pivotal statutory instrument delineating the governmental trajectory and commitment towards orchestrating a substantial transition from fossil fuel dependency to an era dominated by electric mobility, spanning the expansive timeline from 2022 to 2050 (Zefirova & Shadrinaa, 2022).

The Biden-Harris Administration's Vision for an Electric Vehicle Revolution

In June of 2022, the Biden-Harris Administration unveiled a seminal policy initiative, epitomized by the publication entitled "FACT SHEET: Biden-Harris Administration Announces New Standards and Major Progress for a Made-in-America National Network of Electric Vehicle Chargers." This pioneering legislative framework serves as a cornerstone for the extensive proliferation of electric vehicles (EVs) and the concomitant establishment of a resilient EV charging infrastructure across the expansive landscape of the United States. Central to the profundity of this visionary plan is the administration's aspiration to realize a 50% electric vehicle penetration within the American vehicular milieu, with the overarching objective of achieving a fully zero-emission vehicle fleet by the temporal horizon of 2050. An appreciable fiscal commitment of $7.5 billion has been earmarked to undergird the operationalization of this transformative vision, demarcated into two expansive programs of strategic import (The White House, 2023). The inaugural program, designated the National Electric Vehicle Infrastructure (NEVI), is slated to receive five billion dollars expressly allocated to deploying EV charging stations throughout the 50 states, the District of Columbia, and Puerto Rico (The White House, 2023). The second program, under the aegis of the Department of Energy, is entrusted with the disbursement of 2.5 billion dollars in grants, disseminated judiciously to businesses and eligible individuals, with the express purpose of catalyzing the development and installation of EV charging infrastructure.

Beyond the discernible environmental advantages, this epochal legislation aspires to engender the creation of remunerative employment opportunities within the domains of manufacturing and installation, thereby necessitating the formulation of tailored training and educational initiatives to meet the burgeoning demand for skilled labor during this epochal transition toward electric mobility.

The National Electric Vehicle Infrastructure Program (NEVI)

The National Electric Vehicle Infrastructure (NEVI) program, implemented through the Bipartisan Infrastructure Law (BIL) by the White House, is a comprehensive initiative to facilitate the transition to zero-emission transportation in the United States by 2050 (U.S. Department of Transportation, 2023). With an annual budget of $5 billion for five years, the U.S. Department of Transportation (DOT) and the U.S. Department of Energy collaborated with all 50 states starting in 2022 to establish a clear roadmap for achieving this ambitious goal (U.S. Department of Energy, 2022). As part of NEVI, each state must formulate a strategic plan based on the allocated budget, focusing on developing an extensive charging network for electric vehicles. Furthermore, a portion of the funding allocated to each state will be dedicated to training and educational initiatives, ensuring a well-prepared workforce capable of supporting the evolving electric vehicle infrastructure.

The Rise of Electric Vehicles and Their Impact on Employment Opportunities

Electric vehicles (EVs) stand at the forefront of transformative economic opportunities, particularly within burgeoning sectors like electric vehicle charging infrastructure and the nascent domain of computer science dedicated to the intricate design and maintenance of the sophisticated computer systems embedded in EVs, as elucidated in Table 2 (Indeed Team, 2023). The advent of EVs necessitates the adaptation of conventional automotive mechanics to address their distinctive concerns and mandates a strategic pivot toward specialized expertise in electric vehicle technology. This imperative shift is underscored by the profound dissimilarity between conventional internal combustion engines and their zero-emission electric counterparts, a transition catalyzed by governmental initiatives to mitigate emissions.

Table 21: Electric Vehicle Jobs.

Job Title	National Average Salary	Primary Duties
Mechatronics Technician	$55,787 per year	Install, maintain, and repair electric vehicle components.
Marketing Manager	$64,328 per year	Develop and execute marketing strategies for electric vehicles.
Auto Body Technician	$64,803 per year	Repair and restore damaged electric vehicles.
Auto Estimator	$65,928 per year	Estimate the cost of repairs for damaged electric vehicles.
Site Surveyor	$66,651 per year	Survey potential sites for electric vehicle charging stations.
Industrial Designer	$67,756 per year	Design the look and feel of electric vehicles.
Automotive Service Manager	$67,796 per year	Oversee the maintenance and repair of electric vehicles.
Car Sales Executive	$70,328 per year	Sell electric vehicles to customers.
Mechanical Engineer	$83,500 per year	Design and develop the mechanical components of electric vehicles.
Chemical Engineer	$85,000 per year	Develop and improve the battery technology for electric vehicles.
Process Engineer	$87,500 per year	Develop and optimize the manufacturing processes for electric vehicles.

Electrical Engineer	$90,000 per year	Design and develop the electrical components of electric vehicles.
Communications Engineer	$92,500 per year	Develop and maintain telecommunications systems for electric vehicles.
Software Engineer	$95,000 per year	Develop the software for electric vehicles.

Funding Allocation and Educational Objectives in NEVI

Strategic Plans

The state of New Hampshire is poised to receive a substantial financial infusion of $225 million over a five-year period as part of the Strategic Plan for the New Energy and Vehicle Initiative (NEVI). To optimize the utilization of these funds, the NEVI initiative in the state aims to foster collaborations with esteemed universities, with the overarching goal of generating high-quality employment opportunities that align with the visionary objectives of the Bureau of Innovation and Leadership (B.I.L.) within the New Hampshire Department of Transportation (D.O.T.) (New Hampshire, 2023). To ensure a judicious and targeted allocation of resources, it is imperative for the strategic plan to delineate a specific budgetary framework explicitly dedicated to educational pursuits.

Similarly, Arizona has been allocated funding commensurate with New Hampshire under the auspices of the Strategic Plan for NEVI. However, Arizona's strategic plan must explicate the explicit support mechanisms tailored toward educational objectives (Arizona, 2022).

Conversely, according to the Strategic Plan for NEVI, Michigan State stands to receive an allocation exceeding $600 million, with notable earmarking of $130 million designated explicitly for educational initiatives (Michigan, 2022). The present research endeavors to scrutinize the proposed allocation of $600 million for the state of Connecticut, drawing parallels with Michigan State's funding. However, Connecticut's strategic plan is incumbent upon providing a more comprehensive explanation regarding the budgetary allocations directed toward education and training (Connecticut, 2022). While the plan duly emphasizes collaborative efforts with the University of Connecticut, a potential oversight exists concerning capitalizing on opportunities for other educational institutions to benefit from the support extended by the B.I.L.

This research also aspires to investigate the avenues through which current stakeholders in the automotive industry, mainly mechanics, can avail themselves of state-level support. This inquiry is particularly germane in aligning with the White House's overarching vision, which aims to effectuate a transition from conventional fossil fuel-powered vehicles to electric vehicles by the year 2050 (The White House, 2023). Such a transition is envisioned to contribute to environmental sustainability and facilitate the creation of remunerative employment opportunities in the burgeoning electric vehicle sector.

5.1 Statement of the Issue/Problem

The University of Bridgeport's Ph.D. in Technology Management (TM) is a doctoral program catering to the demands of industry and academia. It provides two interconnected study options: creating new technology ventures and exploring current and emerging technologies (Bridgeport, 2023). The electric vehicle industry is currently in a rapid growth stage within its life cycle (Tsang et al., 2020). Implementing Technology Management (TM) as a significant factor is instrumental in swiftly enabling this industry to adapt to evolving trends and challenges. TM empowers the electric vehicle sector to effectively harness technological advancements, optimize production processes, enhance vehicle performance and range, develop efficient charging infrastructure, and capitalize on emerging market opportunities.

The transition to electric vehicles (EVs) represents a profound shift that demands efficient change management. This transformation entails transforming mindsets, processes, and cultures alike. Embracing this change requires a comprehensive approach to navigate through it effectively.

The electric vehicle industry comprises four key stakeholders: customers, manufacturing companies, suppliers, and the government (Khaire, 2022). Suppliers play a vital role by offering essential services such as charging station parts and maintenance to support the electric vehicle ecosystem. Meanwhile, the government assumes a critical responsibility in ensuring a seamless transition from fossil fuel-based transportation to electric vehicles by establishing policies that secure and facilitate this shift, thus promoting sustainable mobility and environmental preservation.

The Bipartisan Infrastructure Law (BIL) marks a significant milestone in promoting the widespread adoption of electric vehicles and achieving a zero-emission future on the roads by 2050. With a strong emphasis on innovation and advancement, the law allocates substantial funding, including $5 billion, to empower companies and individuals to drive groundbreaking developments within the EV industry. Additionally, by implementing the NEVI program, $5 billion will be dedicated to establishing an extensive charging station network, fostering employment opportunities with competitive wages in the electric vehicle sector. Each state will devise a five-year strategic plan outlining its vision for utilizing the funds and realizing the NEVI initiative, ultimately propelling the nation towards a sustainable and emission-free transportation landscape by 2050.

Connecticut state will receive from the NEVI program $605,826,025 over five years. Based on "Connecticut's Charging Ahead a Strategic Plan to Expand Public Electric Vehicle Charging," Connecticut State was one of the early states to approve and apply the California zero emissions laws. The number of electric vehicles in Connecticut is increasing by 800 monthly. However, with this increase in the number of electric vehicles in Connecticut, the state is facing the challenge of achieving this transition without meeting all stakeholders to set a clear road map for this transition together. The Policy and Planning department in the state asks every two weeks for all stakeholders to meet and draw up the road map and answer their questions and concerns. The Strategic plan sounds promising for all stakeholders but without a Clear Vision from them, there will be a gap between the government and the other stakeholders, leading to a waste of the fund the states got from NEVI.

5.2 Research Gap:

The pursuit of knowledge in Electric Vehicle (EV) technician training is confronted by notable research gaps that impede the formulation of informed policies and educational strategies. This research seeks to address these gaps, paving the way for a more comprehensive understanding of the challenges and opportunities associated with preparing a skilled workforce for the evolving demands of the EV industry.

First, Lack of Previous Studies on EV Technician Training:

A critical research gap is a need for a more explicit focus on Electric Vehicle (EV) technician training in previous studies within the governmental landscape. This gap limits the development of policies and educational initiatives necessary to equip the workforce for the dynamic shifts within the EV industry. To facilitate informed decision-making at the policy level, research must delve into the specific requirements, challenges, and best practices associated with training technicians for the electric vehicle sector.

Second, Uncertainty among Current Mechanics:

The existing uncertainty among current mechanics regarding the motivators for pursuing EV technician training is a noteworthy gap in the current body of literature. The decision-making process of these mechanics needs to be more adequately explored, hindering the tailoring of effective educational interventions. This research aims to unravel the factors influencing their decisions, thereby contributing to developing targeted strategies to address the reservations and uncertainties surrounding EV technician training.

Third, Insufficient Exploration of BIL's Educational Role:

The educational role played by Business and Industry Liaisons (BILs) in providing general education for the electric vehicle industry has yet to be sufficiently explored in existing studies. This research gap represents a missed opportunity to comprehend legislative frameworks' impact on EV sector workforce development. By investigating the educational contributions of BILs, this dissertation seeks to fill this void, offering insights into the multifaceted relationships between legislative frameworks, industry players, and educational initiatives in the context of EV technician training.

In summary, this research endeavors to bridge the identified gaps in the literature, providing pivotal insights for the adequate preparation of EV technicians. The anticipated significant transitions in the EV industry from 2022 to 2026 underscore the timeliness and relevance of this research. By adopting an interdisciplinary approach, the subsequent chapters of this dissertation will delve into the nuanced facets of EV technician education, amalgamating insights from adult

learning theories, private sector engagements, and legislative perspectives. Through these endeavors, this research aspires to contribute significantly to the knowledge base and inform the ongoing discourse on EV technician training.

5.3 Research Question:

- What are the key factors influencing the support and integration of electric vehicle education initiatives within regional programs, and how can effective change management processes be applied to enhance these initiatives?
- What qualifications and capabilities are crucial for educational institutes to deliver effective training programs in emerging technologies, focusing on electric vehicles, in the context of statewide initiatives?
- What are the key factors influencing the motivation of automotive mechanics to pursue professional development and training in emerging automotive technologies, with a specific emphasis on electric vehicles?

5.4 Methodology

This research will employ a qualitative methodology, utilizing interviews with critical stakeholders to gain insights into the educational landscape of Connecticut. The stakeholders include representatives from the state's Strategic Plan, an educational institute, and current practitioners involved in implementing educational programs. The aim is to gather diverse perspectives on strategic goals, challenges, and opportunities within the education sector. By engaging with these stakeholders, the research seeks to collect comprehensive data for a thorough analysis, ultimately contributing to informed policy recommendations and strategic interventions to enhance Connecticut's overall quality of education.

5.5 Scope and Limitations:

This research examines the effectiveness and impact of the Connecticut State Educational Institute's electric vehicle training program for technicians, explicitly focusing on current mechanics in Connecticut. The primary objective of this study is to assess the program's ability to equip technicians with the necessary skills and knowledge to work effectively with electric vehicles.

Scope:

1. Geographic Focus: The study will be confined to the state of Connecticut, examining the impact of the NEVI program exclusively within this region.

2. Educational Focus: The research will concentrate on individuals who have pursued training in electric vehicle technology within institutions offering automotive, mechanical engineering, or electrical engineering measures.

3. Temporal Focus: The study will analyze data and outcomes within the specified timeframe, from 2022 to 2026.

Limitations:

1. Regional Specificity: The study's findings will be limited to the Connecticut State Educational Institute's NEVI program and may need to be generalizable to other states or regions with different training initiatives.

2. Short-Term Focus: The dissertation will not extensively explore the training program's long-term outcomes beyond 2022 to 2026.

3. Student Motivation: While the study will include mechanics in Connecticut who are motivated to become electric vehicle technicians, it will not delve into the deeper motivations or personal factors driving their decision to pursue this training.

By acknowledging these scope and limitations, this research provides a detailed examination of the NEVI program's impact within the specified context, recognizing the potential constraints and areas where further research may be required to gain a more comprehensive understanding of electric vehicle technician training programs.

6. Chapter Two: Literature Review

The electric vehicle (EV) sector is undergoing rapid expansion, offering abundant opportunities for job creation in diverse domains, including charging station enterprises and IT firms specializing in electric vehicle software development. Consequently, the government must enact supportive policies catering to the EV industry's emerging job landscape. According to Dijk, Orsato, and Kemp (2013), the trajectory of employment in electric mobility hinges on factors such as technological advancements, the presence of charging infrastructure, and governmental directives. To what extent does the EV industry generate well-paying jobs, and how does this compare to the conventional automotive sector? Walter, Higgins, Bhattacharyya, Wall, and Cliffton's (2020) study underscores the potential of the U.S. auto manufacturing sector to lead the global shift toward EVs, emphasizing job creation in the United States.

Hamilton's (2011) assertion regarding the considerable growth potential in EV industry employment is substantiated by the Bureau of Labor Statistics, which foresees a 20% surge in jobs within the sector over the next decade. Ewing (2023) exemplifies this trend in Ohio, noting that the transition to electric cars generates new jobs but displaces some workers, with the newly created positions typically offering higher wages than the ones they replace.

Before commencing training for EV technicians, it is crucial to thoroughly evaluate the existing market demand for such professionals and the government's policies and initiatives promoting training programs. Additionally, careful consideration must be given to the unique challenges and opportunities associated with training individuals. Technological advancements, industry regulations, and emerging trends should be factored into the design of an effective training curriculum. Furthermore, a comprehensive review of past training methods in this field can yield valuable insights into best practices and areas for improvement. By addressing these foundational considerations, we can ensure that our training program aligns with market needs, equips individuals for successful careers in the field, and contributes to the overall growth of the EV industry (Dijk et al., 2013; Walter et al., 2020; Hamilton, 2011; Bureau of Labor Statistics (Ewing, 2023).

6.1 Governments and EV technicians training:

The government plays a crucial role in transitioning from fossil fuel to electric vehicles, establishing essential regulations and guidelines for all stakeholders. By formulating policies and strategies, the government ensures the provision of infrastructure and funding, fostering a collaborative environment for effective contribution toward a sustainable electric mobility future. Chaturvedi, Nautiyal, Kandpal, and Yaqoot (2022) emphasize that government support is vital for the widespread adoption of electric vehicles, involving financial backing and infrastructure development. Despite potential revenue loss from the absence of taxes on electric vehicle owners, appropriate government policies ensure a successful transition (Rajagopal, 2023). Bonilla, Soberon, and Galarza's (2022) study underscores the need for government-established EV operational regulations, including charging infrastructure, aligning with the Biden Administration's 2022 implementation of public EV procurement.

The Bipartisan Infrastructure Law aims to create high-paying job opportunities for American citizens through state-level government policies and the National Electric Vehicle Infrastructure Program (NEVI) (House, 2021). Debnath, Bardhan, Reiner, and Miller (2021) report that electric vehicle adoption in the United States is a multifaceted process, with political, economic, and legal factors as the most significant catalysts. While social and environmental factors have lesser influence,

government interventions, such as incentives, targets, and automotive industry regulations, can substantially promote electric vehicle adoption. Yeh, Liao, and Petrosky (2013) found that university-community college partnerships can strategically address industry demands for advanced automotive technology, bridging the skills gap, cultivating a qualified workforce, and enhancing the educational experience for students at both institutions.

6.2 The need for EV technicians for the market:

The increasing demand for comprehensive knowledge in electric vehicle maintenance underscores the necessity to provide technicians with extensive training, covering a profound understanding of electric vehicle systems and components. This knowledge is crucial for technicians to diagnose and resolve any issues that may arise effectively. Strong customer service skills are also essential to support electric vehicle owners satisfactorily. Myers, Kenar, and Hankins (2020) highlight the significance of these requirements, emphasizing the apparent need for specialized training programs tailored specifically to individuals working on electric vehicles. Consequently, the proposed training program aims to fulfill this demand by ensuring that professionals in this field possess the appropriate qualifications to work on electric vehicles effectively.

The recent surge in demand for electric vehicle technicians emphasizes the urgent need for a larger workforce with specialized qualifications. Fechtner and Schmuelling (2016) stress the necessity for enhanced training programs that provide technicians with up-to-date knowledge and skills in rapidly evolving electric vehicle technologies. Moreover, there is a growing requirement for comprehensive hands-on training to address the intricacies of repairing and maintaining electric vehicles. Turoń, Kubik, and Chen (2021) also note the insufficient awareness among the younger generation regarding electric mobility, emphasizing the need for comprehensive education facilitated through diverse and efficacious pedagogical approaches. Additionally, Fechtner, Ismail, Braun, and Schmuelling (2017) affirm that the proposed specialized training program aims to adequately qualify individuals working on electric vehicles, addressing the critical need for competence in this field.

Fechtner, Fechtner, and Schmuelling (2015) identify a significant need for training programs tailored to professionals working on electric vehicles. Existing training programs for electric vehicles predominantly focus on academic education, necessitating programs tailored to the needs of professionals with work experience. Brusaglino, Gava, Leon, and Porcel (2013) highlight the need to train and develop European competencies in maintaining electric and hybrid vehicles, with the competency framework developed in their research deemed valuable for training and development.

Over the past two decades in the US, efforts have been made to enhance the skill set of market technicians for effectively maintaining hybrid and electric vehicles. However, McDonald (2010) argues that the existing engineering and technology education system needs alignment with the multifaceted skill requirements of the electric vehicle industry's developmental demands. Similarly, Ebron (2012) contends that existing training and education programs need revision, necessitating the development of a comprehensive curriculum covering all facets of advanced electric drive vehicles.

6.3 Adult learning:

Relying on static data from the year 2020, it is apparent that the United States possesses a significant workforce comprising more than 415,000 mechanics with an average age of 42 years (ZIPPIA, 2022). Given their extensive prior experience and continuous employment, incorporating an instructional approach grounded in adult learning theory becomes imperative to nurture enthusiasm and augment their ability to assimilate new skills. Furthermore, as Brookfield (1995) emphasized, creating compelling and captivating learning environments for adult learners demands an understanding of the multifaceted nature of adult learning and the varied ways in which it transpires.

The unparalleled challenges brought about by 2022, especially within education, presented a formidable hurdle for adults navigating using innovative technologies for online teaching. In their research, Choudrie, Banerjee, Kotecha, Walambe, Karende, and Ameta (2021) discovered that in comparison to younger adults, older adults exhibit heightened exposure to COVID-19 information and misinformation online, coupled with a greater tendency to trust traditional media over new media. Additionally, adult learning encompasses various pivotal factors influencing motivation. Therefore, Aljohani and

Alajlan (2020) assert that social contact, family togetherness, and religious stimulation are crucial motivators for adult learners, underscoring their stronger inclination towards internal motivation than external factors.

6.4 Zone of Proximal Development in EV:

The Zone of Proximal Development, as delineated by Billings & Walqui (2017), encompasses tasks that learners can independently handle and those they can master with the aid of an adult or through collaboration with more proficient peers. This underscores the significance of offering suitable support and scaffolding to learners to foster their growth and advancement. By pinpointing and focusing on the zone where learners can extend their abilities, educators can optimize the learning experience and stimulate optimal development.

However, can ZPD enhance the training of electric vehicle technicians? Smith, Doe, and Jones (2023) discovered that electric vehicle technicians who underwent training tailored to their specific needs were more likely to express satisfaction. Additionally, they were more prone to retain information through feedback during training. Furthermore, Smith, John, and Brown (2022) ascertained that the ZPD represents a promising approach to enhancing outcomes in electric vehicle technician training, with learners who received training aligned with their ZPDs outperforming those who underwent traditional training in a post-training assessment.

Various factors, including individual knowledge, will influence electric vehicle technician training (Smith et al., 2023). The Zone of Proximal Development (ZPD) constitutes a complex and continually evolving process shaped by factors such as the individual's existing knowledge, task characteristics, and social context. Consequently, harnessing the ZPD facilitates practical skill training across diverse domains.

6.5 What will affect the EV technicians training:

Establishing an educational system for technicians seeking expertise in maintaining electric vehicles has yet to originate recently. Instead, it emerged in 2010 with the proliferation of hybrid vehicles during that period. Thus, Gover, Thompson, and Hoff (2010) emphasize the critical nature of Hybrid Electric Vehicle (HEV) technicians' training, underscoring the need to tailor educational programs to meet the distinct requirements and skill sets of automotive technicians in the industry. This targeted approach ensures that training effectively enhances their capabilities and expertise. For instance, Huba and Ferencey (2015) highlight the necessity of electric vehicle (EV) education to prepare highly qualified EV instructors, drawing attention from Slovakia.

The associated costs significantly influence the quality of training for Electric Vehicle (EV) technicians. Therefore, a comprehensive understanding of cost implications is imperative to ensure optimal training outcomes in this domain. Fechtner, Ismail, Braun, and Schmuelling (2017) discovered that training for electric vehicles can be expensive due to the increased complexity of electric cars compared to traditional vehicles, necessitating specialized training. Moreover, they note that the quality of training can vary because there is no standardized curriculum for electric cars, and it depends on the training provider.

In the contemporary landscape, Fayziyev, Ikromov, Abduraximov, and Dehqonov (2022) present a current reality wherein technological processes for the maintenance and repair of electric vehicles are still in their early stages of development. Furthermore, they highlight numerous challenges that must be addressed to enhance the organization of these processes.

6.6 The previous training methods for EV technicians around the world and the US:

Manufacturing companies in the electric vehicle sector prioritize providing specialized training for technicians to meet customer expectations and address market demands. DAF Trucks, recognizing the shift towards electric vehicles, stands ready to support its customers with a robust network of technicians trained in the intricacies of electric vehicles (Point, 2021). The company is investing in new tools and charging infrastructure to accommodate the increasing demand for electric vehicles.

Initial training focuses on diagnosing faults, a crucial step in electric vehicle maintenance, necessitating specific expertise due to the distinct components compared to internal combustion vehicles. Zhang and Guo (2022) propose a training platform for pure electric vehicle fault diagnosis, developing a system tailored to the unique components of electric vehicles. This divergence arises from the differing main components between electric vehicles and their internal combustion counterparts. Furthermore, Tang, Kusumadi, and Chuan (2013) highlight the potential for a remote telemetry and diagnostic system benefiting electric vehicle users and technicians, allowing for efficient monitoring and troubleshooting.

In hybrid electric vehicles (HEV), efforts are directed towards developing educational systems, such as small-scale HEV setups. Fajri, Lotfi, Ferdowsi, and Landers (2016) emphasize the effectiveness of educational small-scale HEV setups in imparting knowledge to students and engineers, providing a user-friendly and hands-on learning experience. Brusaglino, Gava, Leon, and Porcel (2013) also find that a pilot training program successfully cultivates the necessary competencies for maintaining electric and hybrid vehicles.

Electric vehicle technicians also benefit from innovative training methods, including Digital Game-Based Learning. Proulx, Romero, and Arnab (2016) advocate aligning learning and game mechanics with psychological needs to enhance motivation. Another approach involves using the 3D Motion Controller, with Kim and Lee (2020) demonstrating its effectiveness in engaging students in learning about electric vehicles.

Augmented Reality (A.R.) serves as a tool for technician training, facilitating quicker and more accurate part location. Rymer, Damiano, McCombs, and Torre (2018) reveal that A.R. technologies significantly improve the training of automotive technicians compared to non-augmented computer-based manuals. Additionally, digital twin technology and Virtual Reality (V.R.) contribute to developing the educational capabilities for electric vehicle maintenance, creating realistic and immersive training environments (Lee & Jung, 2020).

Lastly, the Problem- and Project-Based Learning (PPBL) method enhances the learning experience for engineering students in the electric vehicle field. Gonzalez-Rubio, Khoumsi, Dubois, and Trov˜ao (2016) highlight the benefits of PPBL, including a deeper understanding of engineering principles, the application of knowledge to real-world problems, the development of critical thinking and problem-solving skills, effective teamwork, and improved communication.

6.7 Change Management

Change management is a multifaceted and essential organizational process, as highlighted by the perspectives of Fusch, Ness, Booker, and Fusch (2020); it is a procedural undertaking to initiate adaptation, renewal, alteration, or transformative shifts in established operational practices. This underscores the dynamic nature of change within the organizational context, emphasizing its necessity for maintaining relevance and effectiveness. Pavlakis, Kaitelidou, Theodorou, Galanis, Sourtzi, & Siskou (2011) contribute to this understanding by emphasizing that effective change management goes beyond procedural and motivational aspects. Their perspective recognizes the pivotal role of individuals within the organization, emphasizing the need for leaders to transform and all members to navigate and adapt adeptly to prevailing uncertainties. In this sense, change becomes a collective endeavor requiring both procedural strategies and a focus on the human dimension to navigate the dynamic economic landscape successfully.

Building on these insights, Stouten, Rousseau, and Cremer (2018) offer a comprehensive framework for successful organizational change initiatives. They stress the importance of articulating the rationale behind change, fostering a sense of urgency, establishing a cohesive change coalition, transparent communication with stakeholders, empowering employees, managing resistance proactively, celebrating milestones, and institutionalizing change within the organizational fabric. This framework encapsulates the recognized principles for successfully managing organizational change, providing a roadmap for leaders and practitioners. Together, these perspectives highlight that change management is not a one-size-fits-all approach;

instead, it involves a strategic blend of procedural considerations and a nuanced understanding of organizational human dynamics, emphasizing the need for a holistic and adaptable approach.

Application for change management: CMI & ERP

In recent years, the significance of Change Management Interventions (CMIs) in successfully implementing Information and Communication Technology (ICT) initiatives has garnered increasing attention. Williams and Williams (2019) emphasize the pivotal role of proficient change management in ensuring the success of ICT investment endeavors. Their research underscores the need for strategic deployment of CMIs to facilitate embracing change initiatives. CMIs, orchestrated by organizational actors like change managers, are purposeful interventions designed to positively influence employees' responses and drive the adoption of planned changes. However, as highlighted by Hagl, Kanitz, Gonzalez, and Hoegl (2023), the effectiveness of CMIs is not universally applicable, suggesting that there is no single "best" intervention for all situations. The success of CMIs depends on the specific context of the change initiative, organizational characteristics, and employees' unique needs. This insight underscores the importance of tailoring change management strategies to the circumstances surrounding the implementation of ICT initiatives.

In the realm of change management, Enterprise Resource Planning (ERP) systems represent a significant component in organizational transformations. Integrating ERP systems is critical in managing change, streamlining processes, and enhancing organizational efficiency. While Bjaalid, Laudal, & Mikkelsen (2015) focus on the importance of CMIs in ensuring successful ICT investments, the literature also points to the critical role of ERP systems in driving and supporting organizational change. ERP systems provide a comprehensive framework for managing various business processes, making them integral to change initiatives. As organizations embark on technological transformations, understanding the interplay between CMIs and ERP systems becomes essential to harness the full potential of information and communication technologies. This intersection of change management and ERP implementation forms a dynamic and evolving field, emphasizing the need for further exploration, and understanding of their interconnected roles in facilitating successful organizational change.

6.8 Conceptual or Theoretical Framework Outlines:

In the United States, the government, represented by the White House, has initiated a law to promote the creation of well-paid jobs, including electric vehicle (EV) technician positions. This vision has motivated current and aspiring EV technicians who seek support from the government in terms of financial aid and educational assistance. However, to achieve the government's vision, educational institutions need to develop robust programs that cater to the needs of EV technicians, offering comprehensive training and capturing attention through innovative educational approaches. By satisfying the requirements of each component - government support, motivated technicians, and practical education programs - the nation can work towards realizing the White House's goal of creating a workforce of skilled and well-compensated EV technicians.

In conclusion, the electric vehicle (EV) industry presents significant opportunities for high-paying employment and job creation, particularly in comparison to the traditional automotive sector. The transition to electric vehicles is fueled by technological advancements, the availability of charging infrastructure, and supportive government policies. Governments play a crucial role in facilitating this transition by formulating regulations, funding, and incentives. To meet the demands of the growing market, comprehensive training programs for EV technicians are essential. The training should encompass a deep understanding of EV systems, hands-on experience, and strong customer service skills. Adult learning principles are vital for effective training outcomes. The Zone of Proximal Development (ZPD) can be leveraged to tailor training to individuals' needs, improving satisfaction and performance. Various training methods, including digital game-based learning, augmented reality, and problem-based learning, have been employed to enhance the training experience for EV technicians. By addressing the market demands and government policies and employing practical training approaches, the EV industry can continue flourishing, contributing to sustainable mobility and economic growth.

7. Chapter Three: Research Design and Methodology

In Chapter Two's literature review, the theoretical framework for assessing the involvement of all stakeholders in training EV technicians is established. This chapter will provide a comprehensive discourse and elucidate the research design and approach. The predominant methodological strategy involves qualitative interviews, complemented by stakeholder analysis, a change management process, and a communication plan to formulate interview questions addressing the research questions. The data analysis segment will employ the hybrid coding technique and value-based thematic analysis.

The primary objective of this research is to investigate strategies for developing a skilled workforce in electric vehicle technology to meet the growing demand across the U.S. aligning with the Bipartisan Infrastructure Law (BIL). The precise questions I aim to address within this research are:

- What are the key factors influencing the support and integration of electric vehicle education initiatives within regional programs, and how can effective change management processes be applied to enhance these initiatives?
- What qualifications and capabilities are crucial for educational institutes to deliver effective training programs in emerging technologies, focusing on electric vehicles, in the context of statewide initiatives?
- What are the key factors influencing the motivation of automotive mechanics to pursue professional development and training in emerging automotive technologies, with a specific emphasis on electric vehicles?

The methodology focuses on answering these questions in the hopes of providing a framework through a clear road map for all stakeholders not only in Connecticut to fix the potential high demand for qualified electric vehicle technicians, But also for all stakeholders in the U.S.

7.1 Rationale for Study Methods

The research design selected for this study is qualitative, investigating research questions to understand former stakeholders engaged in the readiness phase for training skilled electric vehicle technicians. The emphasis of the study is on comprehending the requirements of all stakeholders and their contributions toward facilitating the transition to certified electric vehicles. The qualitative design approach maintains a blend of structure and flexibility during the research journey (Maxwell, 2013).

Stakeholder Analysis

Stakeholder Analysis is a pivotal process in any project endeavor, enabling a comprehensive understanding of the individuals or entities that stand to be impacted by the study's outcomes (Bendtsen et al., 2021). This analysis typically comprises several essential steps, each contributing to a more transparent comprehension of the stakeholder landscape and their respective roles. The first step in this process involves identifying these stakeholders - those the research findings will directly influence. By pinpointing these key players, the groundwork is laid for a structured approach to engaging with them effectively.

In the second step, the identified stakeholders are prioritized into four groups based on their power level and interest. The first group consists of stakeholders possessing both high power and high interest. These individuals or entities wield significant influence over the research's outcome and thus are deemed critical to satisfying and actively involved throughout the research process. The second group comprises stakeholders with high power but low interest. While they hold substantial sway, their enthusiasm about the research may be moderate. The third group comprises those with low power but high interest, indicating their limited influence over decisions and significant investment in the research's outcomes. Lastly, the fourth group comprises stakeholders with low power and interest, implying their minimal impact on the research and limited involvement.

The third step involves delving deeper into the stakeholder categories. This phase is crucial as it involves engaging stakeholders through interviews and other means to grasp their perspectives, concerns, and expectations. This step bridges identifying stakeholders and formulating research questions that address their specific needs and interests. By initiating meaningful conversations, researchers can uncover insights that help tailor the research process to meet stakeholder requirements.

Throughout the stakeholder analysis process, the overarching goal is to ensure that decisions made during the research endeavor are well-informed, considerate of various stakeholder perspectives, and aim to strike a balance between satisfying influential stakeholders and meeting the broader objectives of the research. In essence, the stakeholder analysis process empowers researchers to navigate the complex web of interests, power dynamics, and engagement levels to create research outcomes that resonate with those directly and indirectly impacted.

Kotter's 8-Step Change Model

Kotter's 8-Step Change Model focuses on catalyzing a transformative shift towards electric vehicles (EVs) and preparing a skilled workforce for the evolving automotive landscape. The urgency for change is underscored by challenges faced by mechanics and educational institutions, necessitating a collaborative effort from stakeholders (Kotter, 1996). The model's initial steps emphasize the need for a clear vision, the formation of a guiding team, and effective communication. Subsequent stages involve empowering action, creating short-term wins, and persevering through setbacks. The ultimate goal is to make lasting change by engaging stakeholders, refining strategies based on feedback, and establishing a sustainable roadmap for the future of education and training in electric vehicle technology. This roadmap aims to cultivate a pool of proficient EV technicians by 2030, contributing to a cleaner and healthier transportation ecosystem.

1-Increase urgency:

At the initial stage, it is essential to candidly acknowledge the areas that require improvement and clearly understand the reasons driving the need for change. According to a comprehensive study, a primary concern hindering residents from embracing electric vehicles (EVs) is their apprehension about the vehicles' reliability and the accessibility of maintenance services. Considering the evolving landscape, current mechanics are seeking greater clarity regarding the future of their jobs, necessitating a shift from their familiar comfort zones to embrace the potential of new opportunities. Successfully navigating this transition demands embracing challenges and stress to attain success. In essence, mechanics must actively

engage in shaping their futures. During this critical juncture, the collaboration and support of all stakeholders in the transition to electric vehicles become imperative for their smooth and sustainable progress.

Like mechanics, education institutes need a clear vision for the future. Their lack of experience in transforming educational methodologies hinders their ability to prepare qualified electric vehicle technicians to meet the demands of tomorrow's electric vehicles. Despite their vital role in shaping the future, education institutes face challenges from current and potential students who still need to be more engaged in the program, underscoring the urgency to develop a more robust and professional training initiative. Furthermore, the absence of communication and support from governmental bodies exacerbates the situation, necessitating immediate action to bridge this gap and forge a successful transition into an electric vehicle-focused educational landscape.

By fostering seamless coordination among key stakeholders and implementing an efficient change management process, a clearly defined roadmap emerges, guiding these entities to achieve their ultimate objectives while successfully transitioning towards environmental preservation and safeguarding the planet from the detrimental effects of pollution. This integrated approach ensures collaborative efforts and creates a sustainable legacy for future generations as they work towards a cleaner and healthier world.

2-Build the guiding team:

The visionary strategic plans implemented at the state level are poised to create a promising future for the electric vehicle industry and educational institutions nationwide. This comprehensive approach ensures a stable and prosperous career path for individuals interested in becoming electric vehicle technicians. On a national scale, the education sector is committed to embracing this transformative shift by providing cutting-edge knowledge to aspiring technicians. The success of this endeavor relies on proactive student encouragement and solid governmental support, fostering an environment conducive to the seamless transition of professionals into the electric vehicle field. A well-defined roadmap for the future of these technicians, backed by collaborative efforts between state authorities and educational institutions, aims to empower individuals and cultivate motivation and preparedness for a successful career in the evolving landscape of electric vehicles.

3-Get the vision right:

The researcher will conduct interviews with all stakeholders to thoroughly understand their needs related to ordinary shares. Based on these insights, a visionary guarantee will be formulated to achieve the research goal, encompassing a broader scope beyond specific geographic locations.

4-Communicate for buy-in:

In this phase, a comprehensive project communication plan will be formulated to ensure that all stakeholders receive pertinent information about each other, facilitating the exchange of feedback and requirements. This plan will integrate seamlessly into the stakeholder framework, fostering effective collaboration and information flow (Ruler, 2015).

5-Empower action:

In this phase, the researcher will synthesize initiatives to enhance support for Education Institutes and foster the growth of prospective electric vehicle technicians statewide. These endeavors collectively aspire to drive advancements in electric vehicle technician preparation, with a targeted accomplishment by 2030, contributing to the transition of the entire state towards a more sustainable transportation landscape.

6-Create short-term wins:

In this phase, the researcher will explore the feasibility of developing a training program in collaboration with educational institutes across various states. By seeking support from relevant governmental bodies, the goal is to establish a comprehensive curriculum for aspiring electric vehicle technicians. Identifying a substantial pool of potential technicians marks a significant milestone, signifying promising advancement in facilitating the transition toward electric vehicle technology on a broader scale.

7-Do not let up:

As emphasized in the introduction chapter, embracing change is no simple endeavor; it demands a willingness to take risks. Along this transformative journey, it is inevitable to encounter setbacks and failures. However, these moments serve as

crucial opportunities for learning and growth. Soliciting feedback from all stakeholders involved in the preceding phases becomes paramount. This collective insight is then leveraged to refine and enhance the change process, ultimately paving the way for its practical and successful implementation.

8-Make change stick:

The engagement with all stakeholders will involve incorporating their positive feedback and actions that have propelled this transformation. This collaborative effort aims to ensure the successful realization of change, resulting in a comprehensive roadmap for the future of Education and Training. The goal is to nurture potential electric vehicle technicians nationwide by 2030.

7.2 Data Collection Methods

Qualitative information will be acquired through interviews, commencing in an open-ended fashion, and concluding with a semi-structured protocol, ensuring comprehensive data collection. The initial interview for the transition to electric vehicles will be conducted with the Connecticut State workforce representative. The decision to interview this representative is based on the singular nature of the role. Subsequently, the Strategic Plan representative will be approached for any inquiries related to the research without involvement in data collection. This stage is expected to span one week.

The next category to be interviewed comprises General Repair and Used Car Dealer mechanics across all Connecticut counties. This category constitutes the largest segment within the project scope, spanning from the second week of data collection and lasting for eight weeks. The DMV in Connecticut will provide the public database for all mechanics shops registered in the state by 2022. The database will be utilized to select participants, and they will be contacted to gauge their interest in participating and answering interview questions. There are 5,534 mechanic businesses in Connecticut across various categories; however, the focus will be specifically on general repair and used car mechanics. Business phone numbers will be called to inquire about participation, and upon confirmation, visits to the respective shops will be made to commence the interviewing process with the mechanics employed at the establishments.

Table 3: The categories and numbers for licensed mechanic shops in Connecticut in 2022.

License Type Business	Number of Business
General Repairer	1547
Limited Repairer	65
Used Dealer	2501
New Dealer	696
Leasing License	473
Manufacturer License	134
Recycler	118
Total	**5534**

At the same time, I will be interviewing general repair and used car mechanics. I will use the same time to interview the technical schools that provide Automotive Technology programs. This stage will take two weeks to interview those who would like to participate in interview questions. I will email them first and schedule either a personal meeting or a virtual meeting to make the interview. timeline. I will interview the community college representative for the Automotive major in the 10th week. The universities provide either mechanical engineering or electrical engineering degrees. I will start interviewing the representative for each department in the ninth week for five weeks.

At the same time, the individual will be interviewing general repair and used car mechanics. The exact time will be used to interview the technical schools providing Automotive Technology programs. This stage is expected to take two weeks to interview those who would like to participate in interview questions. Emails will be sent first, and personal or virtual meetings will be scheduled for the interviews. The community college representative for the Automotive major will be interviewed in the 10th week. The universities provide either mechanical engineering or electrical engineering degrees. The representative for each department will be interviewed in the ninth week for five weeks.

Utilizing the Delphi technique for participant interviews ensures the selection of accurate participants, leading to highly effective data collection with minimal standard deviation (Thangaratinam and Redman, 2005). The data collection methodology in this research involves extending invitations or making direct calls to potential participants. Upon approval, participants will be scheduled for research sessions aligned with the Digital Collection timeline. The interview mode, whether virtual or in person, will be determined and communicated to participants, followed by soliciting their authorization for recording. Subsequently, post-interview, the recorded data will be securely stored on a local computer, isolated from cloud connectivity, to ensure the utmost security and confidentiality of the gathered information. Following the IRB requirements to ensure the participants' data in this research, all participants sign a consent form to protect themselves and the researcher.

Figure 1: Data collection timeline.

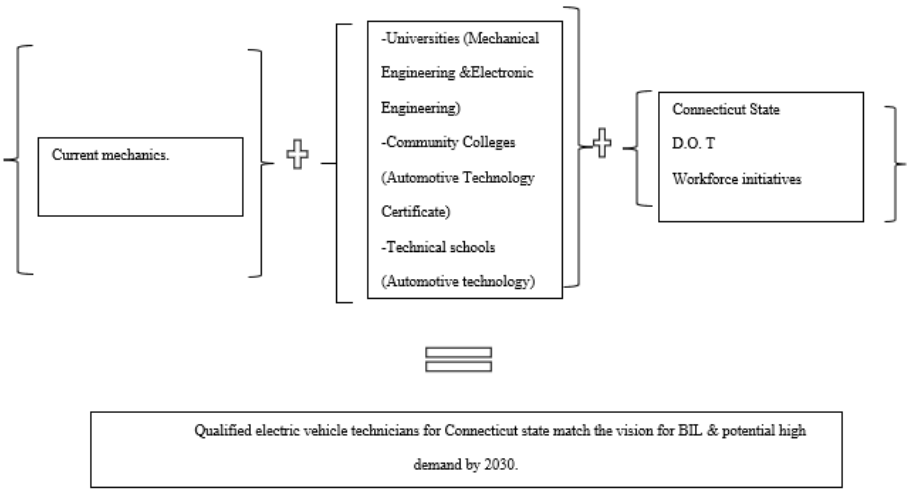
	Project Name	Project duration	Project start dat	Project end date
	Interview participants	13 weeks	Week 1	Week 13

Task ID	Task desciption	Task Duration	Start date	End data	Week 1	Week 2	Week 3	Week4	Week5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week13
1	**CT workforce representative**	1 week	week 1	week 1													
2	**General repair & Used car dealer**	8 weeks	week 2	week 9													
3	**Technical schools representative**	2 weeks	week 4	week 5													
4	**Community Colleges representative**	1 week	week 10	week 10													
5	**Universities representative**	5 weeks	week 9	week 13													

7.3 Site and Participant Selection

The three main categories for the stakeholders are technicians, education institutes, and Connecticut State. Also, each category has multiple kinds of stakeholders, as Figure 2 explains:

Figure 2: Stakeholder's interactions to prepare qualified electric vehicle technicians in Connecticut state between 2022 and 2030 based on Bipartisan Infrastructure Law.



The first set of stakeholders comprises current and potential electric vehicle technicians, explicitly focusing on students in technical schools and community colleges who are in the midst of their journey to becoming mechanics. The objective is to assess the motivation and capability of these individuals to pursue additional classes and become qualified electric vehicle technicians. The research will also examine the current population of mechanics to gauge their availability and capacity to undergo education at institutes offering training programs for electric vehicles (EVs). Interviews will be conducted with

Connecticut's existing electric vehicle technicians to gather insights into how they acquired their knowledge and became qualified in this field. The feedback obtained will then be used to advise potential EV technicians.

The second set of stakeholders involves education institutes, which can be categorized into three groups. The first group comprises technical schools offering majors in Automotive Technology, the second group includes community colleges providing certificates in automotive technology, and the third group consists of universities in Connecticut offering mechanical engineering or electrical engineering programs.

The final stakeholder is a representative from the state of Connecticut. Following previous communication with the Connecticut State, contact has been established with the Special Advisor to the CT Department of Transportation Commissioner. The Special Advisor will provide all the information sought during the interview process.

7.4 Instruments

If all aspects align optimally, they will interview the three stakeholders within 14 weeks. To facilitate this, virtual communication tools such as Zoom or Microsoft Teams will be utilized to connect with the state and Education Institute representatives. If circumstances permit, face-to-face meetings will be arranged at Pearson's location.

For the stakeholders in the General Repair and used car dealership sectors, in-person interviews will be conducted at their respective business establishments. Similarly, in-person interviews will be arranged for student participants at the school premises.

During these interviews, an average of eight open-ended questions will be asked. The participants will be given approximately 20 minutes to respond to these questions, including a 5-minute introduction about the research topic and the interview's purpose.

The interview approach will be guided by an interview guide, ensuring consistency and structure throughout the process. The questions will be designed to encourage detailed responses from the participants. A semi-structured protocol will be used, maintaining flexibility while staying focused on addressing the research questions. This approach will prevent unnecessary deviations, ultimately saving valuable time for the participants and ensuring that the research objectives are met efficiently.

Table 4: Type of interview and Interview participants.

Interview participants	Type of interview	Interview voice Recording	Number of interview questions	Length of the interview
CT workforce representative	In person or Virtual	✔	8	20 minutes
General repair & Used car dealer	In person	✔	5	20 minutes
Technical schools' representative	In person or Virtual	✔	5	20 minutes
Universities representative	In person or Virtual	✔	5	20 minutes

7.5 Data Analysis

Following the procedures detailed in the preceding sections regarding participant engagement, data collection, and storage, the subsequent steps involve meticulous analysis and interpretation of the acquired data. After each interview, the collected data will be transcribed and compiled into a Word document. This document will serve as the primary source for the subsequent phases of data analysis. The chosen analytical approach will be an inductive coding method, given the utilization

of open-ended interview questions. This method allows for a systematic and exploratory examination of the data, facilitating the identification of emerging patterns and themes (Fereday and Muir-Cochrane, 2006).

Upon completion of the inductive coding process, the subsequent stage will involve employing thematic analysis. This analytical technique aims to identify, analyze, and report patterns or themes within the data, thereby providing a comprehensive understanding of the information gathered. At this stage, the results will be presented in thematic categories that directly address the research questions and contribute to the overarching research goal.

The data analysis process ensures a rigorous and structured approach to distilling meaningful insights from the collected information by systematically applying inductive coding and thematic analysis. This methodological framework aims to uncover the intricacies and nuances within the data, ultimately yielding valuable findings that contribute to the overarching objectives of this research.

7.6 Conclusion

This chapter outlines the major methodological choices employed in the research. The chapter commences by articulating the research questions that steered the formulation of the methodological approach. The rationale for adopting a qualitative methodological approach is explicated, along with a summary of the site selection process, participant criteria, and the methods employed for data collection and analysis. These methodological choices have been applied to derive the results detailed in Chapter Four.

8.Conclusion

The journey of this research illuminated the transformative landscape of the automotive industry, emphasizing the imperative shift towards electric power as a response to the challenges posed by climate change. As the world grapples with the need for sustainable practices, the automotive sector emerges as a key player in reshaping its trajectory. The historical evolution of electric vehicles, from their humble beginnings in the 19th century to the present global revolution, provides a backdrop for understanding the industry's resilience and adaptability.

Government initiatives, exemplified by the Bipartisan Infrastructure Law (BIL) and the National Electric Vehicle Infrastructure (NEVI) program, underscore the commitment to expedite the transition to electric vehicles. The Biden-Harris Administration's visionary plan, backed by a significant fiscal commitment, envisions a fully zero-emission vehicle fleet in the United States by 2050. This comprehensive strategy, comprising the deployment of charging stations and financial support

for businesses and individuals, aims not only at environmental sustainability but also at creating remunerative employment opportunities in the evolving electric vehicle sector.

The prospectus delves into the funding allocation and educational objectives within NEVI strategic plans, exemplified by the states of New Hampshire, Arizona, Michigan, and Connecticut. The state-level plans represent crucial steps toward achieving the broader national goal of a sustainable and emission-free transportation landscape by 2050. However, as highlighted in the research gap section, there exists a potential disconnect between the government and other stakeholders in some states, emphasizing the importance of clear communication and collaboration for the effective utilization of funds.

The delineation of electric vehicle jobs and their impact on employment opportunities provides a comprehensive view of the evolving job market. The rise of electric vehicles necessitates a shift in the skills required by current automotive mechanics and in creating entirely new job roles, ranging from mechatronics technicians to software engineers and beyond.

The research questions outlined in the prospectus pave the way for a qualitative methodology, focusing on interviews with key stakeholders in Connecticut. The scope and limitations acknowledge the study's regional specificity and short-term focus, setting the parameters for an in-depth examination of the NEVI program's impact on electric vehicle technician training within the state.

In conclusion, Chapter 1 lays the foundation for an interdisciplinary exploration of electric vehicle technician education, incorporating perspectives from adult learning theories, private sector engagements, and legislative frameworks. The identified research gaps underscore the significance of this study in informing policies and educational strategies crucial for preparing a skilled workforce for the dynamic shifts within the electric vehicle industry. As the automotive landscape undergoes a paradigmatic upheaval, this research aims to contribute substantially to the ongoing discourse on electric vehicle technician training and its role in shaping a sustainable and electrified future of transportation.

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Appendix A: EMAIL Script for Connecticut State Workforce representative for the transition to electric vehicles in the NEVI program

Subject: Invitation to Participate in Research Interview on Electric Vehicle Workforce Transition

Dear [Connecticut State Workforce Representative for the Transition to Electric Vehicles in the NEVI Program Name],

I hope this email finds you well. My name is Saddam Alkhamaiesh, and I am pursuing a Ph.D. at the University of Bridgeport. I am writing to introduce myself and extend an invitation to participate in an interview that is integral to my doctoral research project titled **"Preparing EV Technicians for the U.S. Transition to Electric Vehicles: A Case Study of Connecticut's Implementation of the Bipartisan Infrastructure Law from 2022 to 2026."** This research aims to foster a comprehensive understanding of how to prepare electric vehicle technicians effectively while optimizing resources.

Your expertise as a representative for the workforce in the NEVI program is of great significance to my research, and your insights will provide valuable perspectives specific to Connecticut State.

Please participate in a brief interview that will take approximately 20 minutes. During this interview, I will pose eight questions designed better to understand Connecticut's viewpoint on this critical transition.

I am flexible in the interview format to accommodate your schedule and preferences. We can arrange for an in-person meeting at your convenience, conduct the interview via Zoom or Microsoft Teams, or even schedule a phone call – whichever mode suits you best. As for the timing, I am available whenever it is most convenient for you.

I want to express my gratitude in advance for your consideration and willingness to contribute to the success of my research. Your insights will be pivotal in advancing our understanding of this vital topic.

I eagerly await your response and look forward to meeting with you.

Best Regards,

Saddam Alkhamaiesh.

Appendix B: EMAIL Script for Educational Institutes

Subject: Invitation to Participate in Research Interview on Electric Vehicle Workforce Transition

Dear [Educational Institutes Representative Name],

I hope this email finds you well. My name is Saddam Alkhamaiesh, and I am pursuing a Ph.D. at the University of Bridgeport. I am writing to introduce myself and extend an invitation to participate in an interview that is integral to my doctoral research project titled **"Preparing EV Technicians for the U.S. Transition to Electric Vehicles: A Case Study of Connecticut's Implementation of the Bipartisan Infrastructure Law from 2022 to 2026."** This research aims to foster a comprehensive understanding of preparing electric vehicle technicians effectively while optimizing resources.

Your expertise as a chair for "department name" will significantly benefit my research, and your insights will provide valuable perspectives specific to Connecticut's context.

Please participate in a brief interview that will take approximately 20 minutes. During this interview, I will pose five questions designed better to understand your educational institute's viewpoint on this critical transition.

I am flexible in the interview format to accommodate your schedule and preferences. We can arrange for an in-person meeting at your convenience, conduct the interview via Zoom or Microsoft Teams, or even schedule a phone call – whichever mode suits you best. As for the timing, I am available whenever it is most convenient for you.

I want to express my gratitude in advance for your consideration and willingness to contribute to the success of my research. Your insights will be pivotal in advancing our understanding of this vital topic.

I eagerly await your response and look forward to meeting with you.

Best Regards,

Saddam Alkhamaiesh.

Appendix C: Phone call script for Potential EV technician

{Hello, my name is Saddam Alkhamaiesh. I'm a researcher at the University of Bridgeport. I'm working on Research about Preparing electric vehicle technicians in Connecticut state.

The reason I'm calling you to ask if you would like to participate in my research will be a short interview of 20 minutes. I'm going to ask you five questions as you prefer, in person or over the phone, so your participation will not only help me but also help you to have a better understanding of the way to prepare electric vehicle technicians in Connecticut state.}

If the potential electric vehicle is interested:

{Which way do you prefer for the interview, in person or over the phone?

What is the perfect time for you to schedule the interview with you?

I'm looking forward to meeting you as we schedule our interview meeting. I appreciate your help and understanding of the reason for this research. Have a good day. See you soon or talk to you soon.}

If the potential electric vehicle technician is not interested:

{I understand your situation. Thank you. Have a good day.}

Appendix D: Interview Protocol Connecticut state Workforce representative for the transition to electric vehicles in the NEVI program.

Interview Protocol

Connecticut State Workforce representative for the transition to electric vehicles in the NEVI program.

I. Opening

Project Purpose/ Introduction. { }

{0:00- 0:03}

{Thank you for agreeing to be interviewed for this research project, which is part of my doctoral program at the University of Bridgeport. I'm interviewing you because you represent Connecticut state one of the stakeholders in the transition from fossil fuel vehicles to electric vehicles in Connecticut state.

Specifically, I'm focused on your perspective as a representative for Connecticut States for the workforce based on the NEVI program. In addition, I will ask you for the potential plan for Connecticut state and help with the workforce regarding the transition from fossil fuel vehicles to electric vehicles.

I want to ensure we cover all the topics and questions within our allotted time, so I may occasionally need to interrupt you if a response becomes lengthy. Please don't take it personally, and I appreciate your understanding. If it is okay with you, I will interrupt you in case you took long time we will be recording the interview so that it can be transcribed and analyzed as part of our project. Only I will have access to the names of the people who are interviewed, the transcripts will use pseudonyms to ensure confidentiality. .}

II. Kotter's 8 steps model of change {0:03- 0:18}

Because of the transition, I'm applying one of the modules for change management, Kotter's 8-step change model. There will be 7 questions to build enough Knowledge from your answers. So, the first step is to create a sense of urgency. My question is:

- What is the perspective of Connecticut state on the necessity of providing a training program to prepare electric vehicle technicians based on the NEVI program?

Thank you. Now, I would like to move to the Second Step, which is creating a team, so my question is:

- Who are the current participants in providing the maintenance workforce for the electric vehicle transition, who are the potential participants, and who reject a participant in this transition in Connecticut state?

Thank you. Moving The third step is creating a vision for the change Specifically I'm focusing on the strategy applied by Connecticut state to achieve affordable job opportunities for maintenance workers, so my question is:

- What is the strategy for Connecticut state to use for the workforce to achieve the change from fossil fuel vehicles to electric vehicles within the NEVI program?

The fourth step in this model is creating a communication plan with the other stakeholders in this transition; therefore, my question is:

- How can you describe the communication plan used by Connecticut state to receive and provide feedback and information from and to the participants in providing the maintenance workforce for the electric vehicle transition?

Thank you. The fifth step is removing the obstacles. The challenges Connecticut state faced during encouraging stakeholders to join the transition especially, so my question is:

- How can you describe the challenges have faced from 2022 the starting year of the NEVI program until now in applying the plan to the real situation?

Thank you. Step number six is to create short-term wins. And this is a step I'm looking for achievement from 2022 until today, especially for the workforce in the transition from fossil fuel to electric vehicles. So, my question is:

- What are the current achievements of Connecticut State 2022 for the maintenance workforce for the electric vehicle transition from 2022?

Nothing is perfect in life. There is room for improvement. Step number seven is “Consolidate Improvements.” So, my question is:

- What would you want to improve to accelerate the current plan and create achievements that provide more attention from other stakeholders?

Finally is to "Anchor the Changes,” so my question for the step is:

- If all stakeholders reach that point for a clear road map to achieve the transition, what is Connecticut State's plan to keep this change until 2050 and get %100 EVs on the roads?

III. Conclusion {0:18- 0:20}

{I really appreciate your effort in participating in this study. If you have any questions on how this information will be used feel free to contact me at salkhama@my.Bridgeport.edu.}

Appendix E: Interview Protocol Educational Institutes

Interview Protocol

Education Institutes

I. Opening

Project Purpose/ Introduction. { }

{0:00- 0:04}

{Thank you for agreeing to be interviewed for this research project, which is part of my doctoral program at the University of Bridgeport. I'm interviewing you because you represent **"Educational Institute Name"** one of the stakeholders in the transition from fossil fuel vehicles to electric vehicles in Connecticut state.

Specifically, I'm focused on your perspective as a representative for this educational institute. In addition, I will ask you for the potential plan for this educational institute to help the workforce regarding the transition from fossil fuel vehicles to electric vehicles.

I want to ensure we cover all the topics and questions within our allotted time, so I may occasionally need to interrupt you if a response becomes lengthy. Please don't take it personally, and I appreciate your understanding. If it is okay with you, we will be recording the interview so that it can be transcribed and analyzed as part of our project. Only I will have access to the names of the people who are interviewed, the transcripts will use pseudonyms to ensure confidentiality. .}

II. 2030 CT plan {0:04- 07:}

Each state has a plan to increase the number of electric vehicles and decrease the number of fossil fuel vehicles. So, in Connecticut, the plan is for 50% of cars should be by 2030 electric vehicle and by 2050 100% electric vehicles. Now my question for you is:

- What is your perspective as one of the stakeholders in preparing potential electric vehicle technicians to meet the demand in 2030?

III. Adults Learning {0:07- 0:11}

Thank you. Now, I would like to move to the Second question about the adults learning. The average age for mechanics in the United States is 42, so my question is:

- Can you describe the ability of this institute to provide a training program for adults regarding being electric vehicle technicians?

IV. Communication & Partnership {0:11- 0:15}

Thank you. Moving to the third question about what this Education Institute accomplished to creating communications and partnerships with other stakeholders to share knowledge and feedback, so my question is:

- Can you describe if there is any communication or partnership with any stakeholders in EV industry? If not, is there a plan to communicate or partner in the future regarding sharing knowledge and ideas and preparing training programs for electric vehicle technicians?

V. Connecticut State Support {0:15- 0:17}

The fourth question about Connecticut state is working to support the electric vehicle industry as you are one of the stakeholders in providing education training. My question for you is:

- What is your expectation from Connecticut state to provide the needed support in creating a training program for potential electric vehicle technicians?

VI. Motivation method {0:17 0:19}

Thank you. The last question is about the methods used in this educational institute to motivate and encourage students to learn something they have never experienced before, so my question is:

- How does this educational institute motivate the students and guide them to a new field they have not experienced before, like providing education for electric vehicle maintenance?

VII. Conclusion {0:19- 0:20}

{I really appreciate your effort in participating in this study. If you have any questions on how this information will be used feel free to contact me at salkhama@my.Bridgeport.edu.}

Appendix F: Interview Protocol Potential EV technician

Interview Protocol

Potential EV technician

I. Opening

Project Purpose/ Introduction. { }

{0:00- 0:04}

{Thank you for agreeing to be interviewed for this research project, which is part of my doctoral program at the University of Bridgeport. I'm interviewing you because you represent potential EV technician one of the stakeholders in the transition from fossil fuel vehicles to electric vehicles in Connecticut state.

Specifically, I'm focused on your perspective about what motivate you in EV education. In addition, I will ask you for the potential plan how will you get knowledge about electric vehicle maintenance.

I want to ensure we cover all the topics and questions within our allotted time, so I may occasionally need to interrupt you if a response becomes lengthy. Please don't take it personally, and I appreciate your understanding. If it is okay with you, we will be recording the interview so that it can be transcribed and analyzed as part of our project. Only I will have access to the names of the people who are interviewed, the transcripts will use pseudonyms to ensure confidentiality. .}

II. Motivation to learn {0:04- 0:10}

Artificial intelligence nowadays is causing a huge risk for most people to lose their jobs so my question for you is:

- What makes you interested in growth and a secure job in the future that artificial intelligence will stay away from this job?

Being a mechanic that mean you must update your knowledge every day especially new technology with computers so my second question for you is:

- What interests you in the new technologies, especially in the electric vehicle industry?

III. Connecticut State Support {0:10- 0:013}

Thank you. Now, I would like to move to the third question is about your perspective from Connecticut state to support you as potential EV technician, so my question is:

- What should the rule for Connecticut State be provided to encourage the state residents to be electric vehicle technicians?

IV. Educational Programs {0:13- 0:16}

Thank you. Moving to the fourth question about your preferences for the electric vehicle technicians' program, my question is:

- Which of these programs will match your preference if you are interested in taking the electric vehicle technician training program for six months of training, a diploma degree two years, or a bachelor's degree four years? And why?

V. The psychology of the crowd and making decisions {0:16- 0:19}

The last question. Most people make their decisions based on feeling safe about the new experience with others have done that before, but being an electric vehicle technician is new. There are not too many people who have enough knowledge to be electric vehicle technicians, so my question for you is:

- Are you interested in a high-paying job with a promising future, but only a few people your age has been before? If yes, why?

VII. Conclusion {0:19- 0:20}

{I really appreciate your effort in participating in this study. If you have any questions on how this information will be used feel free to contact me at salkhama@my.Bridgeport.edu.}

A Longitudinal Study of Extreme Weather Discussion on Social Media

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NOTE: At the request of the authors, this manuscript is not included in these proceedings

Abstract

With the increasing number of extreme weather events and various disasters, people are paying more attention to environmental issues than ever, particularly global warming. Public debate on it has grown on various platforms, including newspapers and social media. This study examines emotions of the general public on global warming in the context of extreme weather events, how emotions differ by location and the change of emotion on those topics over the time. Topic modeling is used to reveal dominant topics for each type of extreme weather. The results show that discussions on Twitter predominantly focus on floods and drought/heatwaves. There has been a consistent increase in Twitter conversations about extreme weather over recent years. Emotion analysis indicates that sadness, followed by anger, are the most prevalent emotions in discussions about various extreme weather events. Topic modeling reveals major topics in extreme weather focus on their escalating intensity and the resulting environmental, social, and emotional impacts. Additionally, these conversations often involve debates, skepticism, and considerations of risks associated with climate change/global warming.

SUS402

Evolution of ESG: Historical Roots, Contemporary Significance, and Future Trajectory

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NOTE: At the request of the author, this manuscript is not included in these proceedings

Abstract

This research delves into the dynamic Evolution of ESG (Environmental, Social, and Governance) considerations, meticulously tracing their historical roots, unraveling their contemporary significance, and forecasting their future trajectory. Through a thorough exploration of ESG principles from their inception to their current prominence, the paper scrutinizes pivotal historical milestones that have intricately shaped their development. Employing a comprehensive analysis of academic literature, industry reports, and empirical studies, this research investigates and elucidates the present landscape of ESG practices, emphasizing the nuanced interplay between ethical considerations and economic outcomes. By significantly contributing to the ongoing academic discourse on ESG, this research provides a profound understanding of its evolution, serving as an invaluable resource for informed decision-making in the realms of sustainable finance and corporate governance. Additionally, the study assesses the role of AI in the current ESG landscape and offers insights into its potential for accelerating data collection and dissemination with heightened speed and accuracy. While acknowledging the transformative potential of AI, the research also underscores ethical concerns that may arise from its usage, contributing to a holistic understanding of the intersection between AI and the future of ESG.

Sustainability Across Countries

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January 2024

Abstract

In present times, global sustainability is of utmost concern. This paper delineates a coherent procedure that holistically encapsulates a detailed analysis of the performance of various countries across critical sustainability dimensions. Leveraging the World Bank's ESG Data Draft, which comprises 17 key themes within the environmental, social, and governance (ESG) categories, this research aims to provide a nuanced understanding of the interplay between countries' sustainability practices and the broader financial landscape. The World Bank Group's initiative to enhance financial markets with improved data and analytics represents a pivotal step towards aligning financial flows with global sustainability objectives. Our study focuses on unraveling the myriad sustainability factors and aims to decipher patterns that correlate with the risk and return profiles of relevant investments. By employing advanced data analytics tools, we seek to draw insightful correlations, offering a foundation for informed decision- making in the rubric of sustainable finance and investment. There are two important information levers along which our research aims to scrutinize and disseminate valu- able insights. The first is the change in various sustainability factors over a span of 60 years from 1960 to 2020. The second is the juxtaposition of the previous analysis with the watershed historical events that delineate the presence of these trends. This research aspires not only to contribute to the burgeoning field of sustainability ana- lytics but also to offer practical implications for policymakers, investors, and financial institutions, fostering a paradigm shift in global financial practices towards a more sustainable and resilient future.

Keywords: Electricity Production, Energy efficiency, Food Production, GDP Growth, Life Expectancy

1 Introduction

The World Bank Group has maintained a treaty-based association with the United Nations (UN) since its inception. This enduring partnership is dedicated to fostering collaboration that assists Member States, facilitating effective development outcomes, all the while up- holding the distinct mandates of each institution. Over the years, the WBG has actively cooperated with the UN across various regions and sectors, intensifying its involvement fol- lowing the establishment of the Millennium Development Goals (MDGs) and subsequently with the adoption of the Sustainable Development Goals (SDGs) [1]. Encompassing 17 tar- gets spanning critical areas such as health, gender, employment, and poverty alleviation, the SDGs, introduced in 2015, form an integral part of a comprehensive global agenda aimed at eradicating poverty within a single generation. The 17 SDGs encompass No Poverty, Zero Hunger, Good Health and Well-Being, Quality Education, Gender Equality, Clean Water and Sanitation, Affordable and Clean Energy, Decent Work and Economic Growth, Indus- try, Innovation, and Infrastructure, Reduced Inequality, Sustainable Cities and Communi- ties, Responsible Consumption and Production, Climate Action, Life Below Water, Life on Land, Peace, Justice, and Strong Institutions, and Partnership for Goals [2]. These SDGs, developed with substantial input from the World Bank Group, align seamlessly with the institution's twin goals of poverty eradication and sustainable shared prosperity. The World Bank Group is positioned to play a pivotal role in advancing the SDGs and the broader 2030 agenda through its expertise, global influence, and on-the-ground initiatives. At the country level, it is imperative for the World Bank Group to attentively heed the aspirations of its country partners striving to attain the SDGs. The SDGs, coupled with the twin goals, pro- vide a coherent framework for dialogues with country clients, fostering collective objectives and reinforcing global collaborations to forge resilient global public goods. These efforts are particularly critical in addressing formidable challenges such as fragility, climate change, pandemics, and stunting, each of which inflicts severe repercussions on the impoverished and vulnerable populations.

The paper is structured as follows. In Section 2, we provide insights into the involvement of organizations such as the World Bank and the IMF in environmental and social factors relevant to the development of nations. We also discuss comprehensively the concepts of Environmental, Social, and Government (ESG) factors, along with the underlying ideas and principles implemented to transform major industries, incorporating strategies for capital investment in both growth and sustainable development. In Section 3, we utilize World Bank data to examine the economic performance of countries from 1960 to 2020. Section 4 delineates how integrating ESG into working strategies can impact economic growth. Fi- nally, in Section 5, we summarize our findings and elaborate on how we intend to continue our research on this theme in the future.

2 Literature Survey

2.1 The World Bank's Environmental and Social Safeguards

The Evolution of Environmental and Social Safeguards in the World Bank and its Impli- cations for the Global Legal Order presents a comprehensive examination of the World Bank's Environmental and Social Safeguards (ESS) within the context of evolving global legal paradigms. Scrunity of the Safeguards is across three key dimensions: the interplay between Bank and member state law, the role of individuals constrained by human rights considerations, and the thematic scope of the Safeguards in delineating the nexus between 'development' and other international regimes. Initially introduced in the 1980s in response to detrimental impacts of Bank-financed investment projects, the Safeguards underwent a reform in the 1990s, introducing ambiguities that prompted a subsequent reform process involving the Inspection Panel. A significant overhaul in 2016 replaced the erstwhile 'Safe- guard Policies' with the new ESF. This framework mandates the Bank and its borrowers to assess and manage environmental and social risks, engage in stakeholder consultation, and provide compensation to specific project-affected individuals. The analysis underscores an ambivalent trend in the Safeguards reform, wherein donor countries and civil society orga- nizations have advocated for the defense and expansion of individual entitlements. This is exemplified by an explicit reference to human rights in the Vision statement. The reform has concurrently bolstered member state sovereignty, particularly in cases involving the use of country systems. However, this privilege predominantly benefits stronger borrowers, leav- ing weaker borrowers subject to broadened and intensified standards imposed by the Bank. Broader principles within the realm of development cooperation law have played a central role at the institutional level of the World Bank. The augmented interpretive authority of the Bank, while potentially reinforcing fragmentation, necessitates meaningful dialogues with competent institutions such as the ILO, UN human rights bodies, and climate governance actors. To summarize, the analysis contributes valuable insights into the evolving landscape of international law and its implications for the global order in the twenty-first century [3].

2.2 The World Bank's Growing Investment in Urban Environ- mental Management

The World Bank has significantly increased its engagement in combating urban pollution, aligning with its broader mission to foster sustainable development and enhance the qual- ity of life for urban populations in developing nations. Recent reports underscore a notable escalation in the Bank's commitment to environmental sustainability. This commitment ma- terializes through a range of projects and initiatives aimed at tackling urban pollution, with a particular emphasis on integrating environmental considerations into urban planning and development. Recognizing urbanization as a primary catalyst for environmental degradation, the Bank advocates for a comprehensive approach that encompasses economic, social, and en- vironmental dimensions within urban development strategies. Substantial investments have been channeled into initiatives like the Urban Management Program (UMP) and the Munic- ipal Environmental Infrastructure Project (MEIP). These endeavors target the enhancement of urban residents' quality of life by addressing critical issues such as air and water pollution,

solid waste management, and urban transport challenges. The report emphasizes the pivotal role of stakeholder participation in urban environmental management. The Bank collabo- rates closely with local communities and governments to tailor projects to the specific needs and concerns of each community, a strategy that has proven particularly successful in pro- moting socially acceptable and effective sustainable urban development. Additionally, the report underscores the necessity of building institutional capacity for urban environmental management, given the prevalent lack of technical and administrative proficiency in many developing countries. Consequently, the Bank has made substantial investments in capacity- building initiatives, including training programs targeting urban planners and environmental managers [4].

2.3 Environment, Social, and Governance

ESG serves as a stakeholder framework for the analysis and evaluation of corporate social per- formance, focusing on approaches, models, and methodologies in field studies. Corporations, in managing relationships, distinguish between societal and stakeholder issues. Challenges arise in testing a three-dimensional cube model for corporate data collection and evalua- tion. The Wartick and Cochran model, grounded in Carroll's integrated view of corporate social responsibility (CSP), introduces economic performance as the first dimension. Ethi- cal and discretionary responsibilities pose further definitional and testing challenges. Social responsiveness processes, categorized as reactive, defensive, accommodative, or proactive, are complex. However, the model inadequately tests social responsibility with available cor- porate data. A methodology emerges, emphasizing stakeholder relationship management in evaluating corporate performance. Data collection reveals mismatches with the model's categories, aligning more with stakeholder management concepts. Case studies inform a stakeholder management model, offering a suitable organizing principle and an issue in- ventory. The inventory stimulates consideration of diverse stakeholder issues, providing a standardized entry and coding system. The research urges distinction between stakeholder and social issues at institutional, organizational, or individual levels. Social issue defini- tion complexity hampers understanding corporate social performance. Friedman critiques discussions on business social responsibility, advocating systematic methods to determine corporate social issues. Clarifying analysis levels is crucial, distinguishing between insti- tutional, organizational, and individual perspectives. Not all social issues are stakeholder issues, and companies decide the extent of stakeholder obligation pursuit. Legal require- ments and social responsibilities differ; companies possess discretion in areas like employee training and customer communication. Stakeholders, essential for corporate survival, in- clude primary groups like shareholders, employees, customers, and suppliers, and secondary groups like media and special interests. Failing to manage primary stakeholder relationships carries significant consequences. The RDAP Scale, assessing stakeholder issue management, is essential for performance evaluation. The revised RDAP Scale refines social responsive- ness definition, emphasizing a corporation's economic and social purpose fulfillment. Stake- holder framework application evaluates corporate success, proposing empirical propositions on the stakeholder satisfaction-corporate performance relationship. Fair wealth distribution to primary stakeholder groups is crucial, along with managing ethics and moral principles strategically. Environmental principles influence capital project assessment, community re-

lations, social investment, and performance assessment. The author, Max B. E. Clarkson, is the founding Director of The Centre for Corporate Social Performance and Ethics at the University of Toronto [5].

2.4 Impact of ESG in tech companies

The influence of Environmental, Social, and Governance (ESG) factors has significantly shaped the performance of Information Technology (IT) companies. Assessing IT compa- nies within the ESG rating framework, in comparison to other industries, illuminates the strengths and weaknesses inherent in their ESG components. Presently, IT companies do not lead in terms of ESG rating, suggesting untapped potential for the refinement of their ESG practices to positively impact their position and overall performance. The growing significance of ESG considerations in company valuation is evident, as traditional factors like tangible assets and financial results wane in importance, while intangible assets, such as brand value and intellectual property, gain prominence. This shift is exemplified by the substantial increase in the share of intangible assets within the evaluation of companies on the S&P 500 index, rising from 30% in 1998 to 68% in 2018. Furthermore, the authors underscore the rising demand for firms with commendable ESG scores, catalyzing notable transformations in the financial sector, with socially responsible investing emerging as a prominent trend. The burgeoning interest in companies aligning with ESG principles is underscored by the substantial growth of socially responsible investing in the US, reaching
$12 trillion in 2018, signifying a 38% surge from 2016. The impact of ESG factors on the market value of IT companies highlights that a company's market value serves as a pertinent indicator for assessing the influence of ESG factors. This necessitates hypotheses to test the influence of ESG on the market value of IT companies and the development of a model to evaluate this influence, offering valuable recommendations for data sampling. There exists considerable potential for IT companies to fortify their ESG practices, thereby enhancing their market value and overall performance. Moreover, the imperative of ESG risk manage- ment is emphasized, substantiating that companies with lower ESG risks are more appealing to investors and exhibit improved financial performance and competitiveness. The impact of socially responsible investment on stock return predictability and the relationship between the degree of disclosure of information about a company's sustainable development and its market value are critical considerations. Investors are increasingly directing funds to entities with superior ESG ratings, underscoring the growing influence of ESG factors on company value. In conclusion, a comprehensive analysis of the impact of ESG factors on the perfor- mance of IT companies provides valuable insights into the evolving landscape of company valuation and the burgeoning significance of ESG considerations. The findings underscore the potential for IT companies to fortify their ESG practices, thereby enhancing their market value and overall performance, while also shedding light on the escalating influence of ESG factors on investment decisions and stock returns [6].

2.5 ESG During Financial Crisis

ESG had an impact on stock performance and risk mitigation during the COVID-19 pan- demic in China. There is empirical evidence that ESG performance is systematically priced

during the COVID-19 crisis, offering valuable insights into the resilience of environmen- tal and social stocks in the face of market-wide financial turmoil. Using China's CSI300 constituents, stock price data, and firm characteristics variables extracted from the WIND database the calculated summary statistics indicate that average scores for Environmental and Social factors are higher than for Governance, suggesting a potential focus of Chinese firms on Environmental and Social aspects, with comparatively less attention to traditional governance practices. An accumulation of evidence in three parts, characterizing differentials in trading value and volumes for high-ESG and low-ESG CSI stocks pre and post COVID-19 is used to develop industry-neutral investment portfolios spanning 2015–2020, and illustrate the pricing of ESG factors during the COVID-19 pandemic through an event study. Fur- thermore, it vindicates the conjecture that ESG factors are of relatively higher importance during times of crisis within a multi-factor empirical asset pricing model. The findings reveal that trading activity for CSI300 constituents intensified during the pandemic period, with both high-ESG and low-ESG firms experiencing heightened trade activity, especially among low-ESG firms. This suggests that high-ESG firms may be relatively more resilient during the pandemic period, with investors displaying more patience and refraining from selling their shares to avoid losses during the turbulent market. Additionally, the research presents supportive evidence through industry-neutral, bi-annually re-balanced portfolios constructed using ESG scores from 2015:06-2019:12, indicating that high-ESG portfolios outperform low- ESG portfolios, particularly in the early part of 2020. The most pertinient question however, is whether the negative sentiment among investors during the COVID-19 pandemic trans- fers indiscriminately across all forms, or if ESG performance acts as a valuable indicator to systematically navigate away from negative risk during times of crisis. The empirical evidence provided is consistent with the flight to security hypothesis and underscores the signaling role that ESG performance might offer investors in terms of potential resilience against downside risk. The findings have implications for asset managers and investors, highlighting the incremental importance of ESG performance and its potential to mitigate financial risk during market-wide crises, thereby informing ESG investment practices and decision-making strategies [7].

3 GDP Growth in Countries

The data from the World Bank elucidates the growth in GDP in each year from 1960 to 2020. The trend in GDP growth across 6 different countries is given below:

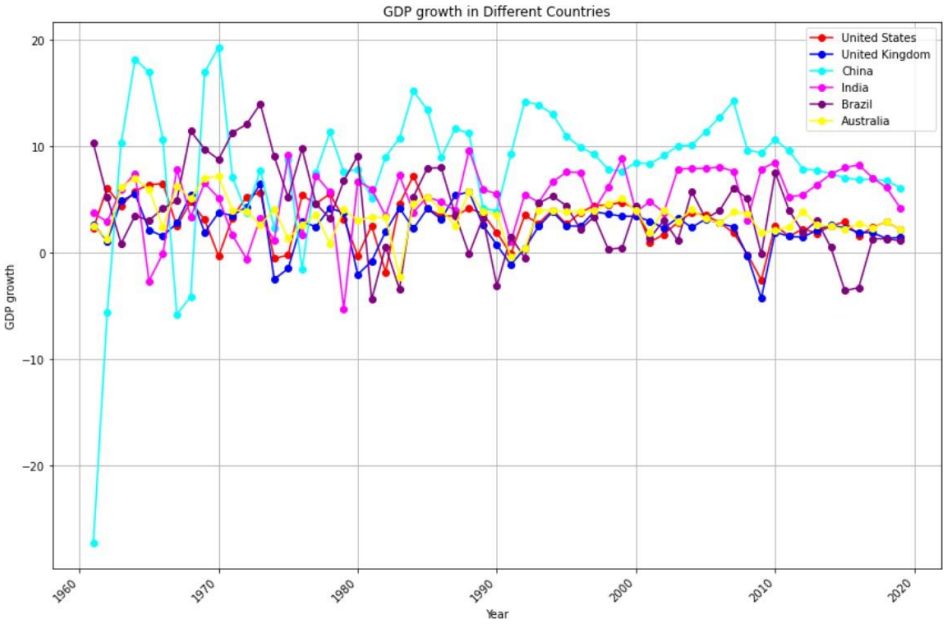

Figure 1: Change in GDP Growth Across Six Decades

The variation in the statistical measures of GDP growth across six countries is shows the shift in the economy over six decades.

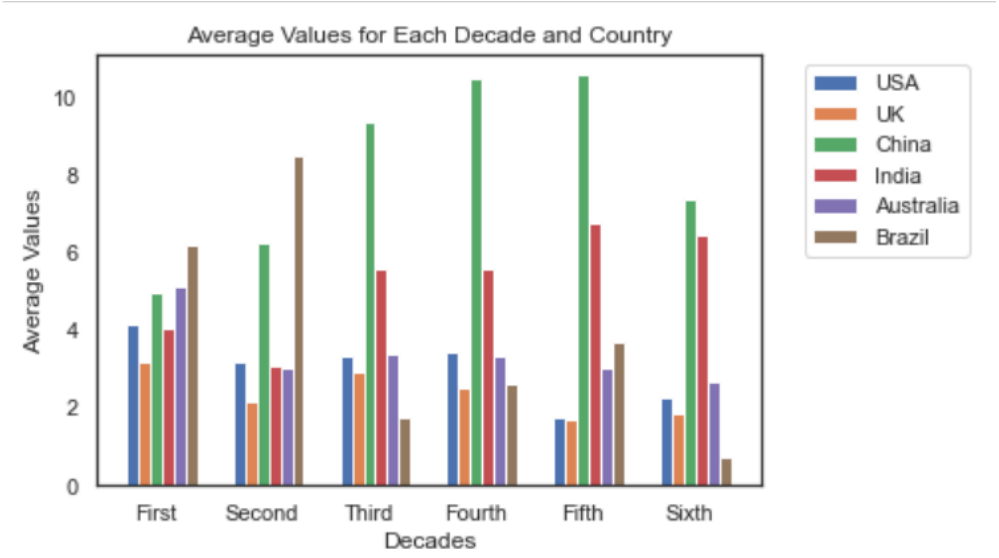

Figure 2: Average Values of GDP Growth across six decades for six Countries

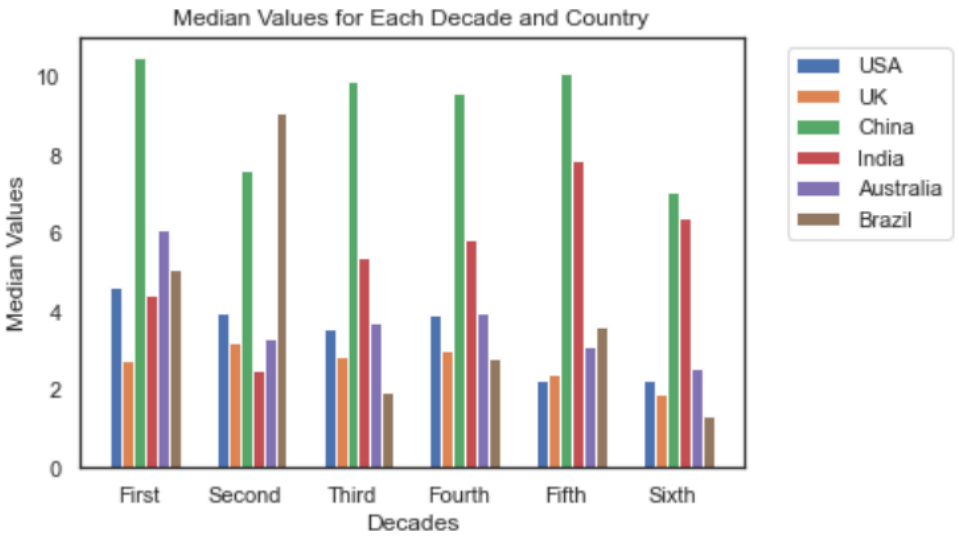

Figure 3: Median Values of GDP Growth across six decades for six Countries

The subsequent sections highlight the pertinent observations that one can surmise from the results and the broader historical circumstances that played a significant factor in shaping these results.

3.1 The 1980s Debt Crisis in Brazil

The performance of GDP growth in Brazil has stymeid after the second decade since the 1980s. The debt crisis of the 1980s sent shock waves across multiple Latin American countries and precipitated their economic performance to a nadir from which most countries haven't been able to find a way to recover. What happened to Brazil was precipitated by a confluence of factors that significantly impacted the economy, ultimately leading to recession and finan- cial instability. The dominance of financial interests on public policies played a pivotal role in shaping the trajectory of the crisis. The external debt negotiations in 1982, which prioritized the interests of international creditors, set the stage for a series of events that had far-reaching implications for the Brazilian economy. One of the key contributing factors to the crisis was the imposition of external adjustment measures, including exchange rate devaluation, public investment cuts, and a substantial increase in real interest rates. These measures, aimed at addressing the external debt burden, had profound repercussions on the economy. The devaluation of the exchange rate and the reduction in public investment adversely affected economic stability, leading to a recessionary environment. Moreover, the hike in real interest rates exacerbated the situation, as it significantly increased the cost of borrowing and debt servicing for both the public and private sectors. The impact of these measures was further compounded by the pervading financial instability, notably characterized by high inflation. The unpredictability of financial and production costs, driven by exchange rate and interest rate instability, disrupted normal pricing practices within the Brazilian economy. As a result, mark-ups had to be adjusted frequently to account for growing costs and to mitigate future increases in financial costs and risks. This environment of financial instability and economic downturn was a direct consequence of the adjustments imposed on the Brazilian economy by

external creditors. Furthermore, the crisis was exacerbated by the burden of public deficits and debts, which became major components of the economic challenges faced by the country. The high instability of exchange and interest rates, coupled with the recession that depressed tax revenues, led to interest payments becoming a significant portion of public deficits. This situation was exacerbated by the stringent demands of foreign creditors, who provided little, if any, debt forgiveness, and compelled Brazil to generate sufficient resources to meet debt servicing obligations. The austerity policies established by the International Monetary Fund (IMF) and foreign creditors further constrained the policy choices available to Brazilian au- thorities, ultimately shaping the economic landscape of the time. In summary, the 1980s debt crisis in Brazil was a complex interplay of external debt negotiations, imposed exter- nal adjustment measures, financial instability, and the burden of public deficits and debts. The dominance of financial interests on public policies, particularly in the context of external debt negotiations, significantly influenced the trajectory of the crisis. The resulting economic downturn, characterized by recession and financial instability, had profound implications for the Brazilian economy, shaping its development during this critical period [8].

3.2 The Rise of China: From the Vestiges of Socialism to Eco- nomic Prosperity

China's remarkable economic ascent has been a subject of global discussion, marked by sig- nificant growth over recent decades. Several key factors have propelled China's economic performance, making it a dominant player on the world stage. One pivotal driver is China's strategic focus on manufacturing, transforming the country into a global manufacturing hub [9]. This emphasis has not only boosted exports, generating substantial revenue but also attracted foreign investment, contributing to China's economic boom. Investments in infras- tructure have played a crucial role in China's economic success. Substantial developments in transportation and communication networks have facilitated smoother business opera- tions, enhancing the overall business environment and attractiveness for foreign investors [10]. China's commitment to infrastructure improvements has been a strategic move to bol- ster economic growth and global competitiveness. China's vast population, exceeding 1.4 billion people, has been a catalyst for economic growth. This demographic advantage has created an expansive consumer market, driving demand for goods and services. Addition- ally, China's abundant pool of skilled labor has attracted foreign investment, further fueling economic expansion. Comparing China's economic performance to that of the United States involves examining key indicators. GDP per capita stands out as a crucial metric. According to the Journal of the Knowledge Economy, China's GDP per capita was 0.82 in 2017, while the United States had a significantly higher figure at 5. In terms of intellectual property, the United States leads in receipts, indicating a focus on intangibles, whereas China em- phasizes tangible products [9]. China's outperformance in economic growth in recent years is evident. The World Bank reports that China's GDP grew by 6.1% in 2019, surpassing the United States' growth rate of 2.3%. The emphasis on manufacturing, coupled with a large population and skilled labor force, has been instrumental in China's economic suc- cess. A comprehensive analysis by the Congressional Research Service emphasizes China's economic reforms since 1979, focusing on modernization and global market integration[10].

These reforms, including trade liberalization and private sector encouragement, paved the way for sustained GDP growth and lifted millions out of poverty. China's adaptability and ongoing economic model restructuring showcase its commitment to long-term sustainability. In conclusion, China's economic rise is multifaceted, attributed to manufacturing prowess, infrastructure investments, demographic advantages, and strategic economic reforms. While the United States maintains a higher GDP per capita and focuses on intangibles, China's out- performance in economic growth underscores its formidable position on the global economic stage.

3.3 Economic Liberalization of 1990s and the surge of Indian Econ- omy

India's GDP witnessed a remarkable surge in growth during the post-1990s era, primarily attributed to the comprehensive economic reforms initiated in 1991. These reforms were a response to the economic crisis confronting the nation at that time, necessitating the government to seek financial assistance from the International Monetary Fund (IMF). In compliance with IMF conditionalities, India implemented a series of deregulation measures as part of the economic liberalization program. The central objective of the 1991 economic reforms was to alleviate the fiscal deficit that had precipitated the crisis. This involved significant cuts in government expenditures, encompassing social sectors like education and health. The adoption of neoliberal principles marked a pivotal shift, as the economy opened up to private players, with the market assuming a central role in governing economic activities throughout the 1990s [11]. Consequently, neoliberal ideology became ingrained in Indian law and public institutions. Despite the positive impact on stabilizing the economy and reducing public debt, the economic liberalization policy led to a discernible reduction in expenditure on social sectors, including education. The allocation of financial resources to education reflected a declining or stagnant priority under this economic policy regime. In essence, the 1991 reforms were instrumental in addressing the economic crisis, but the subsequent focus on fiscal consolidation resulted in notable cutbacks in social sector spending, particularly in education. Building on the momentum of the 1990s, India embarked on significant economic reforms aimed at liberalizing the economy and fostering global integration. Key measures included trade liberalization, deregulation, privatization, and fiscal consolidation. These reforms sought to enhance economic efficiency, promote competition, and attract foreign investment. The impact of globalization on India's economic growth during this period was substantial, particularly evident in the significant growth of exports. Trade liberalization facilitated a remarkable annual growth rate of 12.5% in exports between 1991 and 2000, driven by the expansion of the services sector, particularly software exports, which grew at an impressive annual rate of 30%. This contributed to an improved balance of payments, with the current account deficit declining significantly. Employment and income distribution across sectors experienced significant shifts. The services sector emerged as the largest employer, accounting for 28% of total employment in 2000. Conversely, the manufacturing sector witnessed a decline in employment, while the agricultural sector, which historically employed the majority, saw a reduction in its share of total employment. Changes in income distribution were also evident, with the services sector experiencing a notable increase in

wages, especially in software and IT-enabled services. In contrast, the manufacturing and agricultural sectors faced challenges, including a decline in real wages for unskilled workers. Despite these transformative changes, poverty reduction remained a persistent challenge. While official estimates suggested a decline in the poverty rate from 36% in 1993-94 to 26% in 1999-2000, there were debates about the accuracy of these figures. Some experts argued that the reduction in poverty might not have been as substantial as portrayed by official estimates. In conclusion, the economic reforms of the 1990s significantly impacted India's economy, fostering growth in exports, restructuring employment across sectors, and altering income distribution. These reforms laid the foundation for subsequent decades of rapid economic growth but also underscored the imperative for inclusive policies addressing the persistent challenges of poverty and inequality [12].

3.4 Decline of the Imperial Power post the 1960s

One of the principal reasons for the failure of the policies adopted by the British government in the 1960s was the fragmentation and interdependence of Britain's economic institutions. The source of this fragmentation lay in the particular historical development of Britain's polity. The adversarial two-party political tradition and the lack of a strong central authority contributed to the fragmentation of economic institutions. This made it difficult for the government to implement policies that would promote economic growth and halt relative economic decline. The fragmentation of economic institutions also made it difficult for the government to promote consensus building. The article argues that new conceptions of policy making and implementation were needed to address the issues of governance in Britain's economy. However, the elites saw little need for fundamental institutional change and were imprisoned in a mindset in which the British state was conceived as both centralized and powerful. To address the issues of governance in Britain's economy, the article proposes new conceptions of policy making and implementation. These include strengthening the power of the centre to impose change or promoting consensus building. The article argues that these new conceptions of policy making and implementation require a sufficient shock to the system. This shock could come in the form of a crisis or a major policy failure that would force elites to rethink their assumptions about the role of the state in the economy [13].

3.5 The Decline of a Superpower and Rise of a New One

The decline in US economic growth since 1960 has been a subject of profound scholarly interest. Robert J. Gordon's research contributes to the understanding of this phenomenon by elucidating the intricate interplay of demographic, technological, and economic factors. Gordon identifies demographic shifts, technological maturity, and alterations in labor force participation as key contributors to the deceleration of economic growth in the US. From 1970 to 2006, a discernible slowdown in economic growth is observed, marked by a 1.82 per- cent annual decrease in real GDP growth compared to the preceding period. Importantly, less than half of this decline is attributed to a reduction in productivity growth, underscor- ing the multifaceted nature of the issue. Demographically, factors such as declining fertility rates, rising mortality for specific groups, and a slower improvement in life expectancy com- pared to peer nations have significantly influenced the decline in population growth, thereby

impacting overall economic performance. The intricate relationship between demographic trends and economic trajectories is underscored, with a particular emphasis on the interac- tion between rising inequality and the slower rise in life expectancy, especially across income groups. This disparity has implications for labor force participation and productivity. Ad- ditionally, technological factors, specifically the maturity of the IT revolution, are identified as contributing to the overall decline in economic growth. Gordon's research suggests that ongoing innovation, as measured by patent issuance, has a diminished impact on productiv- ity growth compared to previous decades [14]. The article "China's economic development quality grows faster than economic quantity" provides a complementary perspective on the divergent economic trajectories of China and the US. The study indicates that China's eco- nomic development quality index has shown significant growth, surpassing the average an- nual GDP growth rate from 1978 to 2017. Noteworthy factors contributing to China's robust economic growth include substantial advancements in addressing environmental pollution, reducing income inequality, fostering technological progress and innovation, enhancing eco- nomic efficiency, ensuring social stability, and improving social welfare. China's strategic initiatives, emphasizing intensive development, resource conservation, economic agglomer- ation, and population concentration, have played pivotal roles in enhancing the quality of economic development. Furthermore, the commitment to national innovation and coordi- nated development across various dimensions has propelled sustained economic growth in China. This focus on improving economic development quality, coupled with initiatives to address environmental challenges and promote innovation, has positioned China as a global economic powerhouse, contributing significantly to its economic growth compared to the US. The findings underscore the importance of considering multifaceted factors in understanding divergent economic growth trajectories and provide valuable insights for economic policy considerations and future growth prospects [15].

4 Impact of ESG on Economic Growth

Environmental, Social, and Governance (ESG) factors have become focal points in discus- sions about their potential influence on economic growth. The paper "ESG Performance and Economic Growth: A Panel Co-integration Analysis" offers insights into the relationship be- tween ESG performance and economic growth across 29 OECD countries from 1996 to 2014. This essay examines the impact of ESG on economic growth based on the paper's findings. The paper posits three hypotheses regarding this relationship. Hypothesis 1 suggests a posi- tive link between good ESG performance and long-term economic growth, while Hypothesis 2 proposes a negative or nonexistent link in the short term. The theoretical underpinnings lie in the idea that ESG factors can elucidate long-term growth variations and the differ- ential growth rates among countries. The argument is that a country's ability to uphold the environment, pursue social objectives, and maintain good governance leads to more effi- cient resource use and faster policy implementation, contributing to higher economic growth. Empirical analysis reveals that, on average, ESG performance lacks a significant impact on short-term GDP per capita. However, in the long run, countries with strong ESG perfor- mance exhibit a positive and significant impact on GDP per capita, supporting Hypothesis 1. This suggests that sound ESG policies can foster strong and sustainable economic growth over

the long term. Notably, Iceland and South Korea experienced short-term economic benefits from their ESG performance, contrary to the initial hypothesis. The paper provides theoret- ical explanations for the observed relationship, emphasizing ESG factors' role in addressing output volatility, economic shocks, and growth collapses. It also underscores the integration of ESG into macroeconomic policies to overcome market failure. The endogenous growth model is referenced to highlight the positive influence of economic incentives on long-term growth. Empirical evidence from prior studies is cited to support the positive and long-term relationship between economic growth and specific ESG aspects such as air pollution control and inequality. The findings have implications for policymakers, investors, and businesses. The evidence of a positive and significant impact of ESG performance on long-term eco- nomic growth emphasizes the need to integrate ESG considerations into decision-making processes. Countries with robust ESG policies may have better long-term economic growth prospects, guiding policy formulation and investment strategies. Additionally, the identifi- cation of short-term economic benefits in specific countries underscores the nuanced nature of the ESG performance and economic growth relationship, necessitating context-specific analysis and policy interventions. In conclusion, the paper provides valuable insights into the impact of ESG performance on economic growth. The theoretical framework, empirical evidence, and implications contribute to understanding the complex relationship between ESG factors and economic outcomes. The findings underscore the potential for ESG consid- erations to drive sustainable and inclusive economic growth. The essay's analysis delves into the theoretical and empirical aspects of the paper, emphasizing the importance of nuanced policy interventions to fully harness the benefits of ESG integration [16].

5 Conclusion and Future Scope

reveals intricate dynamics that significantly shape the contemporary social, political, and economic landscape. Post-World War II, the United States and the United Kingdom grap- pled with the repercussions, resulting in dismal economic performances over six decades. Imperialist-centric policies, wealth distribution strategies, and military interventions hin- dered their growth. In contrast, China's embrace of capitalism and economic openness transformed it into a dominant economic force, surpassing its socialist past. India's eco- nomic rise post-1990s through liberalization and Brazil's recovery from the Latin American debt crisis are noteworthy in our findings. Future analysis of 16 additional sustainability met- rics will deepen our understanding of how historical narratives and policy decisions influence diverse countries' sustainability performances.

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Papers

Teaching and Innovative Education

Information Literacy: ChatGPT, Library or Internet?

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As artificial intelligence (AI) based products expand, so do the learning possibilities. New courses need to be developed, and existing courses need to be continually improved to reflect these changes. Businesses want students who can search, collect, organize, and analyze information to make them more competitive. Universities are meeting these challenges by providing "data" focus courses. This paper addresses one part of the data chain: information literacy. As part of continuous improvement, information literacy was included as part of the first introductory information system course learning objective. This undergraduate course is required for all business majors.

According to the American Library Association (ALA), "Information literacy is a set of abilities requiring individuals to "recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information." To be information literate, then, one needs skills not only in research but in critical thinking". Though the new generation of students is quite competent in social media, they still lack systematic search and evaluation capabilities of information-related articles. To keep this in mind, it was decided to develop an assignment that would teach them **search** and **evaluation skills**. Note management and analysis skills are taught in separate courses.

We followed the four steps identified by the Advanced Information Research Skills (AIRS) as part of conducting the search and added a new step of strategy revisions.

A search strategy is a systematic plan for searching. This plan comprises four steps:

1. Understand your topic and define your search terms
2. Create your search strategy
3. Select an appropriate tool
4. Evaluate your resources
5. Strategy Revisions*** (new step)

We mapped this strategy in our assignment and added one more step, change to search strategy in the future.

Steps	Requirements

Understand your topic and define search terms.	Students were asked to identify a topic of their interest and identify 3 sub-topics
Create search strategy	Use keywords or any algebraic terms like and, or, not, phrases, etc.
Select appropriate tools	These were given ChatGPT or something similar, internet, and library
Evaluate your resources	Students had to evaluate the article and its sources (author) for currency, bias, reliability, competency, etc.
Changes to each strategy in the future	What they learned and how will they change their search strategy in the future

The assignment requires students to search three sources: ChatGPT or any such AI-based tool (some students used BARD), any library, and the Internet. Students had to select articles from each of these sources and evaluate them in terms of several factors like currency, bias, grammar, content, etc. Students were required to use keywords and any algebraic combinations. Though students were not required to compare the tools but some provided their assessment of difficulties in each of the three tools.

Our results indicate students preferred library search to any other medium since library allowed for “deep” search. We are continuing more research in this area by focusing on nature of task and search strategy.

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TCH203

Improving Students' Career Readiness Through Innovative Course Redesign

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Abstract

Collaborative University Business Experiences (CUBEs) is a new co-curricular initiative that improves students' career readiness by using semester-long class projects in partnership with real organizations. The CUBEs Initiative provides students with the opportunity to bridge the gap between theory and application. Specifically, faculty members are redesigning courses to integrate hands-on experiences through real-world projects that benefit regional and national businesses. During the first year, seven course-embedded projects were implemented utilizing a collaboration between local organizations and business undergraduate courses. Each of these projects can be shared as individual teaching cases and demonstrate experiential learning outcomes in higher education.

Empowering Personal Branding: A Collaborative Journey in Marketing Education

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As a marketing educator, I was tasked with developing a marketing elective focused on personal branding. Many of the marketing techniques used to market the brand of a product or service can also be used to market the brand of an individual. This course would focus on how students can review and revise their personal brands to be more authentic and marketable.

The students in the course had already taken a marketing principles course and were knowledgeable of the marketing basics. The main goal of the course was for students to apply what they already knew about marketing products and services to marketing their own personal brands. There are numerous marketing techniques to assist students in assessing and revising their personal brands, which made for a difficult task to decide which ones this course would address. I wanted to ensure these topics were of importance to the students and relatable. In an effort to engage the students in the course curriculum, I invited them to collaborate with me in choosing which topics would be included in the course content. Based on their areas of interest, the course learning outcomes would be developed, and the appropriate assignments and assessments would be created by the students and instructor.

The first day of class students were handed a syllabus with the course content section blank. As a class they would develop the course content and determine what areas of interest would be included in the curriculum. It was important for me to share with them my reasons for doing this. This was a collaboration between the class and the instructor to create the course curriculum based on the needs and interests of the students taking the course. I stated I could easily create content I felt was appropriate for this course, but I would rather it be a team effort. I was also hoping the students would be more vested in the course and their learning since they would have skin in the game by participating in the decision-making process.

The majority of them seemed enthusiastic about the opportunity to participate in structuring the course: “I’ve never had a course that has done this before. I’m excited to have a say in what we learn and how we are graded.”; “I like that we get to decide what we are doing in the class and interested to see what other students want to learn about.” As with any process, there were a few naysayers: “I’m the student, not the teacher.” Overall, the students were up for the challenge and genuinely interested in the process.

During the first class session, we discussed personal brands and the components associated with a person’s brand. “A personal brand is about purposefully and strategically showcasing your authentic self to your audience and your customers. Your personal brand should be a true reflection of your skills, passions, values, and beliefs” (Basu, 2022). Students were separated into groups to discuss the many elements that make up a person’s brand (i.e., abilities, behaviors, education, interests, etc.). They also discussed the tools used to communicate an authentic personal brand and how to effectively present them to potential employers (i.e., social media content, resume, networking, interviewing, etc.). After the class discussion, students were asked to individually submit in writing or video the top 10 things they would like to learn about to improve their authentic personal brands. Some of the

comments during class discussion included, “I’m interested to see if my top choices are the same as others.”; “I didn’t realize everything I say and do represents my brand.”; “I don’t know if I can limit it to 10, I have a lot of work to do to improve my brand before I apply for a job.”

As the instructor, I accurately predicted what things would be on most students’ lists, such as how to write a strong resume, how to do a job interview, how to interact with business professionals, and what to put on social media. The remaining topics were numerous and would be based on students’ individual needs and interests. For the next class session, I created a spreadsheet of all of the students’ suggestions and ranked them in order of interest. The list was presented and open for discussion. I found it to be important to share all of the results. It gave the students an accurate picture of what their peers were interested in learning, which may or may not be the same as theirs. The class was reminded topics chosen are based on the entire classes’ suggestions and ranked by importance, so all of their individual suggestions may not appear on the syllabus. It was interesting to hear why students wanted to focus on specific topics. It gave them a good sense of each other’s weaknesses and why they wanted to address certain issue. The students were actively negotiating and compromising to come up with the final list of topics.

After much class discussion, a clear learning outcome was developed for each of the suggestions chosen, and assignments and assessments were created. As the instructor, I finalized outcomes to make sure they were appropriate and measurable. Based on the students’ feedback, I refined the specifics for each of the assignments and assessments and made sure to explain how they related to the learning outcome. Giving students a backstage look at how learning outcomes, assignments and assessments are created, provided them with a better understanding of how each of the components need to complement one another to be effective learning tools. I stressed this is a trial-and-error process. Sometimes you have to try an assignment to know it doesn’t fit the learning outcome. This also holds true for the assessments. Student responses included, “I didn’t know so much work went into creating assignments.”; “I like to know why I’m doing something and it’s not just busy work.”; “I usually pass right over the learning outcome, but now I know why it’s important.”

There were times when the type of assignment was very clear. For example, for the learning outcome “create a professional resume portraying your authentic personal brand”, students participated in a resume writing workshop and were given an assignment to write a resume. Once a draft was complete, a career services professional critiqued it and the student had the opportunity to revise prior to submission. For this resume assignment, multiple assessments were agreed upon. All resumes were double, blindly evaluated by a peer to determine the overall brand perception of the resume’s content and structure and the instructor also graded it for content and professionalism. This triple evaluation (career service professional, peer, and instructor) provided valuable feedback to students and allowed them to make the necessary changes to how they were presenting their brand to others. Some student responses were, “I like getting feedback on my work and the chance to make changes before it is graded.”; “Knowing I have a strong

resume decreases my anxiety about looking for a job after graduation."; "I really need to double check my work ... my reviewer said having multiple grammar errors makes me look like I don't care about my work which is not true".

In identifying the appropriate assignment type, students liked having options. For example, if they had to provide feedback on a particular discussion topic, they wanted the option to write a paper or record a video. It's important to meet students where they are and give them the opportunity to be creative and choose how they want to present their abilities. However, there are some instances where I encouraged students to step outside of their comfort zones. If I sensed apprehension about a particular situation, I encouraged them to challenge themselves. For example, a student who had a fear of public speaking was encouraged to do a video instead of writing a paper. Overall, students liked having options: "I like being able to choose how I do an assignment. I get stressed out when it comes to making a video and would rather write a paper."; "I like making videos, I can be more creative."; "I used Flip for the first time and it was easy."

After each assignment was evaluated, there was a post discussion about whether or not the assessment type chosen was best and if the evaluation process showed an accurate reflection of the students' abilities in learning the specific outcome. Student responses included, "I think a video would have been better than the PowerPoint presentation."; "It would be nice if all teachers asked for student feedback on assignments."; "If my only option was to do a video, I think I would have been too nervous to do well."

As you can see, there is more work involved upfront when you are collaborating with students to develop course content. Yes, it would be easier to do it yourself prior to the beginning of the semester, but the results are worth the extra time and effort. This collaboration with my students gave me the opportunity to build a rapport with them and provided better communication and sharing of ideas. The class discussions were more active, and students were more willing to share their personal experiences and opinions which fostered a greater sense of community.

Learning is a two-way street. To keep our courses interesting and engaging, we need to involve our students in the process of creating course content. If participating in such collaborations seems overwhelming, I encourage you to start small. For example, permit your students to decide what type of assignment they would like to do that would represent their understanding of a particular topic or learning outcome. It can be a 'free choice' assignment. Give students the option to convey their understanding by writing a post on Padlet, creating a video on Flip, creating and commentating a presentation on Screencast-O-Matic, or simply writing an essay. Have fun with it!

These types of student and instructor collaborations promote improved communication and understanding of one another. Students see things differently and can offer a fresh perspective providing new ideas and opportunities for teaching and learning, making it engaging for both the students and instructor.

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TCH301

Introducing Business Analytics Using a Demonstration Model – an Implementation Perspective

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Abstract

Over the last decade, business analytics and "big data" have permeated deeply into the fabric of business organizations. Businesses have been investing significant resources to develop a business analytics mindset within the organization to influence the strategic and operations of their organizations. The influence of this mindset can provide the foundation of analyzing and forecasting new strategic initiatives. In addition, businesses are utilizing business analytics outputs to monitor the progress of current strategies and operations to measure performance. The review of analytics output provides an objective foundation for management to alter and/or develop decisions using the feedback process. Learning and teaching analytics presents a challenge for both the educator and students, especially with the lack of comfort and ability in mathematics topics. This research outlines the integration of a well-structured and scripted analytics process using an easily understood data model and business example. The delivery of the demonstration focuses on guiding students through a process using structured slides and storytelling techniques.

Exploring E-Commerce System Effectively with a Cloud-Based Infrastructure

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Abstract

This paper focuses on innovative teaching in the ecommerce class in college of business. By (1) introducing the PaaS cloud platform (pantheon), the award-winning content management system Drupal, and the Druapl commerce kickstart distribution, and (2) discussing the procedures of installing the commerce kickstart distribution on pantheon, this paper shows how freely available technological resources can be integrated and applied by the instructor to enhance student engagement and improve learning effectiveness – potentially leading to better marketability for students in the job market.

Keywords: innovative teaching, ecommerce, PaaS, Pantheon, Drupal commerce kickstart distribution, student engagement, content management system, learning effectiveness

Introduction

An important objective of an ecommerce class in the MIS curriculum is to help students understand how different technological components work together to support various ecommerce features and workflows. This paper is to demonstrate how to use multiple freely available resources to build an ecommerce cloud infrastructure and effectively teach students the implementation of an ecommerce system. After a brief discussion of the three-tier structure of a web system, all the necessary freely available resources are introduced. Pantheon (as the Drupal based PaaS provider), Drupal (as the open-source content management system), Drupal commerce (as the set of commerce related modules for Drupal), and the commerce kickstart distribution are discussed. Further, the procedure to install commerce kickstart on the Pantheon server is also presented. With this ecommerce cloud infrastructure setup, the knowledge and skills learned from other classes (such as programming, database, networking, enterprise systems, marketing, operations management, etc.) can be integrated and reinforced. More importantly, both the level of student engagement and learning effectiveness could be improved (Panigrahi, et al., 2021; Carini, et al., 2006) - potentially leading to a better marketability for students (Patel, et al., 2011). It is the author's hope that this paper may help instructors of the ecommerce class in business schools.

The Simplified Three-Tier Structure of an E-Commerce System

The essence of an ecommerce system infrastructure is the three-tier structure with (1) the front-end, (2) the web server tier, and (3) the database server tier. Further, there are various data formats, protocols, and server-side programs (such as HTML, HTTP, SQL, PHP) facilitating the communications among these tiers and generate dynamic responses to user requests. In addition, content management systems such as the award-winning Drupal system are libraries of codes that can expedite the development

of an ecommerce system. Figure 1 in the following demonstrates the typical three-tier structure which is likely to be covered in an introduction to information system class.

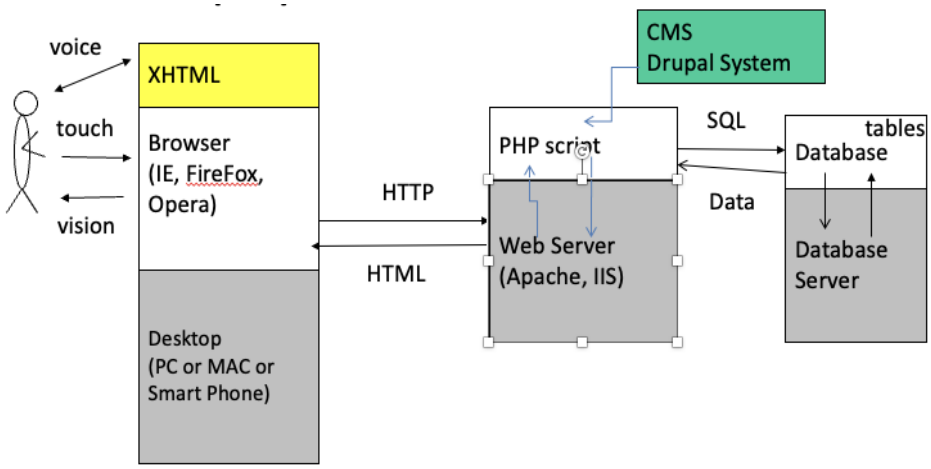

Figure 1: The three-tier structure for an ecommerce system

Pantheon: The Drupal Cloud Hosting PaaS Provider

Pantheon (pantheon.io) is a platform as a service (PaaS) provider and helps "build exceptional Drupal and WordPress sites with streamlined workflows, scalable infrastructure, and a lightning-fast content delivery network". At the time of writing this paper, Pantheon claims that it "is the WebOps platform for websites that deliver extraordinary results" and hosts more than 700, 000 web sites, has more than 2500 partners and more than 17 billion monthly page views[4]. It provides free virtual web and database servers to host an ecommerce system built upon the award-winning content management system Drupal (drupal.org). Pantheon has both a convenient graphical user interface (i.e., pantheon dashboard) for beginners and a more powerful command line interface (i.e., terminus[5]) for site developers to manage the full cycle of system development and maintenance (with the development, test, and production environments). It works with the popular version control system git (so that different versions of local changes of the system under development can be pushed to the remote Pantheon servers). With an elevated membership, it supports multiple branches with the git system. In addition, it also has the secure FTP (SFTP) entry point for file transfer. It supports both the Apache Solr Index Server as "a system for indexing and searching site content" and the Redis Cache Server as "an open source, networked, in-memory, key-value data store that can be used as a drop-in caching backend"[6]. Lastly, a team of developers can work on site development in a coordinated fashion through the Pantheon platform.

[4] Pantheon.io, Accessed on December 22, 2023.
[5] https://docs.pantheon.io/terminus, Accessed on December 22, 2023.
[6] Pantheon.io, Accessed on December 22, 2023.

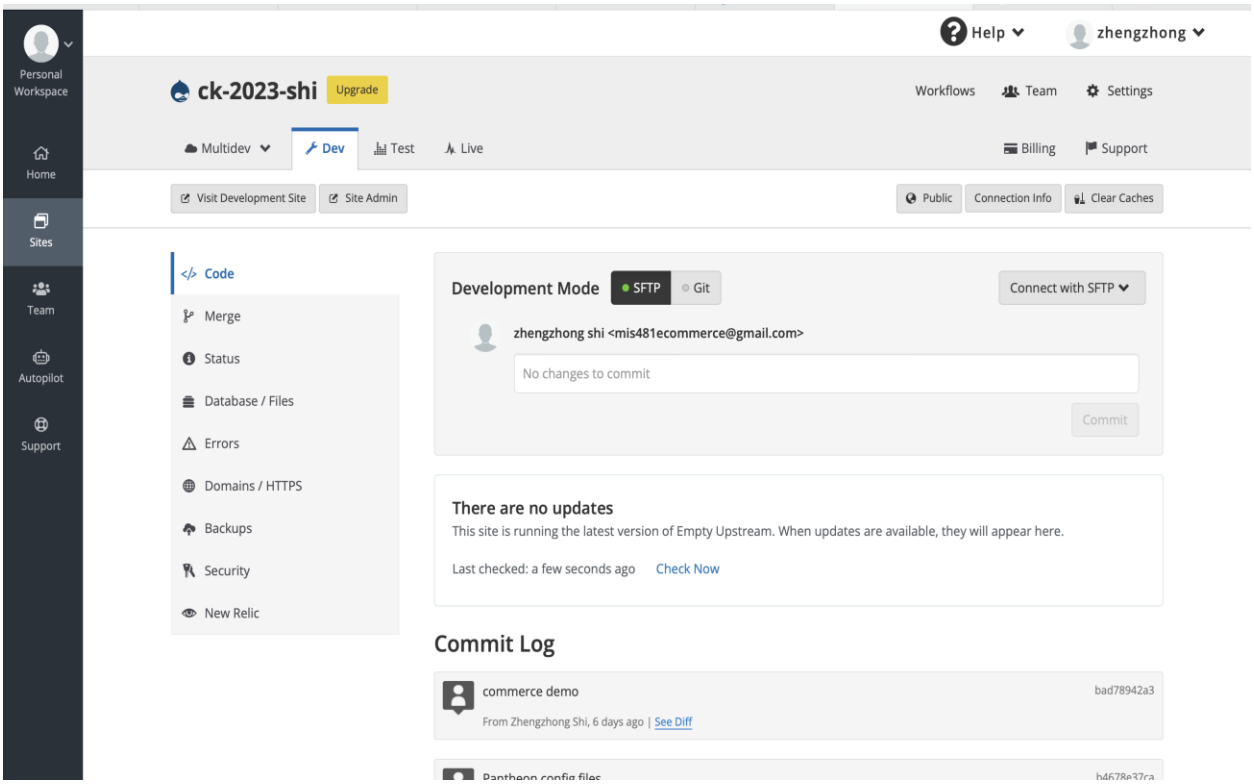

Figure 2: Pantheon Dashboard

Drupal: the award – winning CMS

"Drupal is a free and open-source content-management framework that can be customized and is suitable for developing simple websites or complex web applications."[7] Drupal has a community of more than 1,000,000 developers, designers, trainers, editors, and sponsors. Drupal is applied by many government agencies, universities, and media companies besides all the small and big size companies. This link (https://www.drupal.org/case-studies) shows some case studies about applications of Drupal in different industries.

Drupal is flexible with many modules and themes to extend its features and functions. Some examples are such as views (i.e. graphical UI for the SQL design), Google Map, Charts, Webform, email, social media, media management, taxonomy, data tables, feeds, Drupal commerce, backup and migrate, the Belgrade theme, the Business Responsive theme, etc. By the time of writing this paper, Drupal has more than 40,000 modules and 2500 themes[8]. Figure 3 is the first page for the installation of Drupal on Pantheon.

[7] https://www.drupal.org/docs/getting-started/understanding-drupal/overview-of-drupal, Accessed on December 23, 2023.
[8] Ibid.

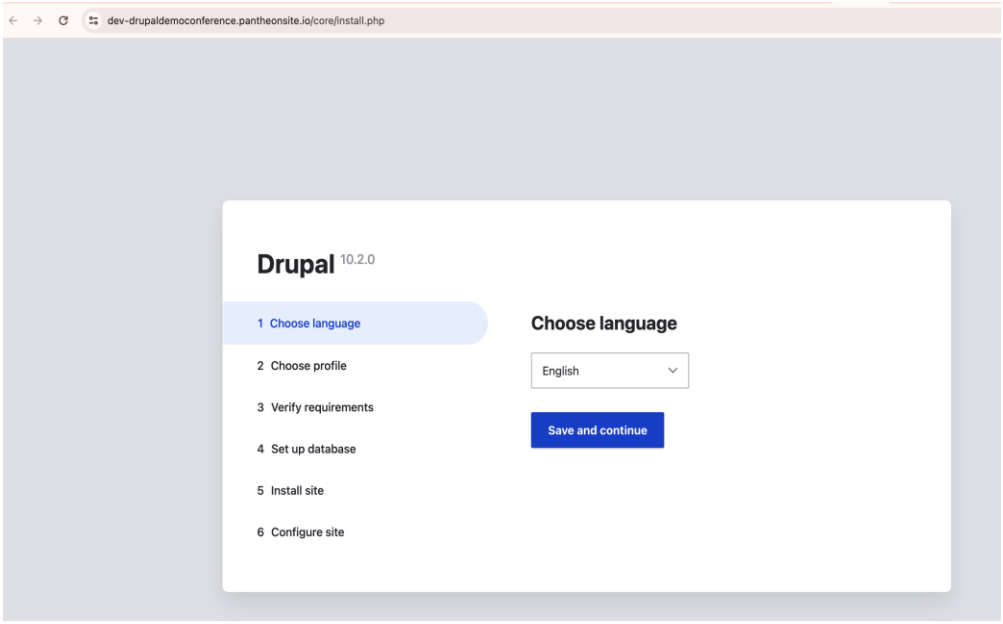

Figure 3: Drupal Installation on Pantheon

Drupal works with the Docker-based development environments for macOS, Linux, and Windows and this feature makes the learning and development of Drupal systems conveniently for both students and instructors. An example of the Docker-based development environments is Ddev[9]. Drupal also works with a local xampp server smoothly[10].

Drupal Commerce and Commerce KickStart

While many eCommerce platforms are developed with an application orientation, emphasizing features out of the box, "Drupal Commerce was developed with a framework first mindset, focusing on what you can build with it"[11]. It supports many ecommerce related functions and workflows. Example features and workflows include such as product types and variations, catalog, cart, checkout workflow, coupon management, order management, shipping, payment, etc. Figure 4 is the installed Drupal commerce site on Pantheon with the commerce kickstart distribution.

Commerce Kickstart[12] is a base distribution built upon Drupal Commerce, not only including Drupal 10 and Drupal Commerce Core but also various Centarro (i.e., the company behind Drupal commerce) maintained contributed modules and themes. As a useful tool for learning and teaching ecommerce, Commerce KickStart has a demo package with many products and views set up already (Figure 4).

[9] https://ddev.readthedocs.io/en/stable/, Accessed on December 23, 2023.
[10] https://www.apachefriends.org/download.html, Accessed on December 23, 2023.
[11] https://www.drupal.org/project/commerce, Accessed on December 23, 2023.
[12] https://www.drupal.org/project/commerce_kickstart, Accessed on December 23, 2023.

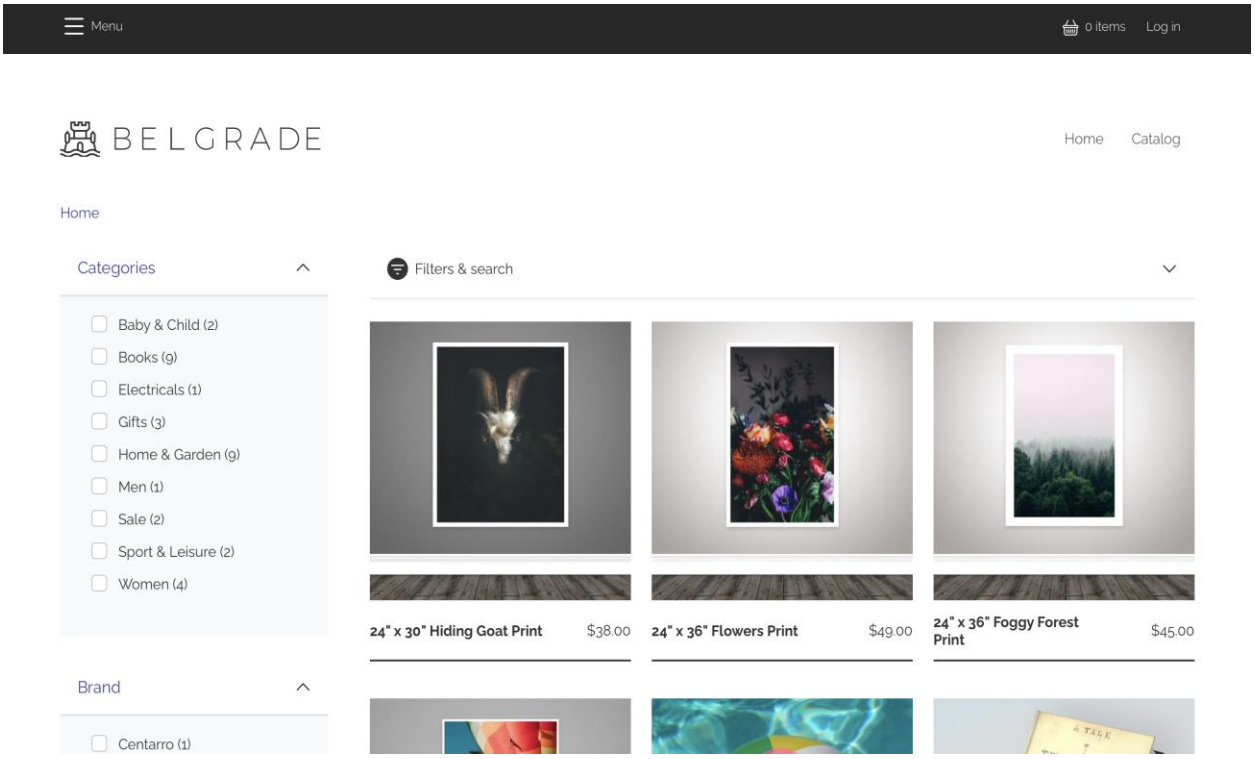

Figure 4: Drupal Commerce on Pantheon (with Commerce Kickstart)

Procedures to Set up a Drupal Commerce Site

To set up a Drupal commerce site on Pantheon, the commerce kickstart distribution can be used. The procedures outlined at this link[13] can be modified to install commerce kickstart. In the installation process, terminus and composer[14] (as the php package management tool) are required. A few issues we need pay attention to are the following:

1. It is necessary create a Pantheon site with the empty tag with the following command. The purpose of this empty site is used as a placeholder to hold the commerce kickstart distribution which will be pushed to the Pantheon server later from a local machine.

   terminus site:create $PANTHEON_SITE_NAME $PANTHEON_SITE_NAME empty

2. It is necessary to create a local commerce kickstart based Drupal site with the following command. This local site will be pushed to the remote pantheon server with git.

   composer create-project -s dev centarro/commerce-kickstart-project $PANTHEON_SITE_NAME --no-interaction

[13] https://gist.github.com/cnovak/38ed1026980b782c886bbd04b8a7f70f, Accessed on December 23, 2023.
[14] https://getcomposer.org/download/, Accessed on December 23, 2023.

3. It is necessary to set a remote origin for the local site (created in step 2). This is to establish the connection between the local site and the remote Pantheon place holder site. The following commands are needed:

```
cd $PANTHEON_SITE_NAME
export PANTHEON_SITE_GIT_URL="$(terminus connection:info $PANTHEON_SITE_NAME.dev --field=git_url)"
git init
git remote add origin $PANTHEON_SITE_GIT_URL
```

4. It is necessary to revise the .gitignore file at the root directory to allow git to push all the necessary codes to the Pantheon Server.

5. It is necessary to take care of a few configuration files including such as pantheon.yml, setting.php, and settings.local.php. The pantheon.yml file indicates the versions of php, database, and pantheon api used in the Pantheon servers. Both setting.php, and settings.local.php can be copied from this link[15].

6. The commerce demo package can be installed locally with the composer command and the .git directory should be deleted as pantheon does not recognize a git repository inside another repository.

```
composer require drupal/commerce_demo:^3.0 composer require drupal/commerce_demo:^3.0
```

7. Git commands are used to push all the local changes to the remote Pantheon Server:

```
git add -A
git commit -m 'Install Commerce KickStart on Pantheon'
git push --force --set-upstream origin master
```

8. Lastly, after the site mode is changed to sftp mode, the site dashboard can be visited in a browser and the button of visiting the development site should be clicked to start the installation process, which will produce the site as demonstrated in Figure 4.

To properly follow these procedures, students need to have some basic understanding of the git system, the composer package management system, the setup of the keys for terminus to communicate with the Pantheon server. Teaching students to follow these procedures and help them debug is a good engagement process for enhanced learning of various concepts such as the three-tier structure, the version control system, the command line, the role of system configuration, etc.

Conclusion

This paper intends to introduce to the instructors of ecommerce classes in college of business about the technological infrastructure of an ecommerce system. Based on this example system, not only can different technical components (such as the cloud, database, code management, and module installation) be discussed, but various business needs and workflows (such

[15] https://github.com/pantheon-systems/drops-8-scaffolding/tree/master/sites/default, Accessed on December 23, 2023.

as product attributes and variations, checkout workflow, email setup, and order management) can also be presented in a practical manner. In this way, student engagement can be enhanced – likely resulting in an improved learning effectiveness.

Reference

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An Alternative Lab Environment for Computer Networks

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Abstract

Teaching computer networks in college of business is challenging as this class is technology intensive with many details. Engagement with students through labs is an effective approach and Cisco Packet Tracer (PT) is a popular simulator used to design various labs to deepen students' understanding of complex networking concepts such as VPN, web server, and email server. However, PT does have some limitations in terms of protocols it can support. For example, PT does not support iBGP and mpls. An alternative lab environment (based on GNS3, VMWare workstation player, and Arista Switch) is developed and an example of network topology with both iBGP and eBGP is presented. It is expected that this paper may help instructors to use an alternative lab environment to better engage with students for more effective learning.

Key Words: Innovative Teaching, Computer Networks, Engagement, Lab Environment, Packet Tracer, GNS3, VMWare workstation player, Arista Switch, Learning Effectiveness

Introduction

Teaching computer networks needs to give students some hands-on experiences to enhance engagement and improve learning efficiency (Prvan and Ožegović, 2020; Panigrahi, et al., 2021; Carini, et al., 2006; Sarkar, 2006). While Cisco Packet Tracer is a very good choice, there are some limitations. For example, DMVPN, iBGP, and mpls are not supported. As an alternative lab environment, this paper introduces Arista on GNS3 to provide opportunities for students to study computer network protocols and features that are not supported by Cisco Packet Tracer. The first reason why Arista is chosen is that the vEOS (the operating system of Arista switches) is freely available[16] while Cisco IOSs are not freely available and students need to pay $199 to subscribe for the Cisco Modeling Lab[17] to download IOS images. The second reason why Arista is chosen is that the commands used to configure the switch are very similar to those used in Cisco Routers and Switches and this feature dramatically reduces the burden for students to learn two sets of commands.

GNS3: The Emulator

"GNS3 is used by hundreds of thousands of network engineers worldwide to emulate, configure, test and troubleshoot virtual and real networks. GNS3 allows you to run a small topology consisting of only a few devices on your laptop, to those that have many devices hosted on multiple servers or even hosted in the cloud"[18]. It works as the graphical user interface that has internal communication channels to router and switch operating systems running in local virtual machines or in the cloud from different vendors (such as Cisco, Arista, and Cumulus). GNS3 has "a growing community of over 800,000 members" who are students, network engineers, and architects. It has been downloaded more than 10 million times to date.

[16] https://www.arista.com/en/support/software-download, Accessed on December 25, 2023.

[17] https://learningnetworkstore.cisco.com/cisco-modeling-labs-personal/cisco-modeling-labs-personal/CML-PERSONAL.html, Accessed on December 25, 2023.

[18] https://docs.gns3.com/docs/, Accessed on December 25, 2023.

Arista and Its Switch Operating System Platform EOS

"Arista Networks is an industry leader in data-driven, client to cloud networking for large data center, campus and routing environments."[19]. Arista develop and produce high end data center three-tier switches and WiFi 6 Access points. "Arista EOS is a fully programmable and highly modular, Linux-based network operation system, using familiar industry standard CLI and runs a single binary software image across the Arista switching family"[20]

VMWare WorkStation Player

VMWare became a part of Broadcom recently, providing "enterprise customers an expanded portfolio of business-critical infrastructure solutions to accelerate innovation and enable greater choice and flexibility to build, run, manage, connect and protect applications at scale"[21]. VMware Workstation Player is a hypervisor that runs a single virtual machine on both Windows or Linux and it is free for personal and non-commercial use[22].

Procedures to Set up the GNS3 System for Computer Network Labs

First, GNS3 client can be downloaded from the link[23]. The following Figure 1 is a screenshot of the user interface in GNS3.

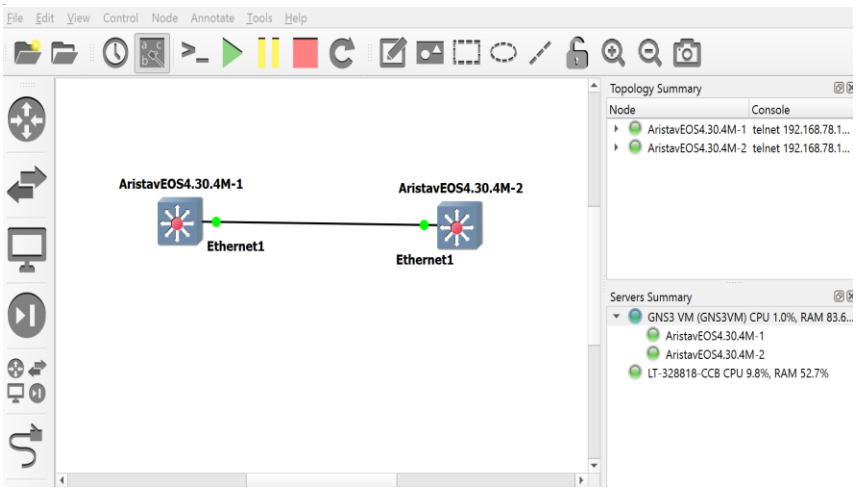


Figure 1: The User Interface of GNS3

[19] https://www.arista.com/en/company/company-overview, Accessed on December 25, 2023.
[20] https://www.arista.com/en/products/eos, Accessed on December 25, 2023.
[21] https://www.broadcom.com/info/vmware, Accessed on December 25, 2023.
[22] https://www.vmware.com/products/workstation-player/workstation-player-evaluation.html, Accessed on December 25, 2023.
[23] https://gns3.com/software, December 25, 2023.

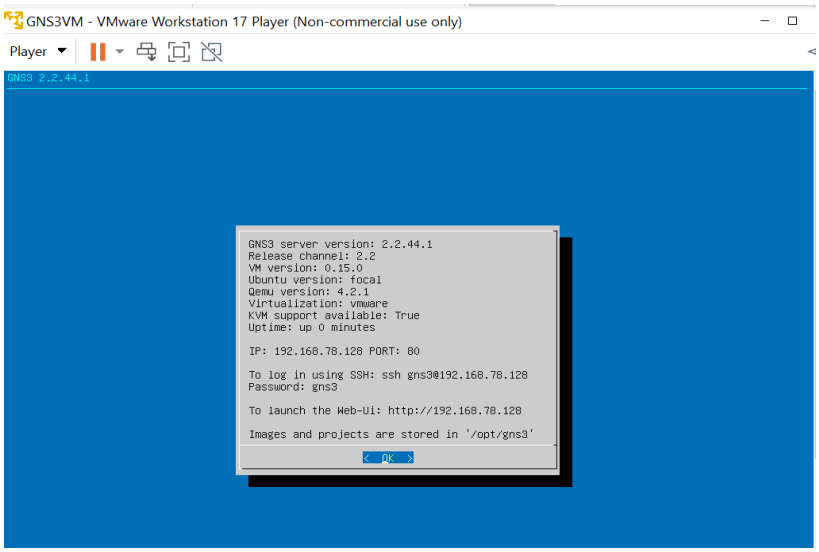


Figure 2: the interface of the running GNS3 VM

Second, VMWare Workstation Player can be downloaded from the link[24]. GNS3 Appliance for VMWare workstation should be downloaded from the link[25] and imported into the player. A few configurations should be set. For example, the number of processors and the amount of virtual machine memory are critical for the performance of the labs, especially for those which have quite a few networking devices. Further, the enablement of Intel VT-x and AMD-V (supporting KVM virtualization) is needed. There are some technical details for windows users to set up to ensure KVM support is provided[26]. For example, Hyper-V service should be shut down and Device Guard should be disabled. Figure 2 shows the interface of the running GNS3 VM, displaying both the IP address and port number. It is necessary to check whether ping is successful from the hosting computer to the VM to ensure smooth communications.

Third, to set up Arista Switches inside GNS3, three software systems are required. (1) The GNS3 appliance for vEOS can be downloaded from this link[27] and it is working as the middle ware between GNS3 and vEOS. The other two are downloadable for free from this link[28]. One is the iso image for the Arista Switch operating system and the other is the virtual machine disk image and both are needed when a new template device is created in GNS3. Figure 3 is the screenshot to show the new device template creation process.

[24] https://www.vmware.com/products/workstation-player.html, December 25, 2023.
[25] https://gns3.com/software/download-vm, December 25, 2023
[26] https://gns3.com/community/featured/fixing-vt-x-or-amd-v-not-available-in-windows-11-with-vmware-ws-pro-and-player, December 25, 2023.
[27] https://gns3.com/marketplace/featured/arista-veos, December 25, 2023.
[28] https://www.arista.com/en/support/software-download, December 25, 2023.

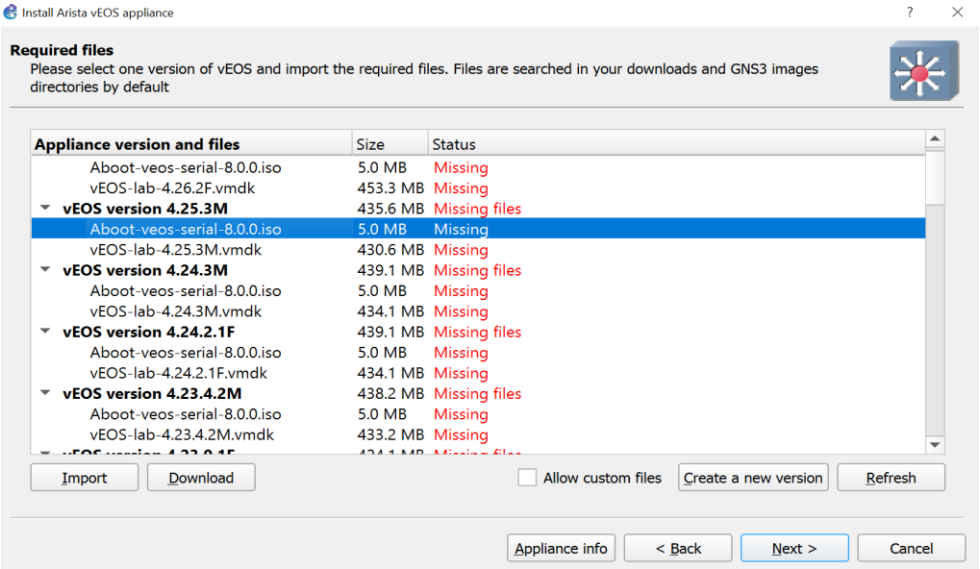


Figure 3: Installing OS Images When Creating the New Switch Device

An Example BGP Network Topology with Both eBGP and iBGP

Figure 4 is a network topology with BGP configuration. S1 is in AS2 and S2 and S3 are in AS1. S1 and S2 are in different ASs, and they establish an eBGP relationship and S2 and S3 are in the same AS, and they establish an iBGP relationship. Each switch has a loopback interface (to represent local area networks) and through eBGP and iBGP, each switch can ping the loopback interfaces of the other two switches. Through working on this network topology with both eBGP and iBGP and debugging various errors, students need to deeply engage with concepts such as routing tables, eBGP, and iBGP relationships and BGP configuration commands, likely resulting in their enhanced understanding of BGP as the backbone of Internet. Figure 5 shows the routing tables in S1, S2, and S3. It is easy to see the role played by both iBGP and eBGP in the dynamic route sharing process among these switches.

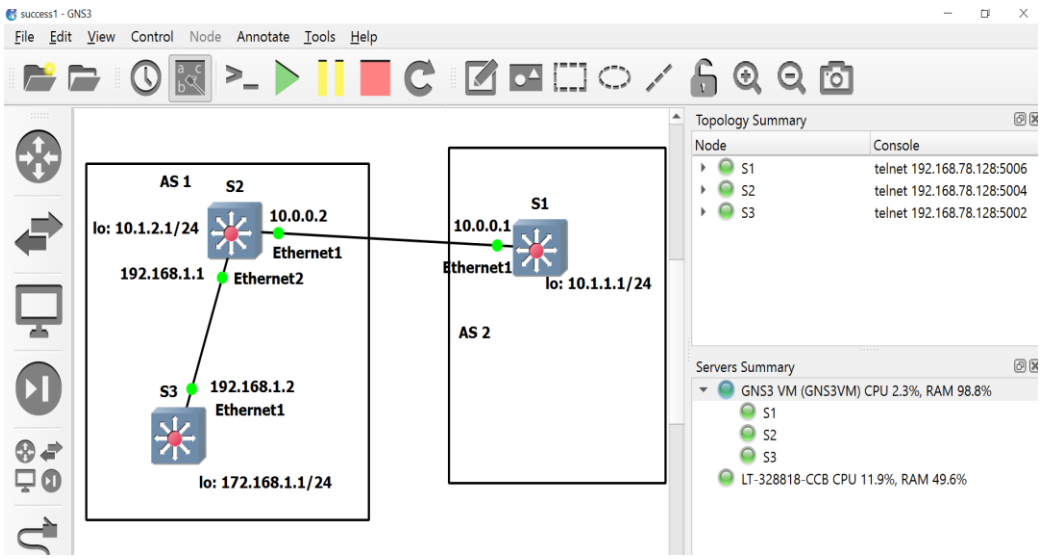
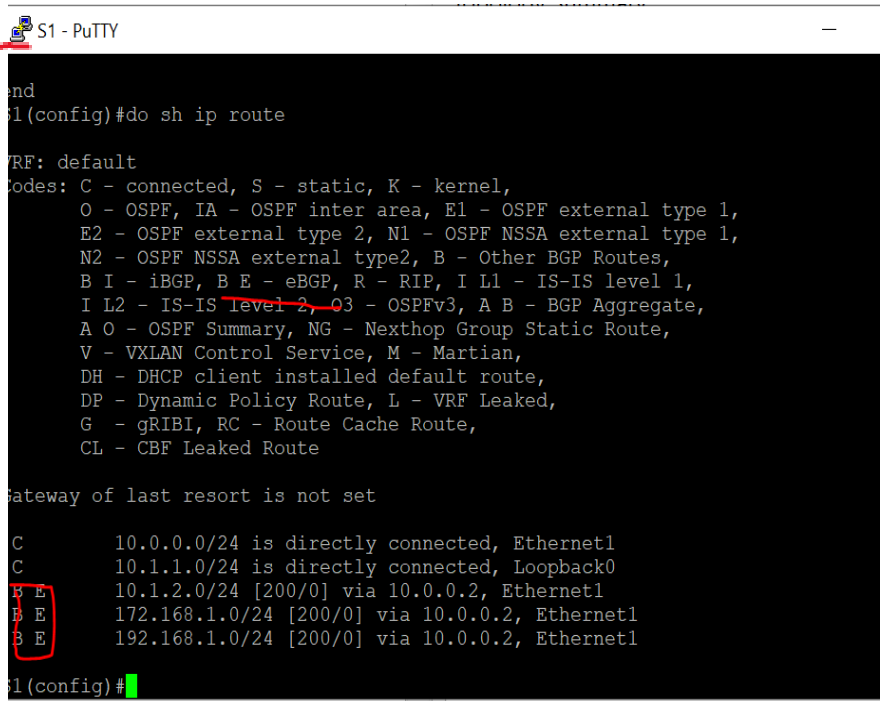
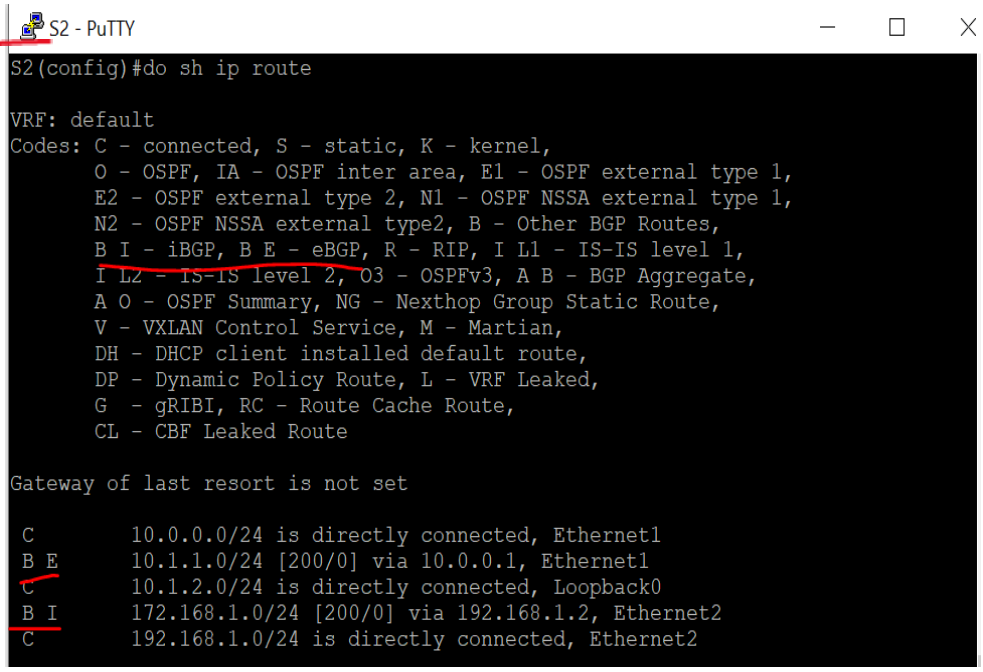


Figure 4 An Example of BGP Network Topology


S1 - PuTTY
end
S1(config)#do sh ip route
VRF: default
Codes: C - connected, S - static, K - kernel,
O - OSPF, IA - OSPF inter area, E1 - OSPF external type 1,
E2 - OSPF external type 2, N1 - OSPF NSSA external type 1,
N2 - OSPF NSSA external type2, B - Other BGP Routes,
B I - iBGP, B E - eBGP, R - RIP, I L1 - IS-IS level 1,
I L2 - IS-IS level 2, O3 - OSPFv3, A B - BGP Aggregate,
A O - OSPF Summary, NG - Nexthop Group Static Route,
V - VXLAN Control Service, M - Martian,
DH - DHCP client installed default route,
DP - Dynamic Policy Route, L - VRF Leaked,
G - gRIBI, RC - Route Cache Route,
CL - CBF Leaked Route
Gateway of last resort is not set
C 10.0.0.0/24 is directly connected, Ethernet1
C 10.1.1.0/24 is directly connected, Loopback0
B E 10.1.2.0/24 [200/0] via 10.0.0.2, Ethernet1
B E 172.168.1.0/24 [200/0] via 10.0.0.2, Ethernet1
B E 192.168.1.0/24 [200/0] via 10.0.0.2, Ethernet1
S1(config)#


S2 - PuTTY
S2(config)#do sh ip route
VRF: default
Codes: C - connected, S - static, K - kernel,
O - OSPF, IA - OSPF inter area, E1 - OSPF external type 1,
E2 - OSPF external type 2, N1 - OSPF NSSA external type 1,
N2 - OSPF NSSA external type2, B - Other BGP Routes,
B I - iBGP, B E - eBGP, R - RIP, I L1 - IS-IS level 1,
I L2 - IS-IS level 2, O3 - OSPFv3, A B - BGP Aggregate,
A O - OSPF Summary, NG - Nexthop Group Static Route,
V - VXLAN Control Service, M - Martian,
DH - DHCP client installed default route,
DP - Dynamic Policy Route, L - VRF Leaked,
G - gRIBI, RC - Route Cache Route,
CL - CBF Leaked Route
Gateway of last resort is not set
C 10.0.0.0/24 is directly connected, Ethernet1
B E 10.1.1.0/24 [200/0] via 10.0.0.1, Ethernet1
C 10.1.2.0/24 is directly connected, Loopback0
B I 172.168.1.0/24 [200/0] via 192.168.1.2, Ethernet2
C 192.168.1.0/24 is directly connected, Ethernet2

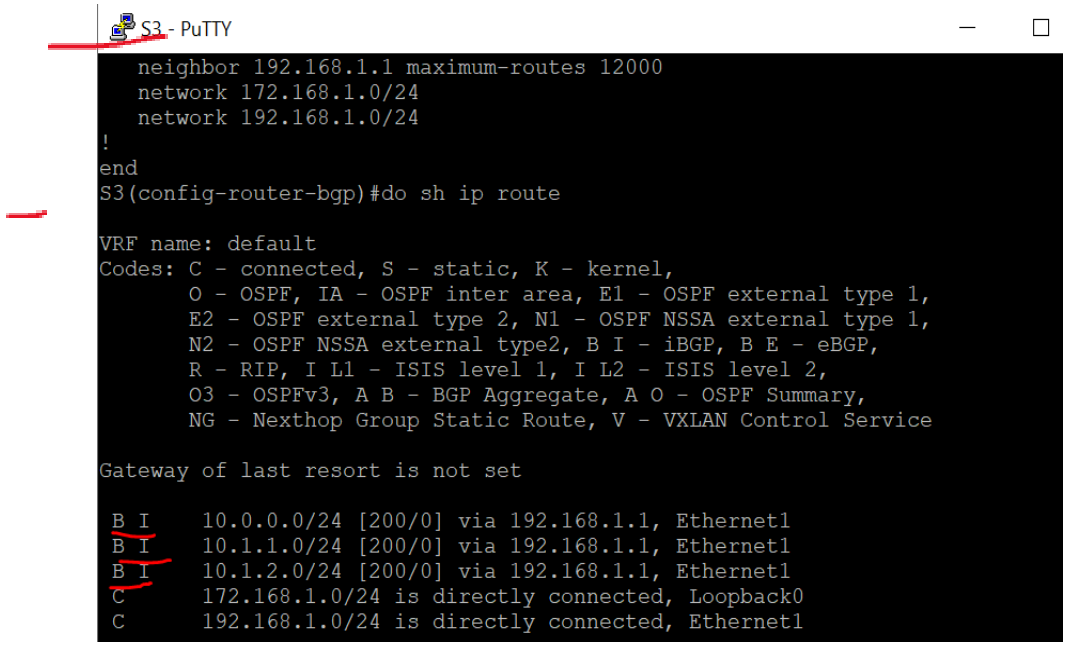


Figure 5: Routing Tables in three Arista Switches in the Example Lab Network

Conclusion

This paper intends to develop an alternative lab environment (with Arista Switch, GNS3, and VMWare Workstation Player) to overcome some limitations of Packet Tracer to enhance the level of engagement with students and deepen their understanding of BGP, MPLS, and other network protocols that are not supported in Cisco Packet Tracer in the computer network class in College of Business.

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Extended Abstracts/ Working Papers

Extended Abstracts

Accounting, Finance and Economics

RETHINKING ORGANIZATIONAL MANAGEMENT AND GOVERNANCE IN ENGAGING IMF

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Abstract

Developing countries, especially in sub-Saharan Africa, frequently face economic crises and turn to the International Monetary Fund (IMF) for assistance. However, the root causes of these crises often lie in domestic institutional and organizational management challenges. This paper examines how deficiencies in areas like central bank governance, corporate governance, financial regulation, economic education, and separation of financial and non-financial activities contribute to the crisis.

Introduction

Several developing countries, predominantly in sub-Saharan Africa, face structural challenges in their economies due to the last two financial crises. Ghana, Kenya, Zimbabwe, South Africa, and many others have had to turn to the IMF to seek solutions to their financing challenges(Pazarbasioglu, 2022). Ghana, for example, is on its 17th trip to the IMF since its independence. However, what is often overlooked and not addressed is the role of the existing institutional challenges around how sovereign organizations are managed in creating these challenges in the first place.

This study focuses on taking apart the interconnectedness of these financial crises and their associated economic challenges and showing their roots in organizational management gaps. For example, to what extent is having an organization engaged in central banking activities also being engaged in banking supervision and offering primary consumer protection as a secondary mandate? Does that have inherent organizational management challenges that distort responsive decision-making in times of crisis? What about the role of corporate governance challenges where governance is not fully engrained in conduct management?

Management and Corporate Governance Challenges

Weak corporate governance prevalent in developing countries exacerbates crises(Adobor & Yawson, 2023). Areas needing improvement include enforcing regulations, protecting minority shareholders, limiting political interference, and reducing corruption(Lin, 2000). Better governance can incentivize responsible management. In most of these countries, we seek to show that structural deficiencies in the corporate management space create further challenges in how stakeholders engage with the government during these crises(McGee, 2009). For example, supervision of the banks and financial services has to change to align with that of other major financial centers to ensure conduct is regulated and dealt with in a way that helps a culture of organizational management supportive of government decision-making in times of crises. Central banks engaged in diverse activities like monetary policy, banking supervision, and consumer protection face organizational management challenges affecting crisis response (Liu et al., 2022).

Reforms to centralize strategic planning, risk management, data reporting, and decision-making autonomy could aid stability. For example, the concept of “approved persons” is one of those changes that is wholly needed and requires participants and specific roles in financial services to be permitted or licensed for the individual with their employer's sponsorship (Khatkhate, 1971).

There is also the challenge of the enormous gap in Economic Education and literacy in these countries, which often creates political buy-in challenges to public decisions. Low economic literacy impedes public support for crisis response policies. Central banks should design practical curricula and regularly engage teachers to promote understanding of the economy across all education levels. For instance, the Bank of Ghana (BoG) has to start aggressively educating the

population and every citizen on how the Ghanaian economy works, the economic priorities, and challenges to lay the foundations for a more literate society that understands the economy. Not only will that help the work of the BoG, but it will also make citizens more responsive to the decisions of monetary authorities. This will mean the BoG becoming a key player in designing practical curricula for teachers across all primary and secondary schools and engaging teachers who teach economics in a systemic program to constantly upgrade their understanding of our economy.

Another area is financial services as an infrastructure and essential service for the economy, which must work properly and be wholly separated from corporate enterprises. No corporate entity or group should be allowed to own a financial services company or have a financial services company as part of its corporate group. It does not happen and is not allowed anywhere in jurisdictions with sound financial regulations. Allowing non-financial corporations to own financial service providers exacerbates crises. Regulations should mandate separation to reduce contagion risk. We all have seen the effects of large corporate non-banking organizations being allowed to own banks and the subsequent effects of deepening economic crises. This is the problem United States regulators recognized in the financial crisis of 2008 and decided to bring companies like GE Capital into line with full banking regulations and required divestiture or operation as a standalone bank. GE today has no such services. This is also what is left with MTN Group in Ghana, which needs to be resolved, or the country risks a major crisis ahead.

Conclusion

In conclusion, organizational management and governance gaps in developing countries contribute to economic crises and hinder IMF engagement. Undertaking reforms, with IMF support, in central bank governance, corporate governance, regulation, literacy initiatives and separating financial and non-financial activities could aid stability.

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Pricing Quanto Options on a non-Gaussian Levy Process Model with a Flow Based Generative Network.

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Abstract

In this study, we discuss a machine learning technique to price exotic options with two underlying assets based on a non-Gaussian Levy process model. We introduce a new multi-variated Levy process model named the generalized normal tempered stable (gNTS) process, which is defined by time-changed Brownian motion. Since the probability density function (pdf) of the gNTS model is not given by a simple analytic formula, we use the conditional RealNVP (CRealNVP), which is a sort of flow-based generative networks. After that, we discuss the no-arbitrage pricing on the gNTS model for pricing the quanto option whose underlying assets consist of a foreign index and foreign exchange rate. We also present the training of generative networks to learn the pdf of the gNTS model based on Monte Carlo simulation. Next, we estimate the parameters of the gNTS model with the trained CRealNVP using the real empirical data observed in the market. Finally, we find the quanto option prices based on the estimated parameters and the pdf values provided by the CRealNVP.

Introduction

A standard quanto option is a European option underlying a foreign asset, whose payoff is converted to another currency at a predefined fixed exchange rate. Since the quanto option provides foreign–asset exposure without taking the corresponding exchange rate risk, the tail dependence between the asset and the exchange rate is instrumental in the valuation. Quanto option pricing based on the Black–Scholes model (Black and Scholes, 1973), assuming a multivariate Brownian motion has been studied by Baxter and Rennie (1996). Recently, Kim et al (2015) presented the quanto option pricing based on the multivariate normal tempered stable (NTS) process which is a kind of non-Gaussian Levy process. This approach is more efficient than the Gaussian approach since the NTS process can capture the fat-tails and asymmetric dependence between the asset and the exchange rate, which are empirically observed in the market. The NTS process model is more realistic than the multivariate

Brownian, but it still has restrictions. Since defined by mixtures of one subordinator to different elements of multivariate Brownian motion, it has limitations in describing flexibility of multivariate asset returns.

In this research, we provide a generalized NTS (gNTS) process which is defined by a mixture of multiple subordinators to multivariate Brownian motion. This enhanced process captures fat-tails and asymmetric dependence of multi-dimensional asset returns. As a consequence, gNTS is more flexible than NTS and describes better the multivariate asset returns. Since the probability density function of the gNTS process is not given by a simple analytic form, we need to have an efficient numerical method to apply the model to derivative pricing such as Quanto options. The Monte Carlo method can be a good alternative, but the simulation takes a long time and is not easy to obtain sensitivity, such as the Greek Letters of the option. For this reason, we suggest the conditional *real-valued non-volume preserving (RealNVP)* model.

This study proposes flow-based generative networks based on the RealNVP designed by Dinh *et al.* (2016). As do other generative models such as GAN (Goodfellow *et al.*, 2014) and VAE (Kingma and Welling, 2013), this generative model can learn the probability density inherent in data and generate new data samples that resemble the original data. Furthermore, only flow-based generative models are able to provide the density functions in explicit form while other generative networks cannot. Hence the RealNVP can be applied to find the pdf of the gNTS process. Since the original form of the RealNVP model is nonparametric, it has difficulty in the arbitrage option pricing theory, which needs to find the equivalent martingale measure. To overcome this drawback, we use the Conditional RealNVP model by Kim *et al.* (2022).

To summarize, we define the gNTS process and apply it to Quanto option pricing in this research. We discuss the CRealNVP model and apply it to estimate a pdf of gNTS distribution. The training method of the CRealNVP model will be presented based on gNTS distribution, and then the parameters of the gNTS model will be estimated using empirical data such as pairs of the market index and foreign exchange rate.

Generalized normal tempered stable process.

Let N be a positive integer, $\mathbb{R}$ be a set of real numbers, $I_2 = (0, 2)$ be an open interval between 0 and 2, and $\mathbb{R}_+ = \{x \in \mathbb{R} \mid x>0\}$ be the set of positive real numbers. We consider an N–dimensional vectors $\alpha \in I_2^N$, $\theta \in \mathbb{R}_+^N$, $\beta \in \mathbb{R}^N$, and $\sigma \in \mathbb{R}_+^N$. Let $R = [\rho_{m,n}]_{m,n \in \{1,2,\ldots,N\}}$ be a dispersion matrix and $R^{1/2}$ given by factorization $R=R^{1/2}(R^{1/2})^{\mathrm{T}}$, such as a Cholesky factorization. Let $T=(T(t))_{t\geq 0}$ be a N-dimensional independent tempered stable subordinator with the n-th element $(T_n(t))_{t\geq 0} \sim \mathrm{subTS}(\alpha_n, 1, \theta_n)$ for $n \in \{1, 2, \ldots, N\}$. Let $B=(B(t))_{t\geq 0}$ be an independent N-dimensional Brownian motion. Assume B and T are independent, and there exists a time series τ_n such that $T_n(t) = \int_0^t \tau_n(u)du$ for all $t\geq 0$ and $n \in \{1, 2, \ldots, N\}$. The N-dimensional process $X=(X(t))_{t\geq 0}$ defined by

$$X(t) = \mu t + diag(\beta)\int_0^t \tau(u)du + diag(\sigma)\int_0^t diag\left(\tau^{\circ\frac{1}{2}}(t)\right)R^{1/2}dB(u)$$

is referred to as a N-dimensional generated normal tempered stable (gNTS) process, where $\tau^{\Diamond\frac{1}{2}}(t) = \left(\sqrt{\tau_1(t)}, \sqrt{\tau_2(t)}, \ldots, \sqrt{\tau_N(t)}\right)^T$, and denote by

$$X \sim gNTS_N(\alpha, \theta, \beta, \mu, \sigma, R).$$

Let $B_n^0(t)$ be the n-th element of $R^{1/2}B(t)$ for $t \geq 0$. Then the process $B_n^0=(B_n^0(t))_{t\geq 0}$ is a Brownian motion and we have the n-th element of X as

$$X_n(t) = \mu_n t + \beta_n T_n(t) + \sigma_n B_n^0\left(T_n(t)\right). \qquad (1)$$

If $X_0 \sim \text{gNTS}_N(\alpha, \theta, \beta, \mu_0, \sigma_0, R)$ where the n-th element of μ_0 is given by

$$\mu_{0,n} = -\frac{1}{2}\alpha_n\beta_n\theta_n^{\frac{\alpha_n}{2}-1}$$

and n-th element of σ_0 is given by

$$\sigma_{0,n} = \sqrt{\frac{2\theta_n^{1-\frac{\alpha_n}{2}}}{\alpha_n} - \frac{2-\alpha_n}{2\theta_n}\beta_n^2}$$

for $n \in \{1, 2, \ldots, N\}$, then $\mathrm{E}[X_0]=(0,0,\ldots 0)^{\mathrm{T}}$ and $\mathrm{var}(X_0(t))=(t,t,\ldots t)^{\mathrm{T}}$. In this case the process X_0 is referred to as the *standard gNTS* process and denoted as

$$X_0 \sim gStdNTS_N(\alpha, \theta, \beta, R).$$

Consider a new process $X = (X(t))_{t\geq 0}$ with $X(t) = mt + \mathrm{diag}(s)X_0(t)$ for $m \in \mathbb{R}^N$ and $s \in \mathbb{R}_+^N$. Then we have

$$X \sim gNTS_N(\alpha, \theta, diag(s)\beta, diag(s)\mu_0 + m, diag(s)\sigma_0, R) \qquad (2)$$

and we obtain $\mathrm{E}[X(t)]=mt$ and $\mathrm{var}(X(t))=s^2t$.

gNTS Market model for indexes and foreign exchange rates

We denote the domestic and the foreign risk–free interest rates by r_d and r_f, respectively. Then, let $(S(t))_{t\geq 0}$ be the price process for the asset in foreign currency, $(V(t))_{t\geq 0}$ the price process of the asset in domestic currency, and $(F(t))_{t\geq 0}$ the exchange rate process of the foreign currency with respect to the domestic currency. That means $V(t)= F(t)\, S(t)$. We assume that

$$F(t) = F(0)\exp\left(Y_F(t)\right), \qquad V(t) = V(0)\exp\left(Y_V(t)\right),$$

where

$$Y_F(t) = m_F t + s_F X_F(t), \qquad Y_V(t) = m_V t + s_V X_V(t)$$

and $X=(X(t))_{t\geq 0}$ with $X(t)= (X_F(t), X_V(t))^T$ is the standard gNTS process with

$$X \sim gStdNTS_2\left(\begin{pmatrix}\alpha_F\\ \alpha_V\end{pmatrix}, \begin{pmatrix}\theta_F\\ \theta_V\end{pmatrix}, \begin{pmatrix}\beta_F\\ \beta_V\end{pmatrix}, \begin{pmatrix}1 & \rho\\ \rho & 1\end{pmatrix}\right)$$

under the physical measure P.

By the equation (2), we have a gNTS process $Y=(Y(t))_{t\geq 0}=((Y_F(t), Y_V(t))^T)_{t\geq 0}$ given as

$$Y \sim gNTS_2\left(\begin{pmatrix}\alpha_F\\ \alpha_V\end{pmatrix}, \begin{pmatrix}\theta_F\\ \theta_V\end{pmatrix}, \begin{pmatrix}s_F\beta_F\\ s_V\beta_V\end{pmatrix}, \begin{pmatrix}\mu_F\\ \mu_V\end{pmatrix}, \begin{pmatrix}\sigma_F\\ \sigma_V\end{pmatrix}, \begin{pmatrix}1 & \rho\\ \rho & 1\end{pmatrix}\right)$$

with

$$\mu_F = m_F - \frac{1}{2}s_F\alpha_F\beta_F\theta_F^{\frac{\alpha_F}{2}-1}, \qquad \mu_V = m_V - \frac{1}{2}s_V\alpha_V\beta_V\theta_V^{\frac{\alpha_V}{2}-1}$$

and

$$\sigma_F = s_F\sqrt{\frac{2\theta_F^{1-\frac{\alpha_F}{2}}}{\alpha_F} - \frac{2-\alpha_F}{2\theta_F}\beta_F^2}, \qquad \sigma_V = s_V\sqrt{\frac{2\theta_V^{1-\frac{\alpha_V}{2}}}{\alpha_V} - \frac{2-\alpha_V}{2\theta_V}\beta_V^2}.$$

Quanto option pricing

To find price of Quanto option, we need an equivalent martingale measure (i.e. risk neutral measure). If there exist $(\theta_F^*,\theta_V^*)^T$ and $(\beta_F^*,\beta_V^*)^T$ satisfying

$$-r_d + r_f + \mu_F - \left(\left(\theta_F^* - \beta_F^* - \frac{\sigma_F^*}{2}\right)^{\frac{\alpha}{2}} - \theta_F^{\frac{\alpha}{2}}\right) = 0$$

and

$$-r_d + \mu_V - \left(\left(\theta_V^* - \beta_V^* - \frac{\sigma_V^*}{2}\right)^{\frac{\alpha}{2}} - \theta_V^{\frac{\alpha}{2}}\right) = 0,$$

then there is an equivalent martingale measure Q under which

$$Y \sim gNTS_2\left(\begin{pmatrix}\alpha_F\\ \alpha_V\end{pmatrix}, \begin{pmatrix}\theta_F^*\\ \theta_V^*\end{pmatrix}, \begin{pmatrix}\beta_F^*\\ \beta_V^*\end{pmatrix}, \begin{pmatrix}\mu_F\\ \mu_V\end{pmatrix}, \begin{pmatrix}\sigma_F\\ \sigma_V\end{pmatrix}, \begin{pmatrix}1 & \rho\\ \rho & 1\end{pmatrix}\right)$$

and $E_Q\left[e^{(-r_d+r_F)t}F(t)\right] = F(0)$ and $E_Q[e^{-r_d t}V(t)] = V(0)$ on the measure Q. That is, the discount price processes of $(F(t))_{t\geq 0}$ and $(V(t))_{t\geq 0}$ are martingales.

We have the quanto option payoff function $F_{\text{fix}}(S(T)- K)^+$ with the time to maturity T, strike price K and the fixed exchange rate F_{fix} where

$$S(t) = \frac{V(t)}{F(t)} = S(0)\exp\left(Y_V(t) - Y_F(t)\right)$$

and hence the current option price is obtained by

$$E_Q\left[e^{-r_d T}F_{fix}(S(T)-K)^+\right] = e^{-r_d T}F_{fix}\int_{-\infty}^{\infty}\int_{-\infty}^{y-\ln(K/S(0))}(S(0)e^{y-x}-K)f(x,y)dxdy$$

where $f(x,y)$ is the pdf of gNTS distribution. In this point, we have to find the pdf of gNTS distribution, which can be obtained by the CRealNVP model explained in the following section.

Conditional RealNVP

Let $i\epsilon\{1,2,\ldots,c\}$ where c is the number of coupling layers. Define a N-dimensional masking vector b as $(1,\ldots,1,0,\ldots,0)^T$ where the first n elements of b are 1 and values between $(n+1)$-th and N-th elements are 0 for $n\epsilon\{1,2,\ldots,N-1\}$. We set a sequence of the masking vectors as $b^{(1)} = b$ and $b^{(i+1)} = I - b^{(i)}$ where I is a N-dimensional unit vector $(1,1,\ldots,1)^T$.

Let x be a given N-dimensional vector (column vector) and the i-th affine coupling layer $f^{(i)}$:$R^N \rightarrow R^N$ be given by

$$f^{(i)}(x) = b^{(i)} \bullet x + (I - b^{(i)}) \bullet \left(x \bullet \exp\left(s\left(b^{(i)} \bullet x\right)\right) + t(b^{(i)} \bullet x)\right)$$

where scale function $\boldsymbol{s}$ and translation function $\boldsymbol{t}$ are both functions from R^N to R^N, and • is an elementwise product. Here, scale functions $\boldsymbol{s}$ and translation functions $\boldsymbol{t}$ are represented by deep neural networks. The normalizing flow f composed of $f = f^{(c)} \circ f^{(c-1)} \circ \ldots \circ f^{(1)}$ is called the RealNVP.

Let $z = f(x)$, and p_Z be the pdf of z. Then the change of variables gives the pdf of x as

$$p_X(x) = p_Z(f(x))\left|\det\left(\frac{\partial f(x)}{\partial x^T}\right)\right| = p_Z(f(x))\prod_{i=1}^{c}\exp\left(I^T \cdot s\left(b^{(i)} \bullet x^{(i)}\right)\right)$$

where $x^{(1)} = x$ and $x^{(i)} = f^{(i-1)} \circ f^{(i-2)} \circ \ldots \circ f^{(1)}(x)$ for $i > 1$. We choose the multivariate standard Gaussian distribution for the prior distribution p_Z for simplicity.

In order to apply the RealNVP model to gNTS model, we consider a set of model parameters Θ in the function $f^{(i)}$ for all i-th affine coupling layers as follows:

$$f^{(i)}(x|\Theta) = b^{(i)} \bullet x + \left(I - b^{(i)}\right) \bullet \left(x \bullet \exp\left(s\left(b^{(i)} \bullet x;\Theta\right)\right) + t\left(b^{(i)} \bullet x;\Theta\right)\right)$$

where scale functions $\boldsymbol{s}$ and translation functions $\boldsymbol{t}$ are represented by deep neural networks whose input variable consists of the N-dimensional $x^{(i)}$ and the set of parameters Θ. Then the pdf of x is given by

$$p_X(x|\Theta) = p_Z(f(x|\Theta))\prod_{i=1}^{c}\exp\left(I^T \cdot s\left(b^{(i)} \bullet x^{(i)};\Theta\right)\right).$$

In this case, this generalized RealNVP model is referred to as the *conditional RealNVP* (CRealNVP) model.

Training CRealNVP for 2-dimensional gStdNTS model

We take 2 dimensional gStdNTS model:

$$X \sim gStdNTS\left(\begin{pmatrix}\alpha_1\\ \alpha_2\end{pmatrix}, \begin{pmatrix}\theta_1\\ \theta_2\end{pmatrix}, \begin{pmatrix}\beta_1\\ \beta_2\end{pmatrix}, \begin{pmatrix}1 & \rho\\ \rho & 1\end{pmatrix}\right)$$

We generate a set of gStdNTS parameters α_1, α_2, θ_1, θ_2, β_1, β_2, and ρ randomly as follows:

$$\alpha_i = 2U_{1,i}, \theta_i = 10\tan\frac{U_{2,i}\pi}{2}, \beta_i = (2U_{3,i}-1)\frac{2\theta_i\left(1-\frac{\alpha_i}{4}\right)}{\sqrt{\alpha_i(2-\alpha_i)}}, \rho = 2U_{4,i}-1$$

for $U_{n,i} \sim Beta(2,2), n = 1,2,3,4, i = 1,2$. Then we generate 2^{10} number of gStdNTS random vectors of $X_0(t)$ for time t=1 using the equation (1). We repeat this process 2^{12} times and finally 2^{22} random vectors of the training set. The CRealNVP consists of six coupling layers and four hidden layers with 128 hidden nodes at each coupling layer for both $\boldsymbol{s}$ and $\boldsymbol{t}$. The activation functions of the hidden layers of the neural network are LeakyReLU functions. The neural networks are trained by minimizing the negative log likelihood function with the ADAM optimizer. After the training process, we obtain the pdf of the 2-dimensional gNTS distribution. A few examples of the pdfs are exhibited in Figure 1.

Parameter fit

For an empirical illustration, we consider USD–valued Nikkei 225 index prices and the JPY-USD exchange rate from September 12, 2013 to September 11, 2023. USD–valued Nikkei 225 index prices are obtained by converting the original JPY–valued Nikkei 225 index levels into U.S. dollars using the JPY-USD exchange rate. Suppose $F(t)$ the process of the JPY-USD exchange rate, such that one JPY to $F(t)$ dollar, and $V(t)$ is the dollar–valued price process of the Nikkei 225 index, that is $V(t)=S(t)F(t)$, where $S(t)$ is the Nikkei 225 index at time t. We estimate market parameters for daily log-returns on $V(t)$ and $F(t)$. The mean and standard deviation are fit to the daily log-returns, then we fit the gStdNTS parameters using maximum likelihood estimation with the pdf trained by CRealNVP model. The estimated parameters are provided in the first row of Table 1. We repeat this parameter fit process for the other pair of a market index & an exchange rate such as HSI & HKD-USD, FTSE & GBP-USD, and DAX & EUR-USD. The estimation results are also presented in Table 1. The 2-dimensional histograms of the standardized log-returns of the 4 pairs are exhibited in Figure 4 together with the pdf contour map of gStdNTS distribution.

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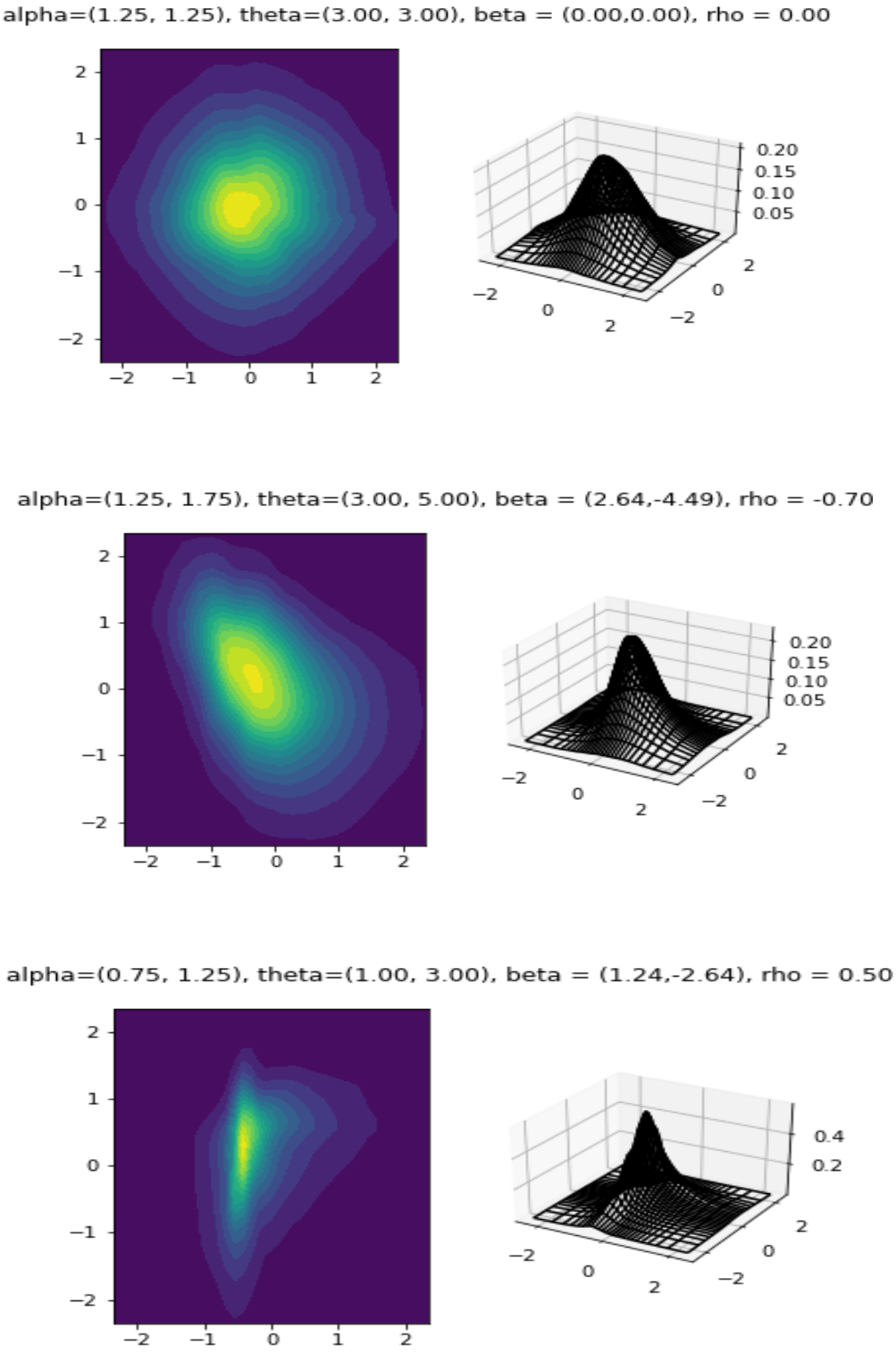

Figure 1: The pdf of gNTS distributions

Table 1. Estimated parameters of the gNTS distribution

Symbol	mean	Std-dev	Standard gNTS parameters			
Nikkei 225	m_V= 1.76E−04	s_V=1.22E−02	α_V=1.11	θ_V=2.30E−01	β_V=−6.55E−02	ρ=0.135
JPY-USD	m_F=−1.60E−04	s_F=5.67E−03	α_F=1.04	θ_F=2.82E−02	β_F=5.05E−03	
HIS	m_V=−9.91E−05	s_V=1.29E−02	α_V=1.03	θ_V=1.36E−01	β_V=−5.96E−02	ρ=0.145
HKD-USD	m_F=−4.62E−06	s_F=3.69E−04	α_F=0.54	θ_F=3.19E−03	β_F= −8.90E−04	
FTSE	m_V=−4.42E−05	s_V=1.16E−02	α_V=1.02	θ_V=1.21E−01	β_V= −8.34E−02	ρ=0.589
GBP-USD	m_F=−9.45E−05	s_F=5.93E−03	α_F=1.27	θ_F=2.58E−03	β_F= −1.34E−02	
DAX	m_V= 1.58E−04	s_V=1.33E−02	α_V=1.07	θ_V=1.62E−01	β_V= −6.15E−02	ρ=0.422
EUR-USD	m_F=−8.67E−05	s_F=5.04E−03	α_F=1.22	θ_F=6.94E−03	β_F= −6.10E−03	

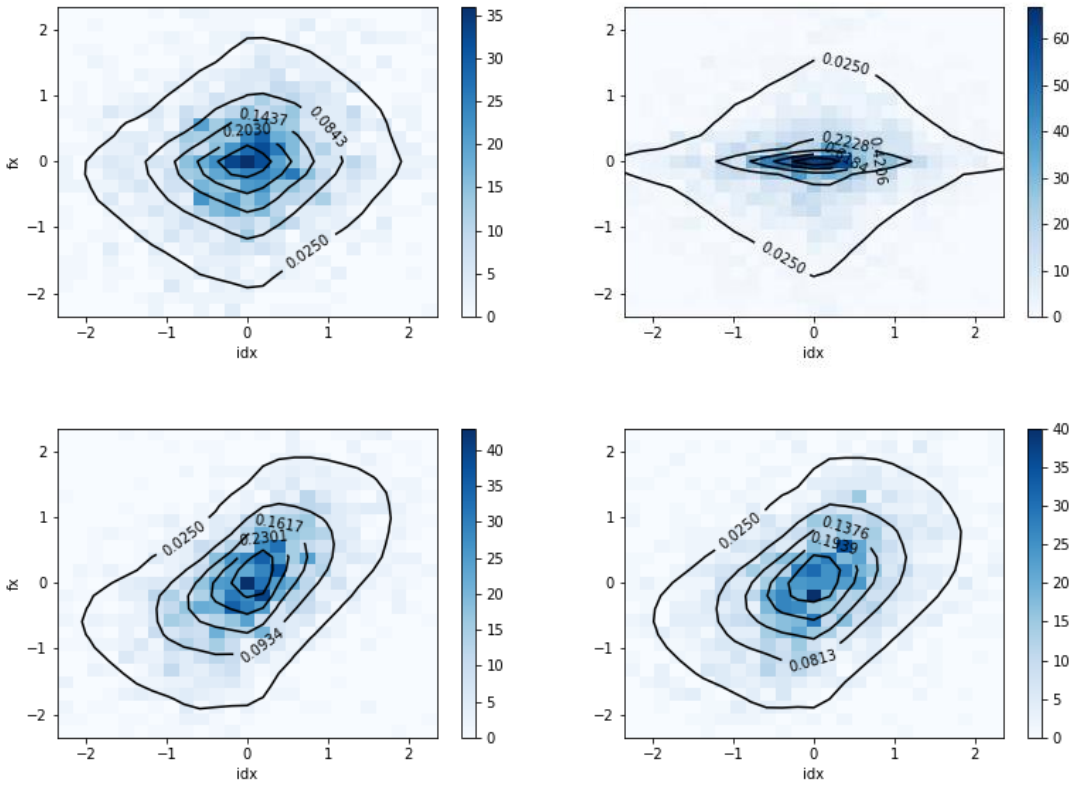

Figure 2: The 2-dimensional histograms of empirical log-returns and stdGNTS pdfs fit to the data. Top-left is for Nikkei255 & JPY-USD, top-right is for HIS & HKD-USD, bottom-left is for FTSE & GBP-USD, and bottom-right is for DAX & EUR-USD.

Do Extreme Observations Impact Common Financial Ratios? a Longitudinal Examination of Bond Indices

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Studies have found that stock portfolio returns are strongly impacted by relatively few extreme return observations in both short and long time periods. This new project extends extant research to demonstrate that this same phenomenon is observable in portfolios constructed exclusively of corporate bond instruments. The implication of these findings is that careful attention must be given to single-period return outliers in both stock and bond portfolios.

Extended Abstracts

Big Data and Business Analytics

Face-Off: Facial Recognition Technologies and Paradox in Retail Asset Protection Environments

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Keywords: Facial Recognition, Loss Prevention, Asset Protection, Paradox Theory, Racial Bias

Extended Abstract:

Retailers are grappling with increasing levels of theft. One current loss prevention tool—facial recognition technology (FRT)—has raised legal and ethical concerns about whether it violates the public's civil liberties. FRT involves comparing a store patron's face extracted from security footage against databases of known offenders to signal when it perceives risk. Unfortunately, FRT has been criticized for inconsistent performance in identifying individuals of non-white race and ethnicity. The goal of this study is two-fold. First, we leverage a Systematic Literature Review (SLR) to report the extant literature on the tension between a firm's need to embrace loss prevention technology to mitigate retail theft while simultaneously pushing against unethical technologies that risk discrimination. Second, to our understanding, this phenomenon has not yet been framed through a paradox theory lens. By categorizing this paradoxical tension, we seek to outline both/and solutions for embracing the paradox rather than choosing between one of the two poles.

Within the retail landscape, security firms offer facial recognition scanning to supplement existing asset protection systems. This functionality allows retailers to compare the faces of store patrons against databases and flag if matches are found linked to high-risk triggers such as prior criminal records. Therefore, the system aims to improve security, curb fraudulent behavior, and reduce the significant expense associated with merchandise shrink

(Woods, 2023; FaceFirst). Achieving these aims can enhance competition and improve the customer experience in an environment where reduced margins have made expense control critical. Losses associated with retail theft constitute a significant issue with which firms contend. CNN reported that "Target [recently announced] it was bracing to lose half a billion dollars…because of rising theft. [While] Nordstrom, Whole Foods, and some other big chains said they were abandoning San Francisco because of changing economic conditions or employee safety" (Kavilanz, 2023).

Unfortunately, empirical studies have shown the current wave of facial recognition technology is plagued with bias (Harmon, 2019). Additionally, while retailers face rising theft rates, a racial reckoning has arisen alongside the progressive development of facial recognition software, leading to utilization challenges in instances where the system gets it wrong (Hill, 2020). As illuminated by Humble and Altun (2020), "AI algorithms and face recognition systems have, on a number of occasions, failed to uphold a basic standard of equality…[and they are] now being used in criminal justice systems around the world" (p. 13).

A paradox is a "persistent contradiction between interdependent elements" (Smith & Lewis, 2011, p. 382). Paradox theory (PT) is a lens that has emerged in organizational and management disciplines and has proven a novel way of evaluating situations where firms grapple with seemingly incongruous goals. PT is often positioned as an alternative to Contingency Theory (CT). CT assumes that "organizational systems are most effective when they achieve alignment…[and evaluates] conditions for selecting among competing demands" (Smith & Lewis, 2011, p. 381). Before PT, selecting one pole within a paradoxical tension was often seen as the only available approach. Instead, PT argues that if firms surface and embrace their paradoxical tensions, they can deploy a 'both/and' (rather than an 'either/or') approach to managing these tensions. A review of the extant literature confirms that, to this point, paradox theory has not been utilized to contextualize the paradoxical tension firms face regarding whether to deploy facial recognition technologies for asset protection protocols.

The goal of this study is two-fold. First, we perform a systematic literature review of facial recognition and racial bias in asset protection. Then, we will execute a Delphi study with industry and academic experts, uncovering the themes that perpetuate the tensions. Leveraging Delphi feedback in concert with paradox theory, we aim to categorize the types of tensions at work and explore potential solutions available to firms. Therefore, this study will make several practical and theoretical contributions and help bridge the theory-practitioner gap (Van de Ven, 2013) by inviting firms to embrace both/and solutions to this issue.

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IMPROVING ECONOMICS FOR DATA MIGRATION IN HEALTHCARE ENVIRONMENTS USING SERVERLESS ARCHITECTURE

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Issues: The popularity of serverless technologies and serverless architecture is at peak across various industries because of their ability to effectively address the constantly evolving demands of scalability, cost-efficiency, and security. Verified market research indicates that the serverless architecture market is projected to experience a growth of 22.7%, increasing from USD 7,585 million in 2020 to USD 21,105 million by 2025[1]. This is particularly true in healthcare, a data-driven field. Implementing solutions that can enhance the quality of patient care and operational efficiency is of crucial importance. Exploring these solutions is only possible with necessary observational tools or environment that work effectively with data. In this paper, our objective is to extend the applicability of the serverless architecture implemented in a current big data research project. We aim to generalize its usage across healthcare organizations and scenarios, encompassing tasks such as data collection, ETL processes, data storage, security, migration, and in the end providing an environment to conduct certain research with the data.

Solution: The South Carolina Center for Center for Effectiveness Research in Orthopedics (CERortho) is a joint initiative involving the University of South Carolina and Prisma Health which aims to expand the comparative effectiveness research in the field of orthopedic care. A serverless architecture was designed and implemented to facilitate the creation of the Orthopedic Patient Data Repository (OPDR) and provide an observational environment for the researchers to conduct research, analysis, and development within this repository.

The system operates in a HIPAA compliant AWS (Amazon Web Services) Virtual Private Cloud and the process has been decoupled from each other into different modules. An AWS SFTP transfer instance automates data transfer from Prisma Health EPIC crystal reports into HIPAA compliant S3 buckets with AES 256 encryption at rest and TLS (Transport Layer Security) 2.0 in motion. The movement and access of data is logged and monitored for audits.

Once this pipeline is defined, Extract Transform Load (ETL) is performed using AWS Glue jobs. Glue allows for extracting valuable information from S3 buckets, transforming the data by setting up rules for de-identifying Personally Identifiable Information (PII) and Protected Health Information (PHI) in patient data, and load the extracted and transformed dataset into databases. SQL databases are used in the instances for datasets requiring recreating relationships and NoSQL databases are used for all other kinds of datasets. These databases are themselves hosted on serverless services using DynamoDB and RDS on AWS. Upon requests received by an honest data broker for specific datasets, the data is securely transferred to the local research instance using AWS DataSync. The research server itself is configured to restrict file transfers, clipboard access and certain user read, write, and modify permissions. As a result, an automated end-to-end all serverless data migration system that requires minimal human intervention has been deployed and proven to be highly cost effective and secure. A figure (1) has been provided as a reference to the above.

Conclusions: Demonstrating cost-effectiveness of serverless data migration in healthcare environments over server environment (Physical and Virtual) has been the highlight of the project. The team demonstrated improved latency performance, security, scalability, and availability of the system with reduced costs incurred for data migration between healthcare providers and research environments. Challenges remain in terms of acquiring architects and developers for enhancement and maintenance of the system. The team plans to create a training program to bridge some of the gaps in skillsets.

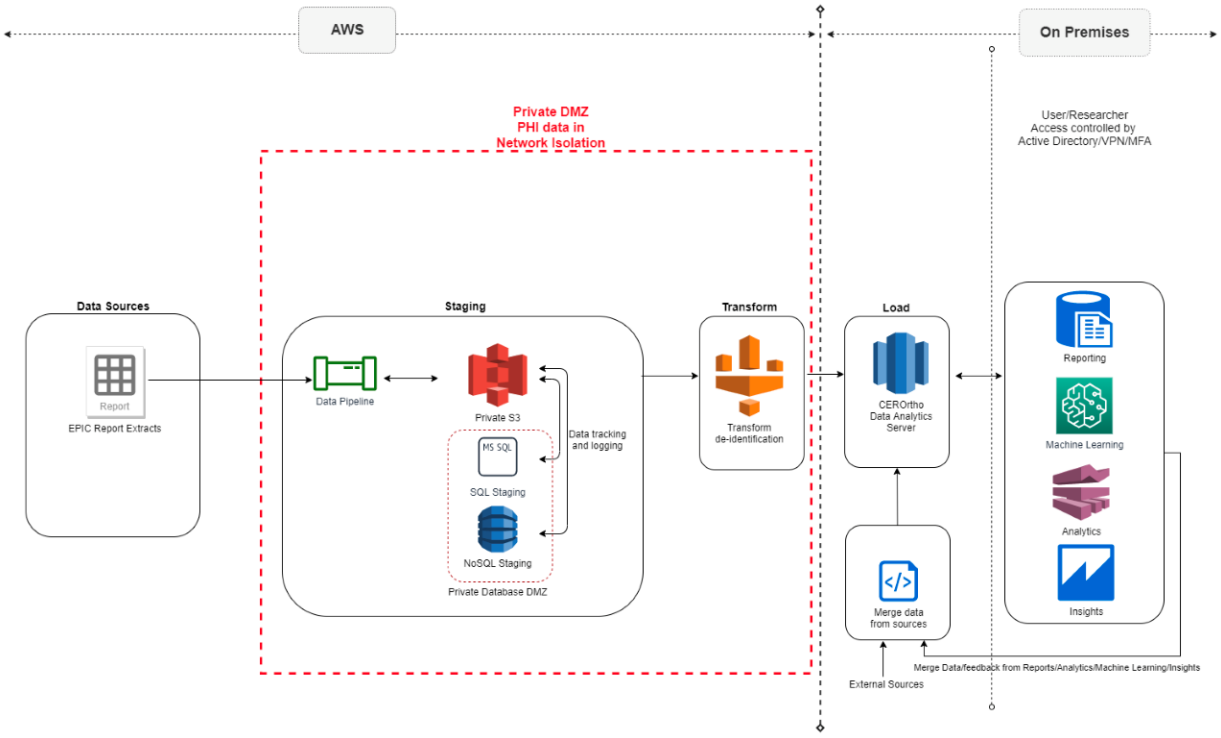

Figure 1. A Serverless architecture for healthcare data migration.

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Extended Abstracts

Education, Curriculum, and Cases

MAESTRO LEGACY: ARTFUL LEARNING APPLICATION TO BUSINESS ANALYTICS INSTRUCTION

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ABSTRACT

Innovation in decision sciences requires thinking about and perhaps redesigning how academics and practitioners learn to implement tools and techniques. In an undergraduate business school, foundational awareness and use of technical skillsets may begin in an Introduction to Business Analytics course. The Artful Learning framework (https://www.leonardbernstein.com/artful-learning/how-it-works) might be applied to teaching this course and improving engagement with aim to effect better student outcomes. With absence of Google Scholar work on Artful Learning and UDL, Universal Design for Learning (https://www.cast.org/) and limited, if any, research in these domains identified with STEM or higher education in general, there is opportunity for study. Preliminary work in two semesters of teaching an Introduction to Business Analytics course will inform the study design. The primary question is to examine how instructional design for artful learning can improve student outcomes in a STEM course. This undertaking is fundamentally different from research on business analytics pedagogy (Jeyaraj, 2019) which aligns with a systems approach of employing technical skills to acquire, prepare, analyze, and visualize data with aim to produce insights for action. Comparison of before and after course elements and student results may yield learnings for student attraction and retention within a post-secondary education institution and in workplace professional development.

INTRODUCTION

This work considers how the artful learning framework (https://www.leonardbernstein.com/artful-learning/how-it-works) might be applied to teaching an undergraduate introduction to business analytics course. This researcher taught such a course with inherited curriculum and materials focused on tactical learning of three focus areas: 1) math and statistics, 2) coding skills, and 3) technology tools – Microsoft Excel and R/R Studio application. In preparation for course delivery in Spring 2023, two other conceptual areas were added. These bookends to the primary course objectives, namely, where does data come from and how are results used for decision making, provided context for learners to engage with the purpose of instruction. The research questions are if and how redesign of a STEM course leveraging AL - artful learning (Brothman, 2013) and UDL - universal design for learning (Meyer and Gordon, 2014) will motivate improved student outcomes. A preliminary Google Scholar search found no study linking the two frameworks with higher education or STEM. Experiential practice for a future case study may provide groundwork for systematic research. The value of learning to succeed in business analytics is an interdisciplinary foundation for critical thinking that can be extended broadly in education and industry.

BACKGROUND

Dramaturgy, in theatre where composition of drama is studied to improve performance, has been used for centuries in England (Østern, 2021). In the 20th century, Maestro Leonard Bernstein espoused a framework for applying conceptual elements of a variety of artistic endeavors to K-12 classroom learning (Drew, 2008). Bernstein championed a connection to learning a required concept by linking it to an artistic masterwork of interest. He then facilitated inquiry questions to build engagement between student and subject. This activity inspires motivation for an original creation which demands discipline and in turn produces learning. The framework is consistent with the multi-faceted Universal Design for Learning (UDL) three pillars: engagement, representation, and action & expression (Meyer and Gordon, 2014). Case studies of Bernstein's Artful Learning have been documented in the literature (Brothman, 2013), and artful inquiry, a corollary technique, has been researched for extension into the workplace with application to individuals and organizations (Lloyd,

2011). An exploratory non-systematic Google Scholar search of literature since 2019 revealed that no recent studies have applied Artful Learning in Higher Education. Moreover, no studies were found linking Artful Learning (AL) with UDL, nor applying AL to STEM in post-secondary education. The proposed study diverges from research on business analytics pedagogy (Jeyaraj, 2019) yet complements its systematic approach to technical skill application in data acquisition, preparation, analysis, and visualization. The objective is to produce professionals who enable business insights for decision-making.

METHODOLOGY

Bernstein's legacy as a teacher continues to deliver value through the work of his son who has supported a foundation to preserve and promote AL (Bernstein, 2021). For this researcher, preparing for Spring 2024 term Introduction to Business Analytics, the AL framework enables the instructor to reimagine the course as an interim step in the continuum of curriculum. There is a math pre-requisite, and for most students there is either advanced study of business analytics, study of business in another functional discipline (e.g., finance, marketing, supply chain), or study in another application area (e.g., music industry, sports management, hospitality/tourism). The tenets of experience, inquire, create, and reflect (Trott and Bernstein, 2018) enable one to rethink the course design. For example, in 2023 the course introduction icebreaker to learn about data acquisition was a paper airplane contest. Following the activity, students identified data that could be useful to determine the design for a winning model. While effective for course material context in general, student engagement was variable and required significant instructor effort to create personal connections with each student to motivate course success.

From a classical perspective, AL implementation would require the instructor to provide an artistic masterwork example, samples of inquiry questions, demonstration of a technical implementation, and results analysis for course concepts. In Spring 2024, the instructor aims to use the Bernstein AL model for guidance in multiple course modules. While retaining the paper airplane icebreaker is a simple, collective experience for the class, it can be supplemented with an artistic example such as a national anthem. For their assignment students would each select a song or picture to share with the class to bring personal meaning and motivate practice with the tactical STEM core skills that will be presented in future lessons.

Additionally, to ensure rigor of inquiry and to support the assignment to complete tutorials in Excel and R/R Studio, students could be asked to create their own examination. The purpose of this effort will ensure that they do not complete the online instruction in rote fashion without processing what they have learned. Similarly, to support the creative element of tool application, students could be assigned a project based on the key technical skills where they must demonstrate competency. At course conclusion, students would be required to reflect on how the results of their business analysis will add value to an organization by selecting a current event and demonstrating mastery of course knowledge and skills end to end, thereby simulating the workplace environment.

RESULTS AND ANALYSIS

As this work is in progress for Spring 2024 semester, there will be experiential learning to report at the NEDSI2024 conference. The research data will be through comparison of before and after course syllabus, assignments, and assessments as well as comparative student outcomes from two semesters.

FUTURE IMPLICATIONS

If the redesigned course is successful, there are several activities that could follow from this work. Firstly, student word of mouth could motivate other students to take the course or enroll in the business analytics major. Secondly, the design can

be explained to prospective students and their parents as an opportunity to thrive at the institution and incentivize enrollment. Thirdly, the design can be modeled for faculty professional development and applied to other courses inside and outside the business analytics discipline. Lastly, learning can be leveraged to structure a formal research plan and obtain detailed data for publication to researchers and practitioners in education, business, and industry.

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Extended Abstracts

Healthcare Analytics

Optimizing Big Data Engineering and ETL Processes in Healthcare: Leveraging PySpark and Docker for Efficient Clinical Data Management

Ehsan Soltanmohammadi[1], Neset Hikmet, Ph.D.[2]

Abstract

The exponential growth of healthcare data necessitates efficient data processing and analysis. This paper proposes a cutting-edge approach to ETL (Extract, Transform, Load) processes, harnessing the power of PySpark, Docker, and Docker Compose. Our experimental results demonstrate significant improvements in scalability, efficiency, and reproducibility compared to traditional Python-Pandas methods.

The healthcare sector faces significant challenges in efficiently managing and processing large datasets, hindering meaningful analysis and decision-making. This study explores the optimization of Big Data Engineering and Extract, Transform, Load (ETL) processes in healthcare, utilizing the MIMIC-III Clinical Database as a robust foundation.

Introduction:

Healthcare data management faces significant challenges due to the volume, variety, and velocity of data. ETL processes are crucial for extracting insights, but traditional methods are often inadequate. This study explores the potential of PySpark, Docker, and Docker Compose for efficient ETL processes.

Background:

Healthcare data is generated at an unprecedented rate, with Electronic Health Records (EHRs), medical imaging, and sensor data contributing to the deluge. Effective data management is critical for informed decision-making, patient care, and research. ETL processes are essential for extracting valuable insights, but traditional methods struggle with scalability, efficiency, and reproducibility[1]

Related Work:

Several studies have investigated ETL processes for healthcare data, but most focus on traditional methods [2, 3]. Recent advancements in big data technologies, such as PySpark and Docker, offer promising solutions [4]. However, their application in healthcare ETL processes remains understudied.

Methods:

We used the MIMIC-III dataset (Johnson et al., 2016)[5, 6] and evaluated performance, scalability, and reproducibility. Our experimental environment consisted of a cluster of servers with adequate processing power and memory. We utilized Python, PySpark, Docker, Docker Compose, PostgreSQL, and relevant libraries such as Pandas for data manipulation and analysis [7, 8].

We designed four ETL processes:

1. Python-Pandas

Figure 1

2. PySpark

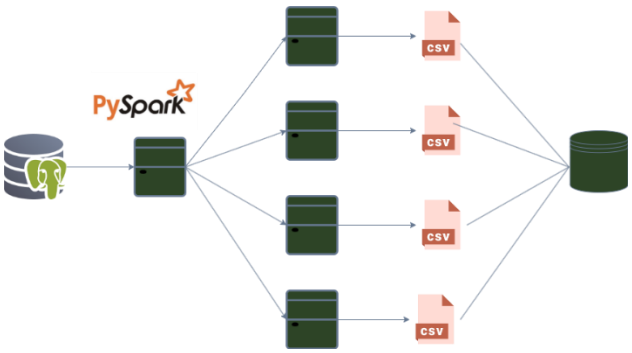

Figure 2

3. Dockerized Python

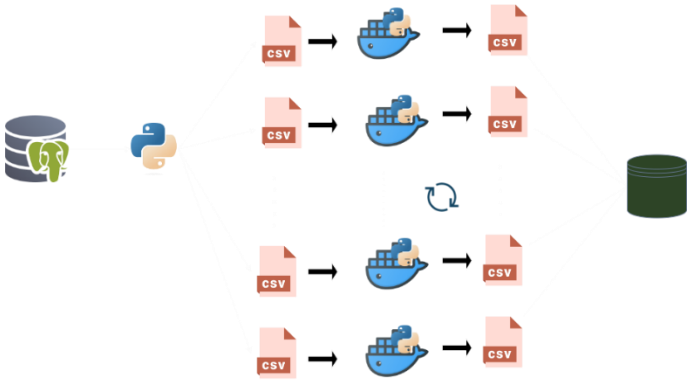

Figure 3

4. Dockerized PySpark with Docker Compose

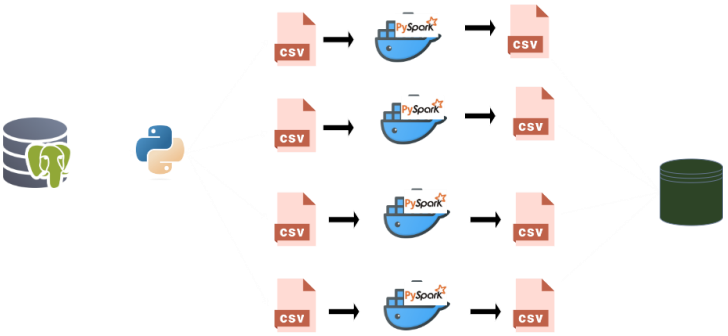

Figure 4

We used the MIMIC-III dataset (Johnson et al., 2016)[5, 6] and evaluated performance, scalability, and reproducibility. Our experimental environment consisted of a cluster of servers with adequate processing power and memory. We utilized Python, PySpark, Docker, Docker Compose, PostgreSQL, and relevant libraries such as Pandas for data manipulation and analysis [7, 8].

Results:

Our results show that:

- PySpark outperformed Python-Pandas in execution time and scalability.

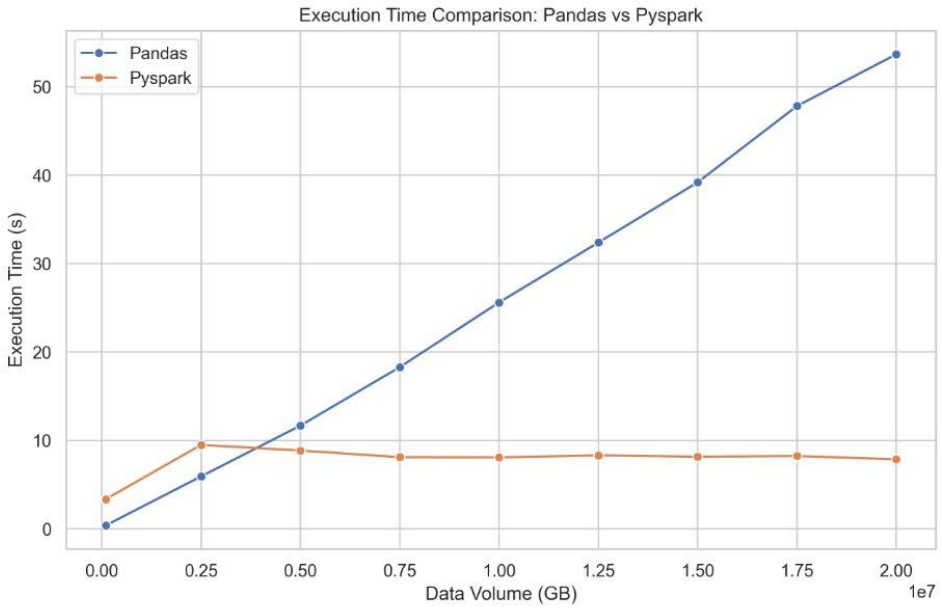

Figure 5

- Dockerization introduced minimal overhead and improved reproducibility.
- Docker Compose efficiently managed multi-container applications.

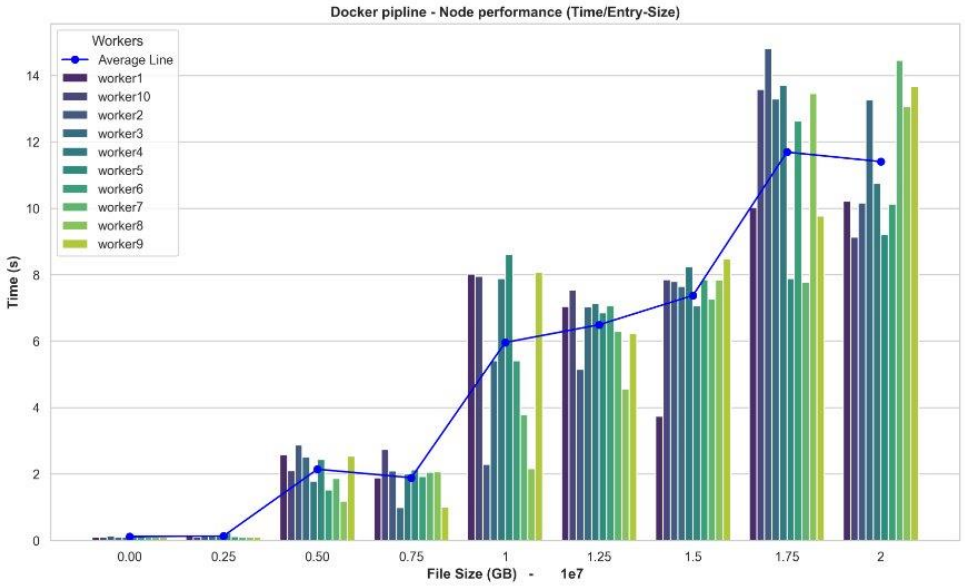

Figure 6

- The Dockerized PySpark ETL process demonstrated superior performance, scalability, and reproducibility.

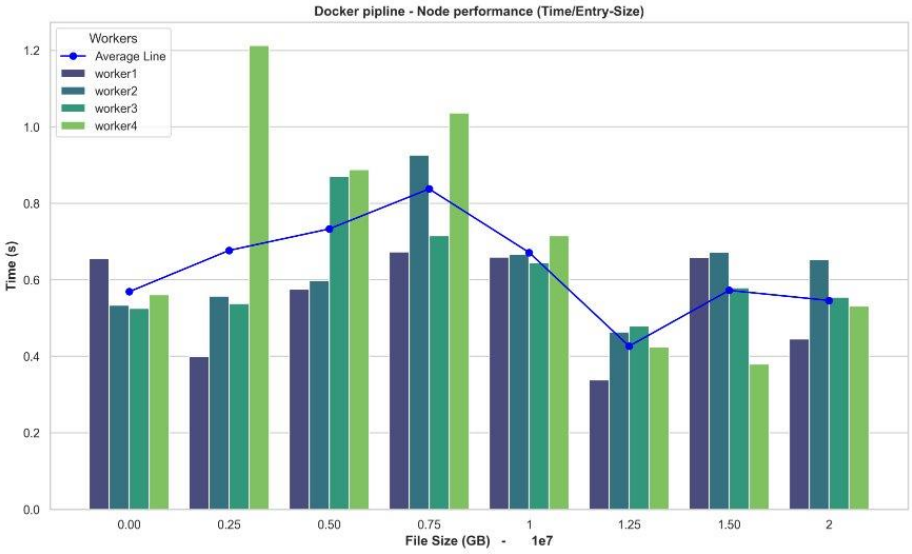

Figure 7

Discussion:

Our approach demonstrates the potential for efficient ETL processes in healthcare data management. PySpark, Docker, and Docker Compose offer a scalable, efficient, and reproducible solution for handling large datasets. The Dockerized PySpark ETL process is particularly promising, as it leverages the strengths of PySpark and Docker Compose. Our findings have significant implications for Big Data Engineering and informed decision-making in healthcare.

Conclusion:

This study showcases the efficacy of PySpark, Docker, and Docker Compose for ETL processes in healthcare data management. Our approach has significant implications for Big Data Engineering and informed decision-making in healthcare. By leveraging these technologies, healthcare organizations can efficiently process and analyze large datasets, leading to improved patient care and research outcomes.

Future Work:

Future studies can explore the application of our approach to various healthcare datasets and use cases. Additionally, investigating the integration of machine learning algorithms and data visualization tools with our ETL process can further enhance the extractive power of healthcare data. Furthermore, optimized data management ways, such as:

- Data compression and encoding
- Data caching and buffering
- Data parallelization and distribution
- Data encryption and security

can be explored to further improve the efficiency and scalability of our ETL process.

Implications:

Our study has significant implications for healthcare data management, Big Data Engineering, and informed decision-making. By leveraging PySpark, Docker, and Docker Compose, healthcare organizations can:

- Efficiently process and analyze large datasets
- Improve patient care and research outcomes
- Enhance data-driven decision-making
- Stay ahead of the curve in healthcare data management

Limitations:

While our study demonstrates the potential of PySpark, Docker, and Docker Compose for ETL processes, it has some limitations. Future studies can address these limitations by exploring additional healthcare datasets and use cases.

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Using DEA to Measure the Financial and Quality Performance of Critical Access Hospitals in Pennsylvania

Christine Pitocco, Herbert F. Lewis, Dinesh Pai, Thomas R. Sexton, Maria Muntaha, Justin Vij, Amanda McMahon

The Critical Access Hospital (CAH) program is a federal program that helps small hospitals in rural areas that serve residents who would otherwise be a long distance from emergency care. A CAH is reimbursed at 101% of calculated costs while providing 24/7/365 emergency care services. A CAH can have no more than 25 inpatient beds that can also be used for swing bed services. Its average acute care length of stay (LOS) must be 96 hours or less.

We use Data Envelopment Analysis (DEA) to analyze the full set of rural hospitals in Pennsylvania during the years 2000 through 2021. During this period, the number of rural hospitals dropped from 182 to 138, and the number of CAHs rose from 14 (7.7% of all rural hospitals) to 15 (10.9%).

One of the DEA models evaluates the financial performance while a second DEA model evaluates the quality performance of each rural hospital. Each model is executed in each of the 22 years. Using the model described in [1], we define SIPs (Smaller is Preferred), LIPs (Larger is Preferred), and site characteristics based on available data. We then compare the performance of CAHs with non-CAHs.

Finally, we evaluate the correlation between financial performance and quality performance to identify whether financial performance and quality performance support or impede one another.

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Scheduling Multi-Job Multi-Machine Multi-Server: A Case of Healthcare Optimization

Extended Abstract

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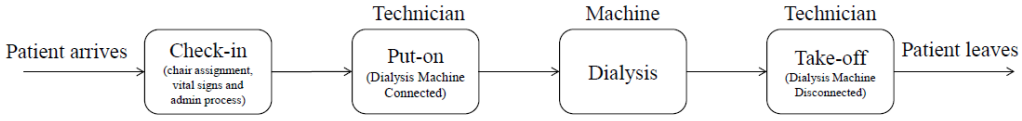
1. MOTIVATION AND BACKGROUND

This article addresses a common ongoing challenge in healthcare management services – Patient Scheduling. We focus on the patient appointment scheduling problem in outpatient hemodialysis clinics. The structure of this specific setting is unlike other common outpatient settings that are studies in the literature in a few aspects (e.g., Gupta and Denton, 2008; Wang and Gupta, 2014; Chan et al., 2021). First, at a hemodialysis center, dialysis appointments have a steady state, and each patient is scheduled for a series of appointments every week (typically 3 to 4) as opposed to only one appointment. These appointments need to be scheduled on available "machines" (dialysis beds). Second, each appointment consists of multiple "jobs", that are required to be completed at certain times by a limited number of "servers" (i.e., technicians). Figure 1 displays the high-level operational flow of jobs in a hemodialysis center with a focus on technicians' put-on and take-off jobs. Finally, while a patient is being treated on a dialysis machine, technicians need to be sequenced to complete other jobs on other beds. Consequently, assigning patients to beds and scheduling the job sequence for each technician is a nontrivial problem for the center's manager daily. In this research we propose unique solution methodologies to address this problem.

Figure 1. Patient-Technician Process Flow



There has been significant research around server scheduling and staffing in medical facilities. In the inpatient care and emergency department setting, there are several papers that studied staffing of nurses (or other care providers) without scheduling patients (Wright et al., 2006; Véricourt and Jennings, 2011; He et al., 2012; Green et al., 2013; Yom-Tov and Mandelbaum, 2014; Chan et al., 2021). However, in our study, we simultaneously schedule patients and servers for a multi-job per appointment system with an application in hemodialysis centers (an outpatient care setting).

There is a close relationship between the current study and the job scheduling literature in manufacturing systems. More specifically, parallel machine scheduling problems with multiple servers or resources. Parallel machine scheduling with an additional resource presents a problem where processing of jobs on the machines requires several units of a scarce resource (e.g., operators). For such problems, Fanjul-Peyro et al. (2017) propose an integer linear model that resembles the strip-packing problem Considering a similar problem, Yepes-Borrero et al. (2021) propose a greedy heuristic to find Pareto front solutions. Parallel machine scheduling problems with a common server present a problem in which servers (operators or machines) are used in the setup operation of the jobs. Bektur and Saraç (2019) provides a detailed literature review of parallel

machine scheduling with a common server and propose a mixed integer linear programming (MILP) model to solve this complex problem. Werner and Kravchenko (2010), Ou et al. (2010), and Lee and Kim (2021) are other examples of multi-server versions of this problem that employ a similar structure.

In this article, we propose a novel discrete-time formulation of the scheduling problem that can be solved within a reasonable time. We also offer a novel heuristic that solves the problem efficiently. To test the performance of our proposed formulation, we simulate real-life instances and compare the performance of our proposed scheduling policy with the current policy at the dialysis centers. The main contribution of this study to the job scheduling and healthcare management literature is that (1) we propose a novel mixed-integer formulation that unlike other studies in the literature, the set of servers (technicians) is unknown and to be determined, (2) we solve the problem with an exact method to optimality, and (3) we propose a constructive heuristic that efficiently solves the problem.

2. MODEL AND METHODOLOGY

We propose a mixed-integer programming (MIP) formulation for optimizing the PTSP at hemodialysis centers, where the number of patients (n), the number of beds (m), and the daily working hours (normally one or two 8-hour shifts) are known. For each dialysis patient, a technician is required to put the patient on a dialysis bed (or a chair) and to connect her to a dialysis machine (i.e., put-on job). Once the dialysis is over, the technician disconnects the patient from the dialysis machine and takes her off the bed (i.e., take-off job). The PTSP therefore includes (1) assigning patients to beds, (2) scheduling the job sequence (i.e., put-on and take-off jobs) for each technician, and (3) selecting the number of required technicians from a pool of technicians.

We reformulate the PTSP as a time slot assignment problem. The objective of the PTSP is to determine a schedule for a fixed number of patients n at a hemodialysis center, minimizing technician operating costs. The technician operating costs include the regular time labor cost (i.e., the hourly regular pay) plus the overtime labor cost (i.e., the hourly overtime pay). We present a set of constraints for Patient-Technician-Job Assignments and a set of constraints for sequencing the jobs. In addition, we add constraints to track the regular time and overtime.

We offer three methodologies to solve PTSP. The first is the equivalent algorithm to the current policy at the dialysis clinics. The technicians are first assigned to a set of certain beds. Then the patients are ordered in a First-Come First-Serve manner, and they are assigned to the available bed-time on a stacked manner (S-FCFS). The first patient is scheduled at time zero, and he second in line will be scheduled at time zero plus the put-on time of the first patient, if that time slot is available. In a second approach, we propose a heuristic that consist of two phases: (1) greedy constructive phase where a feasible solution is generated, and (2) local improvement phase where the solutions are partially deconstructed and improved. Finally, we solve our proposed PTSP model with a conventional optimization solver. The time-slot design of the formulation allows for a fast and efficient solution time, however it has its limitations. We will discuss this in the following section.

In our simulation, the center's capacity is ranging between 12 (small), 16 (medium), or 20 (large) beds. Many centers operate at sub-optimal capacity utilization, however, to address a more challenging scenarios than the current practice we consider 100 percent bed utilization. Therefore, for a one-shift center (2 patient time windows: morning, and afternoon) with small, medium, or large capacity, we consider 24, 32, and 40 patients (P), respectively. Similarly, a two-shift center (3 patient time windows: morning, afternoon, and evening) will accommodate 36, 48, and 60 patients (P), respecting the maximum bed capacity. We also generate three scenarios for average dialysis time of patients. We consider triangular distributions with short dialysis time (D1), average dialysis time (D2), and long dialysis time (D3).

3. FINDINGS AND DISCUSSION

We employed AMPL version 2020/11/23 (MS VC++ 10.0, 64-bit) to solve the optimization models, on a PC with Windows 10 Enterprise 2016, Intel Core i5 CPU with 1.9 GHz cache, and 16 GB memory to solve 540 randomly generated instances of different parameter combinations. Our findings demonstrate significant savings compared to the existing scheduling strategy. The current scheduling policy at the hemodialysis centers is purely based on a S-FCFS order. In our computational analysis, under the optimal schedule, hemodialysis centers can reduce their technician operating costs by 17% on average (in some cases up to 46%). PTSP reduces the regular time and overtime technician requirements in almost all different combinations bed/patient. It is noteworthy to mention that in some cases PTSP opts for a higher number of technicians during regular times to avoid additional cost that incur during the overtime. In other words, in such cases, it is optimal to hire more regular technicians to counterbalance high overtime cost. This is an oversight of the S-FCFS approach compared to the optimized schedule.

We observe several interesting patterns in our computational results with respect to the optimal number of technicians. First, as the number of beds or the number of patients increases, the total number of required technicians increases, as it is inevitable to expand capacity to satisfy increasing demand. We also observe that as the length of patient time windows increases, we need lower number of technicians. This is also reflected in the number of beds per technician (Bed/Tech) measurement. This is particularly an important measure for hemodialysis centers as they are concerned with their number of technicians and how many beds (or jobs) they should be efficiently covering. Second, we observe that longer patient time windows led to larger number of beds per technician ratio. However, the average number of beds per technician (Bed/Tech) appears to remain relatively steady across the two scenarios (2.6 and 2.75 overall average for one-shift per day and two-shift per day, respectively) regardless of the size of the instance (i.e., the number of beds and patients). Third, we observe that centers serving patients with longer dialysis times (under scenario D3) require higher number of technicians compared to centers serving patients with shorter dialysis times (under scenarios D1 and D2).

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Technology in Healthcare: A Review of Current Practices and Challenges

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Abstract

The improvement of healthcare quality requires the engagement of participants with varying knowledge and expertise. This imperative underscores the need for a comprehensive approach—one that is both systematic in understanding the complexities of the problem domain and accessible enough to facilitate the active involvement of diverse stakeholders in quality improvement initiatives.

The current body of literature provides a multitude of studies addressing various aspects of quality and/or technology within the healthcare domain. However, many of the studies fail to address the distinct difference between the quality improvement tools utilized in healthcare and those employed in manufacturing and other service sectors. Similarly, many studies fall short in identifying the specific Industry 4.0 technologies commonly employed in the healthcare sector.

Aiming at filling these gaps, this research focuses on investigating the adoption of Industry 4.0 technologies and their consequent impact on the operational performance of the healthcare sector. To understand the determinants impacting the adoption of technology and quality initiatives in healthcare, multiple expert interviews were conducted with industry professionals. Interview questions were formulated based on a synthesis of prior studies and expert opinions. Healthcare experts were chosen for their alignment with the project's scope, possessing significant expertise in healthcare, quality improvement, and technology implementation.

Keywords: Analytics, Healthcare 5.0, Industry 4.0, Healthcare, Technology, Quality.

I. Introduction

Industry 4.0 stems from adopting advanced technologies such as Internet of Things (IoT), artificial intelligence (AI), big data, additive manufacturing, and digital supply chain, to name a few [1]. Sometimes, simply referred as "Connection" [2], the fourth industrial revolution is a national strategic initiative from the German government [3]. In 2011, the Communication Promoters Group of the Industry-Science Research Alliance (FU) initiated the launch of this project in order to enhance the productivity, efficiency, and flexibility of production processes and drive economic growth by supporting the integration of Cyber-Physical Systems (CPS) and Internet of Things and Services (IoTS) [3].

The assimilation of Industry 4.0 technologies exhibits a non-uniform pattern of adoption in healthcare. While certain technologies, such as Electronic Health Records and wearable sensor devices, seamlessly integrate into the healthcare system with rapid acceptance, other emerging technologies experience a slower rate of assimilation.

As technological capabilities advance rapidly and new technologies gain widespread adoption, it is crucial to understand their current and potential impact on healthcare quality to alleviate concerns about their acceptance. This analysis becomes pivotal for navigating the evolving technological landscape in the healthcare domain, especially considering that budgetary justifications hinge significantly on the delivered quality [4]. Moreover, heightened quality in healthcare not only reduces the overall cost but also provides justification for the allocation and utilization of resources.

With a similar motivation, this study extends its investigation into quality improvement within healthcare from the perspective of healthcare provider organizations. It establishes a correlation between the technological maturity levels of organizations and the benefits they yield. Results indicate variability in technological intensity across organizations within the same healthcare system and organizational units within the same organization. The reasons why such diverse levels of technological intensity manifest in healthcare need to be further elaborated.

The study scrutinizes the typical advantages introduced by new technologies to healthcare organizations while concurrently exploring the extent of their influence. Additionally, the study identifies disparities between conventional quality control tools and methodologies and those employed in healthcare performance measurement and improvement. Detailed elucidation is provided on the notable distinctions between key performance indicators (KPIs) used in traditional service industries and those applied in assessing healthcare practices.

II. Technology and Quality in Healthcare

The emphasis on healthcare quality revolves around safety, enhancing treatment and intervention outcomes, augmenting value proposition, and diminishing instances of harm. Traditional stakeholders in healthcare encompass regulatory bodies, credentialing boards, government and third-party payers, hospitals, and, fundamentally, patients [4]. The United States healthcare system stands as one of the most scrutinized and regulated sectors, with health systems, hospitals, and post-acute care (PAC) providers subject to oversight from diverse federal and state entities [5]. Additionally, several not-for-profit organizations serve as standards-setting and accrediting bodies in the healthcare sector. Of these, the Institute for Healthcare Improvement (IHI) is a global not-for-profit organization that works collaboratively with individuals and organizations to achieve sustainable, large-scale, and science-based improvements in quality and safety [6].

IHI, like many other healthcare organizations, endorses the consideration of six principles called “Aims for Improvement”. Aims for Improvement are a set of overarching principles, first proposed by the Institute of Medicine in 2001. This framework has been widely recognized and applied by U.S. healthcare organizations and stakeholders and includes Safety, Effectiveness, Patient-Centeredness, Timeliness, Efficiency, and Equity [7] as its tasks for advancing healthcare systems. The analysis employs these tasks as Key Performance Indicators (KPIs) to meticulously examine the correlation between the utilized technologies and their impact on each corresponding measure. It is also worth noting that these principles seamlessly align with Healthcare 5.0, given its inherent focus on human-centric values such as quality, safety, and effectiveness. That is, Healthcare 5.0 is considered as pervasive, highly personalized, dynamic, and driven by reason-based analytics, incorporating elements such as smart control, interpretable healthcare analytics, three-dimensional view models, and augmented and virtual reality [8].

Industry 4.0 technologies in healthcare, as in other industries, often leverage cloud-based software and hardware solutions, as well as sensors. The connectivity of these technologies is crucial and is ensured through mobile and online communication technologies. Connectivity leads to the development and implementation of effective health technologies such as telemedicine platforms and wearable or embedded sensors. These advancements enable continuous monitoring and care of patients, contributing to more efficient and accessible healthcare services. These new technologies have drawn considerable attention in the literature due to their potential to transform the healthcare industry by improving the quality, accessibility, and affordability of care. The list of Industry 4.0 technologies is not exhaustive and varies based on the specific scope under consideration.

In this study, Telemedicine, although enabled by IoT, sensors, and cloud computing, is considered a separate technology due to its widespread utilization (Table 1). Similarly, Electronic Health Records (EHR) is considered a distinct technology, given the familiarity of healthcare professionals with its applications. Further, Cybersecurity has been omitted from the list of technologies after the survey of expert opinions has been concluded as its implementation and management are institutionally governed and traditionally centralized within the Information Technology services of the organization, rather than being specific to individual departments. However, it is

important to note that all experts indicated that the Cyber Security technology was at the Expert level in their organizations.

Table 1. Scope of Industry 4.0 Technologies Included in the Study

Artificial Intelligence (AI) [9]
Augmented Reality (AR) [10]
Big Data [9] [11]
Biosensors [9] [12]
Blockchain [11] [13], [14]
Cloud Computing [9]
Cyber Physical Systems [15] [11]
Digital/Additive manufacturing and 3D Scanning [16] [17] [18] [19]
Electronic Health Records [20]
Internet of Services (IoS) [11]
Internet of Things (IoT) [9] [11]
Machine Learning (ML) [21]–[23]
Robotics and Automation (RPA) [9]
Simulation and modeling (digital twins) [24]–[27]
Telemedicine [28]
Virtual Reality (VR) [9]

These Industry 4.0 technologies, also referred as Healthcare 4.0 technologies, provide the following principles to healthcare industry practice:

- **Interconnectivity** [29] [30]: This is the ability of all the available components, such as devices, machines, sensors, and humans, to communicate and connect with each other through the Internet of Health Things (IoHT) or medical Cyber-Physical Systems (medical CPS).
- **Information Transparency** [29]: This is the ability to collect, store, and analyze large amounts of data from various sources, such as electronic health records, medical images, wearable devices, and genomic sequencing, using cloud computing, big data analytics, and machine learning. This enables transparency, which provides the operators with comprehensive information that allows them to make informed decisions.
- **Technical Assistance** [31]: This is the ability to use technologies, such as artificial intelligence, robotics, and augmented reality, to assist the operators in any capacity, such as diagnosis, treatment, surgery, rehabilitation, and education. This also includes the ability to create and use human tissue models and 3D bioprinting, which allow for the precise arrangement of multicellular constructs that replicate how human tissue functions in our body.
- **Decentralization** [32]: This is the ability to delegate decision-making and control to the components themselves, such as smart devices, algorithms, and organoids, based on the data and information they receive and process. This allows for more flexibility, efficiency, and reliability in the healthcare system.
- **Modularity** [31]: This is the ability to design and organize the components in a modular way, such that they can be easily added, removed, or replaced according to the changing needs and demands of the healthcare system. This allows for more scalability, adaptability, and customization in the healthcare system.
- **Service Orientation** [15]: This is the ability to provide and access the components as services, such as software as a service (SaaS), platform as a service (PaaS), or infrastructure as a service (IaaS), through the internet or cloud. This allows for more accessibility, affordability, and quality in the healthcare system.

III. Methodology and Interview Design

The interview design incorporated information derived from relevant literature as well as insights gathered from numerous healthcare practitioners possessing substantial firsthand experience in quality improvement and technology implementation within healthcare organizations.

The initial segment of the interview is dedicated to gathering descriptive information about the organization. This includes details on its core functions, service capacity, size, technological intensity, the expertise level of respondents in technology implementation, and their involvement in technology implementation projects. Additionally, this section encompasses the job description and the scope of the respondent's role within the organization.

The subsequent section is structured around a compilation of technologies commonly associated with Industry 4.0. Respondents are prompted to assess the level of technology implementation in their organization by selecting from a Likert scale, offering insights into the current state of adoption for these specific technologies. After conducting interviews with five experts, certain technologies, including Fog Computing and Precision Medicine were excluded from the list to streamline and simplify the evaluation process.

The third segment of the interview is dedicated to evaluating the operational performance of the healthcare organization. Respondents were asked to provide insights into the degree to which Industry 4.0 technologies contribute to improving operational performance. Following an initial list derived from the literature, the key performance indicators (KPIs) were refined and finalized by the experts. These indicators include:

- Reduced time for clinical impression or diagnosis
- Reduced rehospitalization
- Reduced errors and reportable events
- Employee education and training
- Planning for safety and quality (incident response)
- Regulatory compliance per industry standards
- Diagnosis accuracy
- Enhancing patient experience (i.e., Net Promoter Score (NPS), likelihood to recommend)
- Streamlining administrative tasks
- Increased efficiency in overall operations
- Financial stability (bill collection)

Like the previous section, a Likert scale was employed to capture respondents' assessments.

The fourth segment aimed to gauge healthcare performance according to IHI criteria. The criteria, along with corresponding explanations, are detailed as follows:

- Safety: Ensures Patient Safety
- Effectiveness: Provides services based on scientific knowledge to all who could benefit
- Patient-Centeredness: Responsiveness to individual patient preferences, needs, and values
- Timeliness: Minimizes waits and potentially harmful delays
- Efficiency: Ensures cost-effective care (avoids waste, overuse, and misuse of services)
- Equity: Provides care that does not vary in quality because of personal characteristics such as gender, ethnicity, race, language, or socioeconomic status

The fifth section centered on quality improvement tools and techniques categorized into four classes: the Patient Safety Essentials Toolkit, Quality Improvement Essentials Toolkit, IHI Global Trigger Tool for Measuring Adverse Events, and the Situation-Background-Assessment-Recommendation (SBAR) Tool.

IV. Initial Findings:

Remote monitoring is the most common application of IoT devices for healthcare. IoT devices can automatically collect health metrics like heart rate, blood pressure, temperature, and more from patients who are not physically present in a healthcare facility, eliminating the need for patients to travel to the providers, or for patients to collect it themselves.

While organizational-level integration of Artificial Intelligence (AI) is not currently in practice, healthcare professionals employ these technologies individually to enhance efficiency in crafting informative and educational presentations for training purposes. Additionally, AI is utilized to partially generate flyers and pamphlets, simplifying language for broader public education and awareness campaigns.

Augmented reality stands as one of the least comprehended technologies, with healthcare professionals lacking a clear understanding of its capabilities.

The growing adoption of AI among patients has garnered considerable attention and raised concerns within the mental health care medical community. Mental health practitioners are expressing apprehensions about the potential impact of widespread patient-driven AI use on established healthcare protocols and patient-provider dynamics. This concern is underpinned by the necessity for careful consideration of ethical, privacy, and regulatory implications associated with autonomous patient engagement in AI-assisted health management.

Equity is assessed through the utilization of information extracted from electronic health records and supplementary external data supplied by governmental agencies. This evaluation predominantly relies on factors such as zip code, race, gender, etc., to identify vulnerable populations. The integration of big data analytics plays a crucial role in this phase, as overseeing bodies conduct comprehensive analyses to unveil population statistics and demographics, providing valuable insights to government-sponsored and regulated healthcare organizations.

Virtual Reality and Simulation and Modeling, which includes digital twins, and 3D Scanning are considered cutting-edge technologies commonly covered under Healthcare 5.0. Despite their infancy, one expert noted that a Virtual Reality (VR) project was underway, although its relevance pertained more to facility planning than healthcare.

There exists a substantial disparity in the quality improvement (QI) and measurement tools and methodologies employed in healthcare when compared to manufacturing and other service industries. Table 2 delineates the conventional QI tools and methodologies while Table 3 lists the ones that are utilized in healthcare.

Table 2. QI and Measurement Tools and Methodologies Utilized in Healthcare v. Conventional Approaches

Tools for Lean Principles:	**Lean**	**Six Sigma**	**Both**
Checklists			*
Visual Management	*		
Standard Work	*		
Flowcharts			*
Record Recording (Electronic Health Records (EHR))	*		
RFID Tracking			*
5S Waste Elimination	*		
Continuous Flow			*
Gemba (The Real Place) Walk	*		

Heijunka (Level Scheduling)			*
Just-In-Time (JIT)	*		
Kaizen (Continuous Improvement)			*
Mistake Proofing			*
Overall Equipment Effectiveness (OEE)			
PDCA (Plan, Do, Check, Act)			
Poka-Yoke (Error Proofing)			
Single-Minute Exchange of Die (SMED)			
8Waste			
Takt Time			
Time Study	*		
Total Productive Maintenance (TPM)	*		
Value Stream Mapping	*		
Bottleneck Analysis			
Standardized Work	*		
One-Piece Flow			
Andon			
Hoshin Kanri			
Cellular Manufacturing			
Total Quality Management			
Right First Time			
Six Big Losses			
A3 Problem Solving			
Tools for Six Sigma Principles:			
Define			
Project Charter			*
Stakeholder analysis			*
VOC/VOB/VOP			*
Interview			*
CTQC tree diagram			*
Operational definition			*
QFD			*
FMEA		*	
VSM			*
Process Map			*
CTQ			*
Measure			
Pareto chart		*	
Histogram		*	
Failure Effect Mode Analysis		*	
Data collection plan			*
KPIs			*
Process Capability		*	
Spaghetti Charts			*
Basic Statistical Terms		*	
Variable MSA - Gauge R & R		*	
Attribute Measurement System Analysis		*	

Calibration of Measurement Systems		*	
Collecting Data-Data Sheets			*
Developing a Sampling Plan		*	
Baseline Performance		*	
Performance Metrics - Throughput Yield		*	
Calculating the Sigma Level		*	
Analyze			
Kanban			*
Cause & Effect Matrix (Ishikawa-Fishbone)			*
5-Why, 1-How			*
Root Cause Tree Analysis			*
Scatter Plot Toolset		*	
Correlation and Regression		*	
Multiple Regression Toolset		*	
Binary Logistic Regression		*	
Factors In Determining Sample Size		*	
Estimating Population Mean		*	
Statistical Testing		*	
Hypothesis Testing		*	
Confidence Intervals		*	
Comparing One Proportion to a Standard		*	
Comparing Two Proportions Toolset		*	
Comparing Multiple Proportions - Chi-Square		*	
Comparing One Mean to a Standard - t-test		*	
Comparing Two Means - t-test Toolset		*	
Comparing Multiple Means - ANOVA Toolset		*	
Comparing One Variance to a Std. - Chi-Square		*	
Comparing Two Variances - F-test Toolset		*	
Parametric vs. Non Parametric Tests		*	
Non-Parametric Toolset		*	
Design of Experiments (DOE) Power and Sample Size	*		
Improve			
Benchmarking			*
Brainstorming			*
Error-proofing			*
Prioritizing and Selecting a Solution			*
Continuous Flow			*
Quick Changeover			*
Cellular Processing			*
Leveling Production (Heijunka)			*
The Theory of Constraints (TOC)			*
Pull System Overview			*
Replenishment Pull Overview			*
Kaizen			*
Corrective Action Matrix			*
Piloting a Solution		*	
FMEA			*

Visual Management	*		
5-S Approach			*
Total Productive Maintenance (TPM)			*
Standardized Work - Documenting Process Changes			*
Control			
Control plan		*	
SPC Chart		*	
Attribute Control Chart		*	
X-bar and R Chart		*	
Process Capability		*	
Audit Analysis			*

Table 2 is created based on the consensus of two industry experts with significant experience in academia. The initial expert has actively contributed to quality implementation projects in various roles, holds a Ph.D. degree with a decade of teaching experience at the university level. As a former Vice President of Quality with global responsibilities, they have gained significant expertise from supplier components to end customer usage. In prior roles, as a General Manager of Quality/Regulatory and later as Vice President of Operations and Technology, they showcased a comprehensive understanding of quality initiatives and regulatory functions.

The second expert currently holds the position of OpEx Manager and has previously worked as an Advanced Quality Planning (AQP) Manager. With a Ph.D. degree and teaching experience at the university level, their professional background includes roles as a Principal Quality Engineer, Senior Quality Engineer, and Quality Engineer. They have actively participated in numerous quality implementation processes within the medical technology sector.

Table 3. Primary Tools for Quality Improvement and Measurement in Healthcare [Adopted from: [26]–[28]

Patient Safety Essentials Toolkit
Action Hierarchy (part of RCA2)
Ask Me 3®
Cause & Effect
Developing Reliable Processes
Five Whys
Flowchart
FMEA
Huddles
SBAR
Quality Improvement Essentials Toolkit
Cause and Effect Diagram
Driver Diagram
Failure Modes and Effects Analysis (FMEA)
Flowchart
Histogram
Pareto Chart
PDSA (The Model for Improvement) Worksheet
Project Planning Form
Run Chart & Control Chart

Scatter Diagram
IHI Global Trigger Tool for Measuring Adverse Events
Situation-Background-Assessment-Recommendation (SBAR) Tool

Table 3 is created based on feedback from three industry experts with more than 50 years collective healthcare organization experience. The first expert is a Vice President Human Resources at a small, long-term acute care hospital and rehabilitation organization. The organization has multiple sites and provides a variety of inpatient and outpatient treatments through over 30 different programs. This individual is directly responsible for hiring medical and non-medical executives and professionals for which the criteria of quality service and exceeding industry standards is paramount.

The second expert is a Certified Patient Experience Professional (CPXP) and a Board-Certified Patient Advocate (BCPA). This professional has over a decade of experience as a Senior Patient Relations Partner for a medium-sized acute care hospital. This individual has led or participated in several technology implementation projects and has been consistently involved in quality efforts, institutional metrics, and industry standards.

A practicing physician, Clinical Professor of Medicine, Medical Director, Hospital Department Chief, and System Chief in an adult specialty area for a regional health system, the third expert who provided feedback has multiple decades of experience in healthcare quality leadership.

Collectively, all the experts agreed that quality of care, innovation, and technology as well as their joint impact on diversity, equity, and inclusion (DEI) are topics that require healthcare organizations to have rigorous programs measuring, evaluating, and improving quality of service at multiple levels within each institution. Hospitals hire interview organizations to provide data collection on quality measures, and some general departments use quality tools, but the formality and familiarity with systematic methods varies widely outside of specific quality departments and professional roles.

Healthcare professionals have their own jargon that is not aligned consistently with the jargon used in the quality literature based on the manufacturing sector. Experts advised to separate the effort to understand technology implementation decision-making from the administrative elements of technology implementation and from the ongoing documentation required to use technology for benefit realization.

V. Conclusions and Future Research

Effective decision making today depends on being connected and sharing data and information with stakeholders across different organizations. It also requires consideration of the situational relevance of each decision, which means choosing the best option for the specific context. Lastly, by integrating varying levels of automation into the decision-making processes, the organization can become more adaptable and responsive to new opportunities and quickly adjust to changing situations [36]. Healthcare 5.0 technologies, used efficiently, enable better-informed decision making with higher responsiveness via decision support, augmentation, and automation. According to industry experts, implementation of Healthcare 5.0 technologies to improve quality in a provider organization simply makes sense because it fulfills the institutional mission in terms of sustainability criteria for public benefit.

However, a significant concern associated with the growing adoption of emerging technologies in healthcare pertains to their efficacy in meeting needs and improving productivity. The question arises: can these technologies maintain their effectiveness while concurrently addressing the challenges posed by the rising number of patients and escalating expectations? The corollary to systematically prioritizing technology implementation is to provide the most significant and measurable value proposition for healthcare organization stakeholders. This challenge is not necessarily well-documented.

Thus, exploring the impact of novel and emerging technologies on decision-making in healthcare would be a promising avenue for future research. Future research will focus on this objective and will use interview questions developed from expert opinions received.

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Extended Abstracts

Marketing and Consumer Behavior

Using Binary DEA to Evaluate the Nutritional Performance of Food Items

Herbert F. Lewis, Christine Pitocco, Thomas R. Sexton, Shuran Liao

The pursuit of a healthy diet involves multicriteria decision making. We face many alternatives, each containing a variety of important nutrients. When we choose an entree for tonight's dinner, we must remember that many people will partake of that meal. Yet the nutritional requirements of an adult male, an adult female, older children, younger children, pregnant or lactating women, and elderly people are different. Moreover, different family members are likely to have different nutritional goals. Dad wants less cholesterol, mom needs more vitamins, the son wants more protein, and the daughter wants fewer calories.

We develop a binary DEA model that identifies a replacement food item, if it exists, for any specified food item. The replacement food item has more of every desirable nutrient and less of every undesirable nutrient relative to the food it replaces. We illustrate the model using the food groups defined by the US Department of Agriculture in its database showing the nutrient content of over 8000 food items. Specifically, we use the poultry food group that contains 228 food items to illustrate the application of our model.

We refer to desirable nutrients as LIPs (larger is preferred) and to undesirable nutrients as SIPs (smaller is preferred). It is generally understood that nutrients such as protein and vitamins are LIPs while cholesterol and saturated fatty acids are SIPs. We also introduce the concept of SLIPs, nutrients for which we want at least a specified minimum amount but no more than a specified maximum amount.

HOW UNCERTAINTY IMPACTS BIOTECHNOLOGY FIRMS' GOVERNANCE DECISIONS: A TRANSACTION COST ECONOMICS PERSPECTIVE

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ABSTRACT (200 words)

Through a specific governance structure, either hierarchical and within the firm, or through partnership in the market, a firm may find a balance in reducing direct costs while keeping indirect costs to a minimum. This paper aims to understand the impacts of different types of uncertainty on firms' decisions to adopt market versus hierarchical governance structures within the biotechnology industry. The purpose is to draw attention to the potential benefits or risks of adopting an open innovation model, which can be understood as an extreme case of market governance method. Adopting theories from Transaction Cost Economics and Business-to-Business Relationship Marketing disciplines, we suggest a set of hypotheses to explore the impact of different types of uncertainty on the firms' governance decisions. The proposed hypotheses are intended to be empirically tested through a field survey.

1. INTRODUCTION

Innovation in many industries requires a combination of working processes and significant investments either directly or indirectly. Within the biotechnology industry, innovation requires a mixture of direct costs as a result of research and development, product design, testing, engineering, manufacturing, distribution, and many other procedures involved in the development of new products or processes (Pisano, 1990). The big question that many of these firms face is whether it is more worthwhile to undertake the development of a new product or process through their own efforts or seek the market for collaborative relations, joint ventures, and many other contractual mechanisms. The idea is that through a specific governance structure, either hierarchical and within the firm, or through collaboration in the market, a firm may find a balance in reducing direct costs while keeping indirect costs to a minimum. Through the market, it may be possible to reduce those direct costs associated with innovation, yet there are indirect costs associated with opportunistic behavior, uncertainty between firm relations and the possibility of firms trying to take advantage of their partners, and also uncertainty within the environment as well, in the form of an unstable market, or uncertainty of sourcing technology. These are all various factors that may influence a firm's decision between a hierarchical form of governance and that of a market form of governance. Pisano (1990) seems to believe that the biotechnology industry prefers a form of closed innovation that prioritizes hierarchical governance structures rather than openly innovating within the market. For the sake of lowering costs and having access to massive amounts of capital, biotechnology firms would only partner with commercial firms or established corporations rather than other biotechnology firms. Furthermore, statistics from this study in 1987 show that biotechnology companies were fulfilling 80% of their manufacturing needs in-house rather than approaching collaborative efforts through the market. Becoming less dependent on partners also allowed many biotech firms to hold on to manufacturing, and marketing rights, also allowing these firms to see greater revenue for their own products.

To better understand the case of open innovation in the biotechnology industry, it is important to examine current day biotechnology alliances, or firms within the industry that have preferred vertical integration through hierarchical governance. This paper aims to better understand the effects of uncertainty within the biotechnology industry in an effort to draw attention to the potential benefits of open innovation in the industry. The major comparison is the potential direct costs of R&D, and other costs associated with the development of new products or processes, versus the indirect costs as a result of uncertainty between allied firms in the form of behavioral, and environmental uncertainty. Though many of the papers within this study bring up the potential influences of environmental uncertainty or behavioral uncertainty on a governance structure decision, their application in the biotechnology industry is quite limited. The basis for the paper will be extended from the Transaction Cost Economics theory as defined by Williamson (1973), to gain a better quantification for indirect (transaction) costs. This framework as seen in various other industries will be applied to gain valuable insight into the effects of uncertainty as a whole on governance decisions within the biotechnology industry and showcase a comparison between direct and indirect costs of open and closed innovation.

2. LITERATURE REVIEW

2.1 Transaction Cost Economics

Transaction Cost Economics or TCE is a framework used in organizational boundaries and the respective decisions surrounding such. Scholars widely acknowledge TCE as a fundamental theory in understanding organizational behavior and decision-making processes, particularly in the context of business relationships and alliances. TCE posits two kinds of governance structure, market and hierarchical, which is influenced by transaction costs. These costs include the expenses incurred in searching for information, negotiating contracts, and monitoring and enforcing agreements (Williamson, 1973).

With the rise of biotechnology companies and increasing interests in their governance decisions, scholars have turned their attention to the application of Transaction Cost Economics (TCE) in this area. TCE helps analyze how transaction costs influence the choice between internalizing transactions or engaging in external alliances (Williamson, 1973). Santoro and McGill's (2005) research extensively analyzed the impact of uncertainty and asset co-specialization on the governance of biotechnology alliances. Biotechnology firms face unique challenges due to the nature of their industry, characterized by high technological uncertainty, asset specificity, and information asymmetry. TCE offers insights into how these factors influence the formation and sustainability of alliances in the biotechnology industry. Therefore, TCE provides a theoretical framework to understand why and under what circumstances biotechnology firms might be hesitant to form alliances, shedding light on the intricate relationship between transaction cost

2.2 Governance Structures

2.2.1 Market governance structure

Market governance structure plays a significant role in understanding how transactions are organized and governed in the dynamic landscape of the biotechnology industry. Williamson (1973) believes that market governance structures involve the strategic choices firms make between market transactions and hierarchical arrangements. Geyskens et al. (2006) contribute to this understanding by delving into the "Make, Buy, or Ally" decision-making process, shedding light on the factors that influence market governance structures. Uncertainty and asset co-specialization were previously found to have an impact on firm alliances in the biotechnology industry (Santoro

and McGill 2005). The findings highlight the challenges faced by biotech firms in determining the appropriate market governance structure, especially under conditions where transaction costs associated with external collaboration outweigh the benefits.

2.2.2 Hierarchical Governance Structure

Hierarchical governance structure emphasizes a larger role within a particular firm rather than across two different firms. The hierarchical governance structure is also known as vertical integration within a particular firm. Williamson (1973) asks whether a transaction is performed more efficiently within a firm (vertical integration) or outside of it (market transaction). Hierarchical governance or vertical integration is defined by internal organization, and transactions within the aforementioned internal organization. Geyskens et al. (2006) defines hierarchical governance through vertical integration as “the performance of a transaction within a firm.” Rindfleisch and Heide, (1997) also further distinguish the market and the firm itself as alternative governance structures. Transaction costs are what truly differentiate the two ideologies. As noted above, Transaction costs are the indirect costs of performing a transaction, for example, negotiating contracts, or monitoring, and enforcing agreements. Under certain circumstances, such costs of conducting economic exchanges in a market may exceed the costs of the same within the firm itself. This is where it is essential to consider hierarchical governance structures as an alternative to seeking the market, as a reduction in transaction related costs may outweigh the reduction of any direct costs as a result of collaboration with the market.

These two governance structures depict the choices that firms must consider in the process of research and development of new products and services. To further understand the potential influences on such decision making, there are several factors of Transaction Cost Economics that must be considered. Of the various factors, the ones discussed in this paper are related to uncertainty. These variables of uncertainty are further elaborated on in the following section.

2.3 Environmental uncertainty

2.3.1 Technological uncertainty

In this study we discuss the two components of Environment uncertainty: Technological uncertainty and Market uncertainty. Firstly, Technological uncertainty is a critical concept within the Transaction Cost Economics (TCE) framework. Teece (1986) and Santoro and McGill (2005) underscore the intricate relationship between technological uncertainty and the propensity of biotechnology firms to form alliances. Teece (1986) also argues that technological uncertainty introduces complexity into strategic decisions, affecting firms' choices between internalizing activities and engaging in external alliances. Moreover, Santoro and McGill (2005) suggest that high levels of technological uncertainty can discourage firms from forming alliances due to the challenges associated with coordinating and sharing highly specialized knowledge and resources. Technological uncertainty impacts the choice of governance structures, particularly in the biotechnology sector. Firms facing high levels of uncertainty may opt for internalization to retain control over sensitive information. On the contrary, low levels of uncertainty may lead to external collaborations to share risks and costs (Williamson, 1985). The governance structure becomes a strategic response to the challenges posed by technological uncertainty. In conclusion, technological uncertainty plays a pivotal role in shaping the decisions of biotechnology firms, particularly in the context of alliances. Understanding how uncertainty

influences governance structures is crucial for comprehending the intricacies of strategic decision-making in the ever-evolving biotechnology landscape.

According to the previous research, this study posits that as technological uncertainty increases in the biotechnology industry, firms are more likely to opt for market forms of governance or alliances.

Hypothesis 1: There is a positive relationship between technological uncertainty and likeliness to opt for a market form of governance or an alliance.

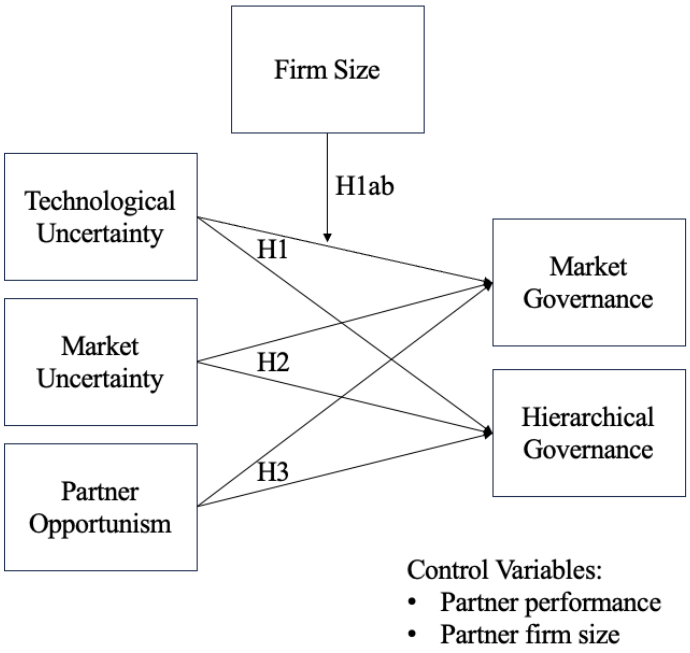

Figure 1: Conceptual model

Navigating the complex terrain of the biotechnology industry involves a careful consideration of governance structures, especially when influenced by factors like technological uncertainty. A critical aspect in this exploration is the moderating variable of firm size, which plays a pivotal role in shaping alliances within the biotech sector. As exemplified by Harada et al. (2021), the rapid pace of innovation and inherent uncertainties in biotechnology necessitate a nuanced understanding of how firm size influences the likelihood of forming alliances (Harada et al., 2021).

Technological uncertainty, a central theme in the literature, underscores the challenges faced by biotechnology firms. As identified by Scillitoe et al. (2015), external contexts significantly impact alliance governance decisions in biotech-pharmaceutical collaborations, reflecting the intricate relationship between contextual factors and governance choices (Scillitoe et al., 2015). Ebers and Oerlemans (2016) further emphasize the variety of governance

structures beyond traditional models, highlighting the need for tailored approaches in alliance formation (Ebers & Oerlemans, 2016).

Considering the impact of firm size as a moderating variable introduces a layer of complexity to the governance choices made by biotechnology firms. We have:

Hypothesis 1a: The positive relationship between technological uncertainty and market form of governance or an alliance will be weakened for larger firms; larger firms will likely opt for hierarchical governance, such as in-house R&D initiatives, when there is high technological uncertainty.

Hypothesis 1b: The positive relationship between technological uncertainty and market form of governance or an alliance will be strengthened for smaller firms; smaller firms will likely seek external governance structures, such as strategic alliances, when there is high technological uncertainty.

In this exploration, the study aims to contribute insights into the nuanced conditions under which biotechnology firms, varying in size, are either discouraged or encouraged to form alliances amidst the uncertainties of technological advancements.

2.3.2 Market Uncertainty

Market uncertainty is the second component of Environmental Uncertainty. Krishnan, Martin, and Noorderhaven (2006) define environmental uncertainty as results of changes in economic conditions faced by a firm that are outside the realm of its control and harder to anticipate. The market in this case refers to the market environment in which firms can act in a hierarchical or market governance structure. To maintain performance between two firms in an unpredictable environment, partners will need to constantly monitor changes and adjust their alliance strategy accordingly. Uncertainty in the environment limits cognitive efforts and can cause strategic blindness. This blindness refers to insensitivity towards changes within the market or environment as firms in an alliance commit resources, effort, and time and are, as a result, wary of potential actions that could harm their relationships. In these situations, firms are more likely to weigh losses that come from the result of responding to the changing environment, more than the gains, due to those investments along with the possibility of having to cut previous relationships, building new trust, and various other potential requirements of the changing market environment.

Huo, et al. (2018) brings to attention another aspect of environmental uncertainty. They argue that environmental uncertainty results in an adaptation and evaluation problem that increases transaction costs in terms of both coordination costs and transaction risks. Prior contractual agreements between firms might not cover every contingency creating room for further uncertainty, and even potential for opportunistic behavior. Therefore, we set competing hypotheses for the relationship between market uncertainty and likeliness to opt for a market form of governance or alliance.

Hypothesis 2: There is a positive/negative relationship between market uncertainty and likeness to opt for a market form of governance or alliance.

2.4 Behavioral Uncertainty

Behavioral uncertainty lies in the evaluation of performance. Geyskens (2006) extends the notion that behavioral uncertainty occurs when firms must determine whether full contractual compliance has taken place. The solution according to TCE is simply through vertical integration due to the idea that greater control is required in a circumstance where there is potential for greater behavioral uncertainty. If firms cannot assess between themselves whether full contractual compliance has been achieved or not, then they cannot fully evaluate each other's performance, leading to increased uncertainty. This study provides the idea that in an environment of potential behavioral uncertainty, firms are more likely to opt for vertical integration to mitigate the effects of that uncertainty. To test this idea, this paper will examine Behavioral Uncertainty under the lens of Opportunism, and Perceived Opportunism across firm alliances.

2.4.1 Opportunism

In Markets and Hierarchies, Williamson (1973) defines opportunism and opportunistic behavior as an effort to retain individual gains in an alliance through lack of candor or honesty in a transaction. An example of opportunistic behavior between firms includes disclosure of information in a strategic manner that places some individuals or firms at an advantage over their partners, harming original negotiations between two firms. According to Deeds, and Hill (2019), opportunism occurs because "one or more participants chooses at their own advantage to maximize individual returns at the expense of their partners." In order to deter opportunistic behavior, it is important to reduce the potential benefits either party of an alliance may see from opportunistic behavior to begin with. This is usually through equity investments, contingency claim contracts, and contractual safeguards that protect firms in the situation of perceived partner opportunism. The potential for opportunistic behavior is a possible source for transaction costs due to the necessity of contractual safeguards, monitoring costs, and these other protections for firms in an alliance or transaction. TCE does not assume that all actors in an alliance are opportunistic, but that it is difficult and expensive to distinguish those ethical actors from the potentially opportunistic ones. Any firm entering an alliance may be placing specific assets, and risks both themselves and the assets to opportunistic behavior. For this reason, our third hypothesis states that there is a negative relationship between perceived partner opportunism and likeliness to opt for a market form of governance or alliance, simply due to the riskiness associated with the potential for opportunistic behavior with any new firm partners.

Hypothesis 3: There is a negative relationship between perceived partner opportunism and likeliness to opt for a market form of governance or an alliance.

Behavioral Uncertainty can also take the form of opportunistic behavior by a firm partner (Mellewigt, 2015). Knowledge is a good shared between firms that cannot be valued until after it is shared. Once it is shared between

the firms, there is no longer a real "incentive" to pay for the newly obtained knowledge. If the value of a particular firm's knowledge can only be acknowledged through the combination of another firm's knowledge, then the alliance faces the potential for opportunistic behavior. Value creation in knowledge sharing and management provides an additional source for opportunistic behavior, as shown in Williamson's original example of strategic disclosure of information. The level of this perceived opportunistic behavior can influence how much firms may have to be wary of resulting transaction costs, and therefore contribute to the choice of governance form to reduce those costs overall.

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Extended Abstracts

Operations Management/Operations Research

Are you barking up the wrong tree?

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Extended Abstract

Operations managers frequently end up pursuing inappropriate priorities in the name of lean management and waste elimination. One common mistake occurs when managers are busy chasing cost-cutting measures, whereas the company's customers value operations capabilities other than cost – such as flexibility, speed, or quality. This can result in knee-jerk, short-term measures that run at counter purposes to long-term strategic interests. For example, in an effort to compete with low-fare airlines, many full-service airlines adopted the thinking that "the customer doesn't value the food" and cut free snacks to save $1 to $2 million. That sounds like a lot but, put in proper perspective, represented only about 0.01 to 0.02 percent of their operating costs. This was despite food service being recognized as an important "window to the brand" since passengers primarily experience an airline's brand after boarding the aircraft. Such cost-cutting efforts led to a situation where leisure travelers exhibited more brand loyalty than the high-frequency business travelers highly coveted by the airlines – a stark example of misplaced priorities.

A related mistake is that managers can get sidetracked from more salient concerns when cost-cutting blinders steer them to low-hanging, but trivial fruit. A McKinsey report identified how "an airline that fully embraced lean operations could slash its overall costs by a further 5 to 10 percent." Instead of chasing $1 to $2 million, the airlines could have been pursuing $1 to $2 billion.

In this paper we trace out many such examples of companies pursuing misplaced priorities and highlight the lessons learned for how to and how not to pursue waste elimination under lean management.

Keywords

Lean management; Waste elimination; Cost cutting; Operations priorities.

Extended Abstracts

Strategy, Knowledge Management and Organizational Behavior

Envisioning Responsible Integration of Generative AI in Academia and Human Resource Development

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Abstract

Recent advances in generative artificial intelligence (AI) models have demonstrated capabilities for producing remarkably human-like text, images, and speech. This has fueled enthusiasm for applying these technologies in academic contexts to enhance research, teaching, and knowledge creation potentially. However, integrating emerging generative AI requires thoughtful evaluation to ensure responsible and ethical adoption while upholding academic integrity. This extended abstract provides a balanced perspective on the promise and perils of deploying generative AI within academia and human resource development (HRD). It proposes a framework grounded in incremental integration, continuous evaluation, and human oversight for assessing appropriate applications in scholarship and learning.

Introduction

The advent of powerful generative AI models like GPT-3, DALL-E 2, and ChatGPT has shown enticing potential to augment human knowledge creation and sharing capabilities. However, open questions remain regarding risks, limitations, and responsible integration paradigms to maintain academic values. This extended abstract examines technical factors requiring assessment and proposes an evidence-based approach for selective, ethical adoption of generative AI to enrich scholarship and learning without undermining human integrity.

Background

Substantial equivalence and precautionary principles represent two perspectives on evaluating emerging technologies like generative AI. While valuable insights can be drawn from both viewpoints, a balanced approach assessing demonstrable capabilities while proactively mitigating risks through incremental integration under human guidance is advised. Responsible governance frameworks are essential.

Assessing Promise and Perils

Realizing the promise of AI assistants collaborating with scholars or rapidly analyzing datasets could accelerate research and expand access to education globally. However, the current limitations around reasoning, inconsistency, perpetuating biases, and environmental costs necessitate caution. Extensive domain-specific testing and monitoring mechanisms must demonstrate academic competence and prevent harms before consideration of integration.

A Responsible Integration Paradigm

The way forward likely involves restricted pilot deployments of generative models in targeted academic contexts with continuous human oversight. AI could synthesize datasets then validated by scholars, or function as co-authors on papers with academics directing key arguments. These assistant roles recognize AI's augmenting

potential while retaining human scholarship virtues. Formal policies and critical digital literacy development are instrumental for responsible adoption.

Conclusion

Increments of demonstrable progress addressing risks like inconsistency and environmental costs should guide integration. With ethical implementation under human guidance, AI could enrich scholarship. However, academic values must take primacy over efficiency or capability gains. Further discourse on appropriate integration balancing promise and perils is essential.

Extended Abstracts

Supply Chain Management and Logistics

DIGITAL TWINNING IN THE AGE OF ARTIFICAL INTELLIGENCE FOR SUPPLY CHAIN MGT.

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Digital Twinning (DT) is one of the newest applications of technology to the Supply Chain. It incorporates Machine Learning, Artificial Intelligence, and Simulation in a single package that describes, predicts and prescribes supply chain solutions. Traditionally these technologies have been the domain of Computer Science disciplines, but recent advances require the input of several systems including business applications. This study seeks to incorporate DT into education and training. In doing so, an advantage is gained in creating better decision-making algorithms for those organizations that incorporate DT.

METHODOLOGY

Compare a traditional simulation of a Supply Chain developed by the Goldratt Institute with a Digital Twin of the same system. After 40 hours of simulation, metrics will be collected and compared for cost, throughput time, resource utilization and lead time to meet customer demand. It is hypothesized that the DT will be superior in developing a decision-support algorithm that will increase the speed to optimize the simulation model to minimize lead time.

Simulators:

Goldratt Simulators .310, .360, and .390 using the Drum-Buffer- Rope methodology

Microsoft Azure Digital Twin cloud-based software using Artificial Intelligence

The Impact of Non-competitor on Outsourcing Decisions in the Presence of Learning-by-doing Effect

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Choosing to manufacture a product in-house or delegating to a contract manufacturer (CM), also known as make-or-buy, is often a strategic decision for an original equipment manufacturer (OEM) due to its potential impact on various aspects such as costs, manufacturing capability, core competency and profits in long-run. One of the factors that impact the OEM's outsourcing decision-making on its future profits is the CM's capability to reduce production costs over time from its experience, which is known as the effect of learning-by-doing. Learning-by-doing enables production costs to evolve over time, which has been incorporated into many studies to capture the dynamic effect of firms' outsourcing strategies. For instance, Anderson and Parker (2002) analyze the impact of learning by doing on the OEM's make-or-buy decision. They demonstrate that outsourcing decisions can lead to a path-dependent outsourcing trap, wherein a firm incurs higher long-run costs after an immediate cost benefit. Under certain conditions, partial outsourcing becomes a dominant strategy. In a similar vein, Gray et al. (2009) examine a two-period game between an OEM and a powerful CM, where both firms could reduce their production costs through learning by doing. They conclude that a simultaneous approach of partial outsourcing, wherein the OEM outsources while also producing in-house, could be an optimal strategy.

Xiao and Gaimon (2013) introduce a two-period Stackelberg game involving a supplier (CM) and a buyer (OEM). The buyer has the option to partially outsource component demand, fully outsource, or produce entirely in-house. The study explores how suppliers can influence buyers' outsourcing decisions through price and investment in integration process improvement (IPI), reducing the buyer's unit cost of integration. The research explores how the buyer's future value of the manufacturing experience impacts the supplier's pricing and investment in IPI.

Longauer et al. (2023) investigate OEM decisions on the optimal mix of outsourcing and in-house production and the impact of learning by doing in the semiconductor industry. Despite the short-term cost efficiency of outsourcing, the study revealed that choosing in-house production in the long run might be rational. The paper incorporated industrial data, such as learning rates, purchasing prices, life cycle lengths, and the

economic impact of chip shortages, into the model to assess both pre-pandemic and current industry states. Despite the advantages of in-house production, the study demonstrated that this optimal strategy might be fragile due to changes in production costs or the severity of the economic impact of chip shortages.

Deng et al. (2021) investigate two competing OEMs outsourcing to a common CM with production exhibiting the learning-by-doing effect. Excluding learning cooperation between OEMs, the learning-by-doing effect intensified price competition to the extent that OEMs' two-period overall profits could be lower than in cases of no learning. However, outsourcing to a common CM brought higher learning benefits, which dominated the negative effect of intensified competition.

Lu et al. (2023) explore the complex relationship between the OEM and a competitive CM. The CM not only supplies core components to the OEM but also generates profits by directly marketing their own-branded products, entering into direct competition with the OEM in the same market. Faced with the learning-by-doing effect, CM encounters a dilemma—choosing not to offer core components to the OEM provided a first-mover advantage in the end-product market but with a weak learning effect. Conversely, fully leveraging the learning effect through amplified production quantities resulted in fierce competition from the OEM in the end-product market. This study aims to investigate whether the CM should seize the first-mover advantage in the end-product market without supplying core components to the OEM immediately or fully exploit the learning effect through amplified production quantities while allowing the OEM to enter the end-product market early.

While the topic of outsourcing with the learning-by-doing effect has received extensive attention, the majority of the research studies the context of either one OEM (Xiao and Gaimon (2013), Gray et al. (2009), etc.) or multiple OEMs that engage in market competition (Deng et al. (2021)). If two OEMs are not competing but outsource to the same CM, intuition suggests that their decisions would be identical to those with only one OEM and a CM. However, the aim of our paper is to demonstrate that the presence of another OEM, even without direct competition, can change the outsourcing decision of an OEM.

We consider a two-period decision model in which two OEMs (A and B) outsource to the same CM. Without loss of generality, assume OEM A has a lower production cost, i.e., $c^A < c^B$. In period t, t = 1, 2, each of the OEMs faces deterministic, price-dependent, linear and independent demand. The OEMs can meet the demand volume by choosing from three strategies: producing in-house only, outsourcing only, and the partial strategy with the combination of in-house production and outsourcing. The CM's learning ability allows it to reduce the production cost in the 2nd period. Suppose the marginal production cost is c_1^S in period 1. The marginal production cost in period 2 is given by $c_2^S = \{c_1^S - \gamma q_1^S,\ \underline{c}\}$, where we assume that production costs decrease by a learning rate γ based on q_1^S, the firm's production quantity in the initial stage.

The learning effect often abates after the production process reaches a mature or steady-state stage. The learning model captures this diminishing effect by setting a cost plateau $\underline{c}$, the minimum cost that the firm enjoys after reaching a certain cumulative production volume. The CM's production volume in each period is the sum of the two OEMs' outsourcing quantities. The CM has the market power to offer a take-it-or-leave-it wholesale price to the OEMs and act as the Stackelberg game leader, but the prices need to be identical for both OEMs. In each period, the sequence of events goes as follows with each party striving to maximize their total profits in the two periods:

(1) The CM announces the wholesale price.

(2) Each of the OEMs determines the total production quantity.

(3) Each of the OEMs decides the in-house production quantity.

(4) The OEMs and the CM produce according to their decisions in (2) and (3).

We first show that, in the case of no learning effects, i.e., $\gamma = 0$, the CM will implement a static pricing strategy in both periods if he has a cost advantage against at least one of the OEMs. As a result, the OEMs adopt a static outsourcing strategy that is either to outsource exclusively or to produce everything in-house in both periods. If the CM's production cost is higher than both the OEMs' cost, it is obvious that the CM cannot offer an acceptable contract to the OEMs. Neither partial outsourcing strategy nor dynamic strategy exists in this special case.

Next, we provide a complete analysis of the case with the CM learning ($\gamma > 0$). We apply the backward approach and start with the analysis of the OEMs' decisions in the second period. The outsourcing strategy in the second period is the same as the model without learning except that it depends on the CM's initial cost in the second period, which, in turn, is determined by the decisions in the first period and the CM's learning rate. The more the CM produces, the further his cost will be driven down. As a result, the CM is induced to charge a lower wholesale price, which equals to OEM A's cost c^A instead of c^B. Therefore, in the first period, OEM B has an incentive to prompt the CM to lower his period-two cost as she gains more profits when the wholesale price drops to c^A. It is a different story for OEM A though. The lower-cost OEM enjoys the same profits independent of the CM's period-two costs. Therefore, she has no incentive to help the CM lower his costs in the second period. Despite OEM A's indifference to learning, the presence of a lower-cost OEM (OEM A) still plays an important role in determining OEM B's outsourcing strategy, as shown when we explore the outsourcing decisions in the first period.

We fully characterize the optimal wholesale price set by the CM and the OEMs' outsourcing strategies in period 1. In Table 1, we list different strategies adopted by the OEMs under various cost parameters.

Table 1: List of Possible Strategies

	OEM A Strategy		OEM B Strategy	
	Period 1	Period 2	Period 1	Period 2
S1	No outsourcing	No outsourcing	No outsourcing	No outsourcing
S2	No outsourcing	No outsourcing	Complete outsourcing	Complete outsourcing
S3	Complete outsourcing	Complete outsourcing	Complete outsourcing	Complete outsourcing
D1	No outsourcing	Complete outsourcing	Complete outsourcing	Complete outsourcing
D2	Complete outsourcing	No outsourcing	Complete outsourcing	Complete outsourcing
DP 1	No outsourcing	Complete outsourcing	Partial outsourcing	complete outsourcing

One of the interesting results emerging from our analysis is that it is possible for OEM B to outsource even if the wholesale price charged by the CM is higher than her own production cost. It is due to OEM B's incentive to outsource in the first period to lower the CM's cost so that the CM could choose a lower wholesale price in the second period. The partial outsourcing phenomenon does not exist when there is only one OEM. The presence of another OEM with a certain degree of cost advantage, even when he does not compete directly with the existing OEM, changes the outsourcing strategy of the existing OEM and makes partial outsourcing the best choice under some conditions. Our study also characterizes the sufficient conditions under which it is optimal for OEM B to choose the partial outsourcing strategy.

Our paper contributes to the literature by identifying this interesting phenomenon – when the CM has pricing power, having a non-competitor joining the game may change an OEM's outsourcing decision. The model can be extended by considering the cases where the OEMs can also learn and reduce production costs, or by adopting other formats of learning functions.

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CHALLENGES AND BARRIERS IN VACCINE SUPPLY CHAIN: A SYSTEMATIC LITERATURE REVIEW 2000 & 2021

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INTRODUCTION

As the costliest component of the national vaccination programs [1], vaccines could save up to three million people each year and reduce the mortality rate by 97.8% in certain diseases [2, 3]. Routine immunization is imperative to achieving the majority of the 17 Sustainable Development Goals (SDGs) adopted by the United Nations [4]. Statistics show that more than 700,000 children die every year in Africa due to vaccine-preventable diseases such as measles, tetanus, diphtheria, meningitis, yellow fever, pneumonia, and diarrhea [5, 6], and 19.5 million newborns annually do not receive basic vaccines [7]. Immunization is globally known as one of the most effective and cost-efficient public health interventions [8, 9]. As practice and research demonstrate, successful routine immunization programs rely heavily on properly functioning vaccine supply chain (VSC) systems [e.g.,10, 11, 12, 13, 14]. Although the interest in VSCs have risen over the last decades [13, 15, 16], the current VSCs in many countries are outdated and are unable to meet today's immunization priorities and the expectations of the Decade of Vaccines (DoV) set by WHO or individual countries [10, 11, 17, 18]. VSCs still operate based on the systems created in the 1970s [15, 19], and current VSCs cannot effectively function while new vaccines are constantly being added in the existing vaccination programs. As evidence, Chandra and Kumar [11] stated that one of the reasons for low child immunization coverage in India is poorly designed and operated VSCs and barriers limiting the VSCs. Additionally, estimations show that one-third of the world's population does not have access to essential medicines, and poorly designed VSC systems is one of the contributing factors [20]. Ineffective and outdated VSC systems cause missed opportunities to vaccinate the target population and risk the effectiveness of the vaccines when they are administered [e.g., 21, 22]. Eliminating these challenges and barriers requires a radical and structural change in the current VSCs.

VSCs are expected to provide the right vaccines, at the right time, in the right quantity, at the right place, in the right condition and quality, and at the right cost [e.g., 11, 23]. VSCs are complex, containing multiple layers, multi-faceted sub-systems, problems, and multi-dimensional management systems including decision support systems and advanced logistics systems that are designed by multiple local, national, and global stakeholders [24]. VSCs become more complex, costly, and harder to optimize, as new vaccines are added in the national vaccination programs [e.g., 25]. After the COVID-19 vaccine was developed, those with roles in the vaccine roll out processes faced a great variety of challenges, barriers, and decision-making problems. Considering these critical factors, this paper aims to answer the following research question: What are the challenges and barriers of the VSCs identified in the national purchasing systems in the literature and practice?

The contributions of this study are several. This study comprehensively analyzes the challenges and barriers experienced in the VSCs and reported in the relevant literature. To the best of our knowledge, this is the first study analyzing the challenges and barriers of VSCs using a systematic literature review (SLR) method that constructs a strong base to identify the relevant studies and practices. The results and findings of this study are expected to help future researchers, practitioners, and policy-makers identify effective ways to overcome these challenges and barriers seen in the VSCs.

PROPOSED METHOD

The research method implemented in this paper is constructed upon the Systematic Literature Review proposed by Kitchenham and Charters [26]. The SLR process contains three main stages: 1) planning, 2) conducting the review, and 3) reporting the review (Figure 1).

Figure 1 about here

Planning

The systematic review identified in this study aims to search the current literature of the VSCs and identify the challenges and barriers of the VSCs reported in the literature and experienced in practice. Kitchenham and

Charters [26, p. 9] asserted that "specifying the research questions is the most important part of any systematic review." Based on the need identified in this study, the research question was articulated as follows. RQ1: What are the challenges and barriers of the VSCs identified in the national purchasing systems in the literature and practice?

Kitchenham and Charters [26] proposed SLR to implement a well-structured review protocol and minimize the potential bias of the review process. The following sub-steps are included in this step: develop search strategy and resources, identify study selection criteria and procedure, develop study quality assessment procedure, data extraction and synthesis strategies, and review schedule. In developing search strategy and resources, primary and secondary searches using digital databases were identified. Web of Science, ABI/INFORM Complete, Business Source Premier (EBSCO), EBSCO Medline, and ScienceDirect were selected in the primary search since these digital databases cover most of the relevant papers. The secondary search was planned after the primary search was completed and consisted of the papers cited in the references of the articles identified in the primary search. The study selection criteria were developed in the inclusion/exclusion criteria (Table I) to identify the material related to the research question analyzed in the SLR. The keywords were 1) "vaccine" and 2) "supply chain." Keywords were searched only in "title" and "abstract" and constructed using Boolean ANDs. Inclusion/exclusion criteria were determined to ensure that all relevant previous studies were added to answer the research question of the SLR.

Table I about here

The study quality assessment procedure was developed to minimize researcher bias and ensure the internal/external validity in SLR. The following questions were answered in the quality assessment step.

QA1: Are the identified digital databases capable of covering potential materials published on the VSC topic?

QA2: Do the researchers thoroughly follow the inclusion/exclusion criteria for each digital database in this SLR?

QA3: Is the topic analyzed in the paper directly related to the VSC?

QA4: Does the paper cover any challenges or barriers in the VSC?

The last component of the review protocol development step details how to extract data and synthesize the findings in the SLR. The data extraction process focused on full-text paper scanning, and each article was thoroughly analyzed by the researchers. The data synthesis step was constructed on the *systems thinking* and *transformation process* that includes vaccine producers, government purchasers, central storage hubs, and vaccine centers (Figure 2). The review protocol constructed in the previous step was evaluated by the researcher with regard to availability of information and research timetable. The evaluation process showed that digital databases were available for searching the literature based on the inclusion/exclusion criteria.

Figure 2 about here

Conducting the review

In this step, the SRL was conducted, and the papers were systematically listed. The title, publication year, author/s, and page numbers of the article, volume and issue of the journal were noted in a matrix table. The primary search generated 110 papers using the review protocol as detailed in the previous steps. Secondary search also brought five additional papers in the SLR. Then, the quality assessment process was performed through asking four questions identified in the review protocol. To answer QA1 in the quality assessment, the number of articles found in each digital database was used to identify if any database revealed low/high numbers of articles, but none of the databases satisfied that condition. In QA2, the details of the searches in each digital database were double checked to ensure that the inclusion/exclusion criteria were followed in each digital database. The answers in QA3 and QA4 were identified as binary variables that resulted in two conditions: Yes and No. These questions were answered after each article was analyzed via full-text scanning. The results of the quality assessment showed that twelve papers were excluded from the primary search based on the answers given to these questions. As a result of the study selection, the SLR resulted in 98 articles in this study. The quality assessment results were noted in the matrix used in the data extraction step. In the data extraction process, papers were read and analyzed to answer the research question. A matrix table was used to extract data from the articles identified in this review.

Reporting the review stage

It is critical for researchers to report the findings of the SLR to the related audience on time effectively and efficiently [27]. As presented in Figure 1, reporting review outcomes are technically completed in three steps. This paper will present the findings of the SLR about the challenges and barriers in the VSC systems.

LITERATURE REVIEW

Because this research proposal is built upon a SLR, the findings will be presented in the final version of the paper. The challenges and barriers identified through the SLR in the relevant literature are categorized into the *systems thinking* approach and *transformation process* that includes four components: i) vaccine producers, ii) national vaccine purchasing systems, iii) central storage hubs, and iv) vaccine centers. This paper focuses on one of these components: national vaccine purchasing systems.

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Figure 1. Systematic literature review flow chart

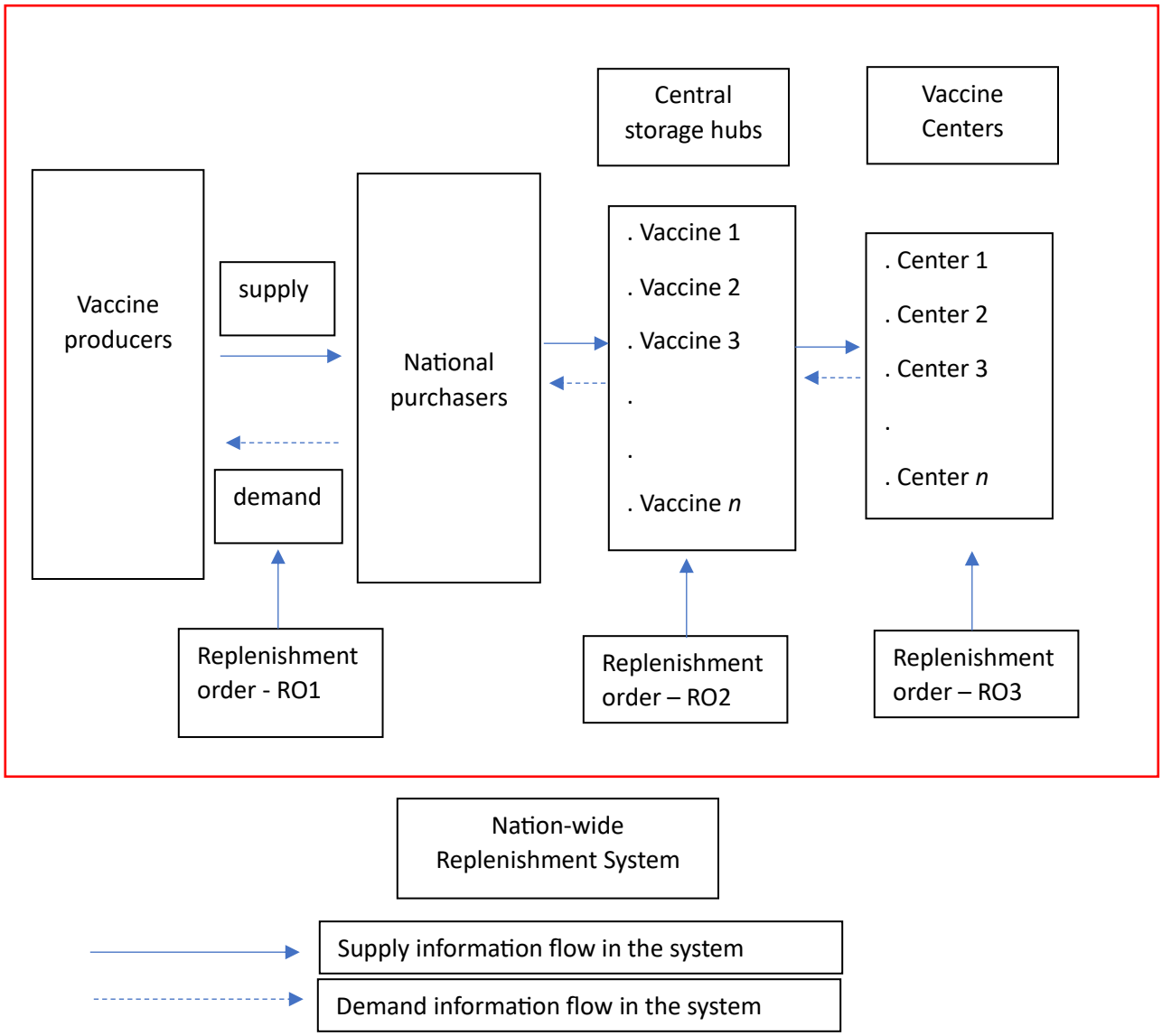

Figure 2. The flow of VSC systems

Table 1. Inclusion/exclusion criteria

Criteria	Items
Inclusion criteria	• Full-text articles published in peer-review scholarly journals, theses, book chapters, and books • Published in English between 2000 and 2021 • The publications found in selected digital databases in primary search • The articles including identified key words • The articles used in the previous literature reviews (secondary search)
Exclusion criteria	• Articles published in non-scholarly journals • Not full-text articles • Materials published in other languages • Duplicated studies • Conference proceedings

Extended Abstracts

Sustainability

Stochastic Structures of Generations of Renewable energies in U.S.

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Abstract

Renewable energy can be a solution for problems caused by fossil fuels. It is gradually more cost-efficient and less negative impact on the global environment and thus will be a sustainable supply for our energy needs. This paper identifies valid stochastic models for annual renewable energies generated by U.S. since 1965. Renewable energies this paper analyzes are ones from wind, hydro, solar and other (biomass and geothermal). This paper entertains several stochastic models from three approaches. One is the structural time series model approach populated by Harvey. This approach assumes that a time series can be modeled directly with the unobserved components such as trend, slope, seasonal, cycle and daily effect. Each unobserved component is further characterized by its own stochastic structure and a distribution of its irregular component. The structural time series models use the Kalman filter to validate an entertained stochastic model, to estimate unknown parameters of a stochastic model, to forecast future data, and to do filtering data. The structural time series models this paper entertains are local level with random walk model, fixed trend model and linear trend model. The second approach is ARIMA models populated by Box and Jenkins. For each renewable energy generation data, several ARIMA models are fitted, and valid ones are identified by diagnostic checks. The best fitted ARIMA model is selected using AICs among valid ones. Since the annual U.S. renewable energy generation data is available from 1965, data size is very limited so grey prediction model approach proposed by Deng is also entertained in this paper. The grey prediction model approach can be applied for system with incomplete information and/or uncertain mechanisms. The valid stochastic models identified by three approaches can be used to forecast future renewable energy generations in U.S. Understanding the stochastic structures and these forecasts could help for decision making process related with renewable energy policy in U.S.

Keywords: Renewable energy generation, Structural time series model, State space form, Kalman filter, ARIMA model, Grey prediction model.

The Exploration of Logistics Green Transformation and Sustainable Development of Enterprises

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The development of the global economy has been accompanied by the extensive consumption of non-renewable resources, leading to a significant generation of air emissions, wastewater, and waste. These factors directly impact the ecological environment of the entire planet. The United Nations' Sustainable Development Agenda for 2030, unanimously adopted by all member countries in 2015, along with its 17 sustainable development goals, 169 specific targets, and 231 unique indicators, have collectively influenced the direction of international and national development policies. This agenda provides a new entry point and opportunities for bridging the gap between human rights and development. This is not only the overall framework guiding international and national development actions but also the primary task for business sector development. Enterprises must adjust their operations and strategies to the requirements of sustainable development goals (Tsalis et. al., 2020). The business sector addresses the challenges of sustainable development by introducing strategies such as "clean production" and "eco-efficiency" into strategic management (WBCSD, 2000).

As an indicator for evaluating corporate sustainability, Environmental, Social, and Governance (ESG) encompasses the evaluation of companies' environmental protection efforts, social responsibilities, and corporate governance practices (Linnenluecke, 2022). Specifically, the "E" (Environment) focuses on the impact of companies' resource consumption, energy usage, and waste emissions on the environment. The "S" (Social) pertains to the coordination and balance of relationships between the company and external stakeholders. The "G" (Governance) emphasizes internal mechanisms, governance structures, employee compensation, and ethical standards within the company. ESG reports have become an important disclosure for listed or potential listing companies and a crucial material for attracting investments. As a result, considerable literature researches ESG-related issues and their connection to assets. While ESG scores can represent overall performance in environmental and social aspects, they cannot track specific potential problems within companies (Clément, Robinot & Trespeuch, 2023). ESG ratings may have biases and fail to reflect ESG issues in the supply chain or their impact on local communities (Linnenluecke, 2022). They also cannot directly address these issues. There is limited research on how companies can reduce pollution or improve the environment through corporate governance and social coordination. This refers to how companies transform, change their previous strategies, and find new paths to achieve high ESG scores, thereby realizing sustainable development genuinely.

During the development process, enterprises have inevitably caused environmental pollution, such as emitting exhaust gases, wastewater, and waste, as well as depleting valuable resources and reducing biodiversity. The Sustainable Development Goals (SDGs) and the Paris Agreement on climate change require profound transformations in every country, necessitating complementary actions from governments, civil society, the scientific community, and the business sector (Sachs et. al., 2019). Companies need to collaborate with other societal stakeholders, including governments, associations, customers, suppliers, consumers, banks, and universities, through their corporate governance and interactions to reduce environmental pollution. Some of the sustainable development goals are relevant to various supply chain stages. Suppliers need to achieve clean water and public health objectives, logistics and distribution should contribute to sustainable cities and communities, product usage should eliminate the impacts of climate change, and the final stage of product use should contribute to sustainable production and consumption (Tsalis et. al., 2020).

The study collected ESG reports, corporate social responsibility reports, or sustainable development reports from 11 Chinese listed companies for 2018-2022. Among them, there was one company primarily focused on e-commerce platforms, one clothing brand company, three companies with automobile manufacturing as their core business, three companies with smart electronic products as their core focus, two companies with logistics as their core service, and one company primarily engaged in logistics equipment manufacturing. [29]

The first part of this study primarily focuses on data analysis to identify the actions taken by businesses in various stages of the supply chain (such as research and development, production, logistics, sales, and investment) to achieve energy efficiency, emissions reduction, recycling, and conservation goals through green transformation. In summary, by improving corporate governance and fostering synergistic development with other societal stakeholders, businesses aim to reduce

[29] Our samples include: Alibaba, ANTA, BYD, SAIC MOTOR, Geely, Xiaomi, Lenovo, HIKVISION, JDL, SF Holding, CIMC.

environmental pollution and achieve sustainable growth through green transformation initiatives at different supply chain stages (Figure 1).

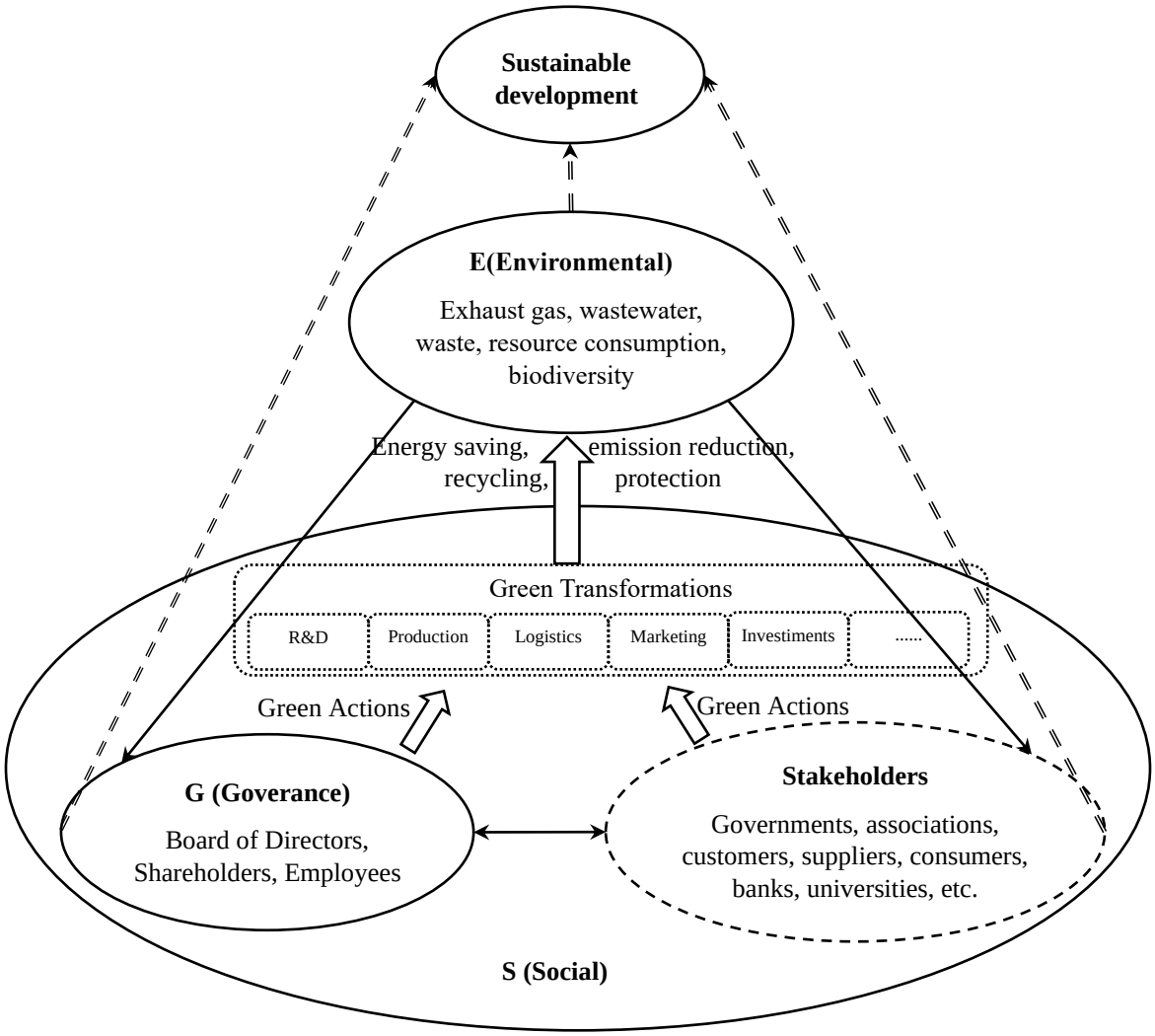

Figure 1. Enterprise ESG, green transformation and sustainable development

Among these 11 companies, apart from SF Express and JD Logistics, as well as Cainiao Network (a logistics company under Alibaba), the rest (not specialized logistics enterprises) primarily focus on actions related to product research and development, design, and manufacturing materials. These non-logistics enterprises' logistics green transformation mainly revolves around green packaging and low-carbon transportation. One primary reason is that most logistics operations are outsourced to specialized logistics companies. Hence limited information is revealed in the report. Logistics activities span the entire process of the product supply chain and serve as a vital link for the circulation of goods among different members of the supply chain. Whether a manufacturing company or a trading and distribution enterprise, they rely on logistics activities for support. However, activities such as transportation, warehousing, packaging, and distribution in logistics heavily rely on resource consumption, which can have a negative impact on the environment. Green logistics, on the other hand, contributes to achieving net-zero emissions and improving environmental sustainability (Rashidi & Cullinane, 2019; Jianguo, Cheng & Ali, 2023).

In the second part of this study, we explore the developmental paths for green transformation in enterprise logistics with ESG issues (Figure 2). The impetus for green transformation in logistics often stems from government policies that reward or penalize environmentally friendly practices, customer demands green initiatives throughout the supply chain, or businesses recognizing the competitive advantages in the green logistics market. The pressure from organizational and regulatory stakeholders influences the adoption and implementation of green logistics practices (Baah, Jin, & Tang, 2020). Factors such as the government's green governance capabilities, logistics companies' awareness of green logistics policies, and social

monitoring levels directly affect the effectiveness of green logistics policies (Zhang et al., 2020). The interaction between enterprises and their suppliers directly impacts the implementation of green supply chain management practices (Azevedo, Carvalho & Machado, 2011). Therefore, it is evident that the interaction between enterprises and other stakeholders significantly influences their green transformation in logistics.

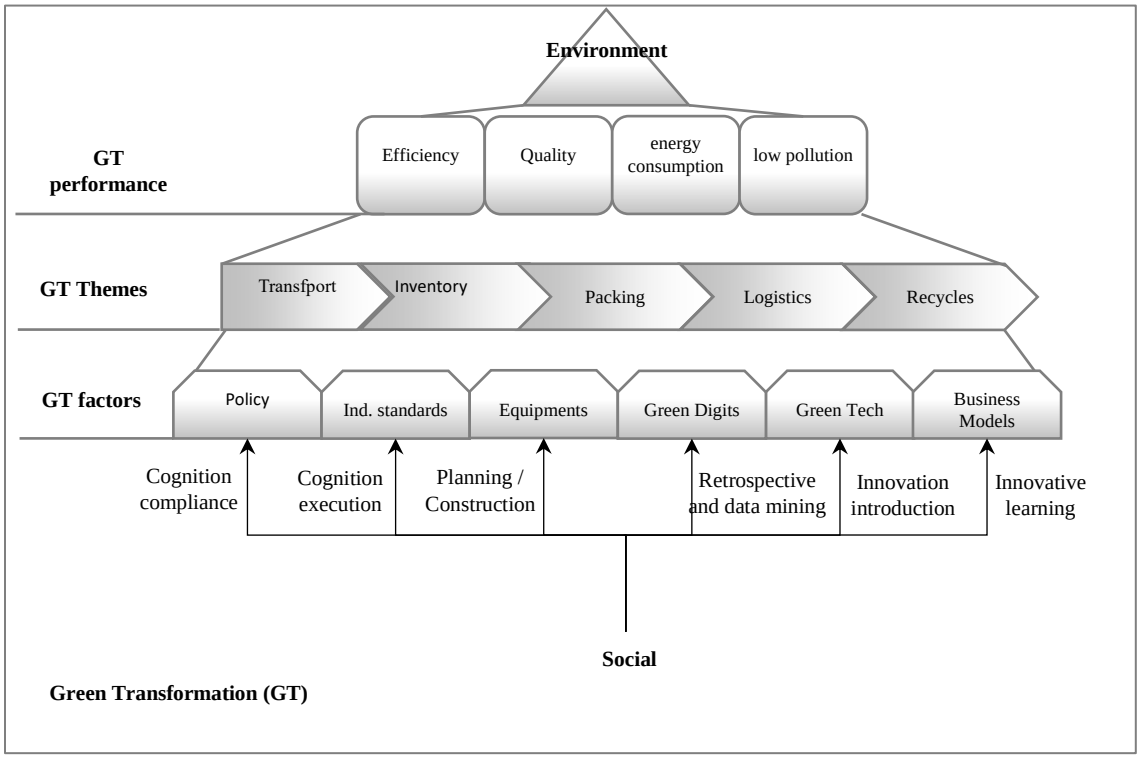

Figure 2. Green logistics and transformation of enterprise logistics with ESG

The government must establish a long-term vision for sustainable national infrastructure systems, including transportation services, guided by the Sustainable Development Goals. It should develop adaptive plans that can effectively achieve this vision (Thacker et. al., 2019). Efficient infrastructure and green logistics performance has a favorable impact on export performance and the international trade environment for services. Green logistics services are essential to business growth and competitiveness (Yingfei et. al., 2022). Information sharing, logistics networks, and transportation are the most influential factors affecting sustainable development, business, and supply chain performance. Green packaging is associated with financial and social performance. Logistics managers are increasingly aware of utilizing all available resources, expertise, and competitive advantages to achieve sustainable performance (Trivellas, Malindretos & Reklitis, 2020). Logistics businesses' category and industry experience influence green logistics initiatives and sustainability indicators. One-third of the logistics managers surveyed were unaware of the environmental impact of logistics activities, highlighting the need for collaboration between the government and experienced logistics companies to implement green logistics policies, particularly in transportation and warehousing (Ibrahim Kabiru Maji, Nur Surayya Mohd Saudi, Muhammad Yusuf, 2023). Improved packaging, rearranging loading methods, and unit loads can reduce material usage, increase warehouse and trailer space utilization, and decrease the required handling volume (Ganeshkumar, Murugaiyan & Madanmohan, 2017).

Based on the ESG evaluation system, enterprises are required to establish internal governance practices, which include effective internal communication, strategy development, and innovative learning. Furthermore, they must actively collaborate with various stakeholders by providing suggestions, guidance, participation, support, supervision, cooperation, and learning opportunities. This collaborative effort aims to lay the groundwork for the green transformation of logistics. This transformation encompasses several crucial aspects, such as policy regulations, industry standards, infrastructure development, green digitalization, adoption of green technologies, and the implementation of sustainable operational models. As a result, the green transformation extends to diverse logistics scenarios, including transportation, warehousing, packaging, distribution, and recycling. The ultimate objective is to achieve high efficiency, high quality, low energy consumption, and

minimal pollution in green logistics. By pursuing these objectives, enterprises can effectively contribute to their green transformation and sustainable development endeavors.

Based on the analysis of reports from 11 companies, this study found that enterprises, based on ESG evaluation indicators, formulate green transformation strategies in various aspects such as product research and development, production, logistics, sales, and investments through internal governance and interactions with other societal stakeholders. The ultimate goal is to achieve sustainable development for the company. The logistics that connect various members of the product supply chain are a crucial aspect of the company's green transformation. Enterprises must collaborate with other stakeholders to build the foundational elements for logistics' green transformation, implement green actions in different logistics scenarios, achieve green logistics goals, and become an essential component of the company's sustainable development.

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Extended Abstracts

Teaching and Innovative Education

NEDSI 2024 SUBMISSION

INNOVATING TEACHING WITH A.I.: A LITERATURE REVIEW AND CURRENT APPLICATIONS IN HIGHER EDUCATION

Track: Teaching and Innovative Education

Katja Schroeder, Assistant Professor, St. Francis College, and
Dr. Esther Klein, PhD, Professor, St Francis College

Extended Abstract

The recent launch of OpenAI's generative artificial intelligence (AI) tool ChatGPT (OpenAI, 2022) has accelerated the debate about how educational institutions should treat the use of generative AI tools for learning and teaching, (Hu, 2023; Dwivedi et al., 2023). Some institutions have banned ChatGPT attributing the rise of plagiarism and academic integrity violations (Stringer & Wiggers, 2023) to it. Others have embraced the potential of generative AI tools to advance digital literary skills (Ciampa et al., 2023) personalize learning (Chan & Hu, 2023), enhanced learning outcomes (Baidoo-Anu & Ansah, 2023), and ability to nurture innovation (;;; Dai et al., 2023). According to the World Economic Forum, technology literacy is among the top ten skills in 2023, with AI being a key area for future skills training (Masterson, 2023). The purpose of this paper is to review the current state of adoption of AI tools to innovate teaching and research at higher educational institutions. The paper starts with a literature review of the challenges and opportunities of using AI in teaching and research at institutions of higher education. . Specific examples of AI tool adoption in the classroom are examined as well as exploration of the adaption of the most nurturing academic integrity policies to support learning. The examples include how a small liberal arts college in the Northeast is approaching AI in the classroom. The paper concludes with recommendations for higher educational leaders to embrace the power of AI tools in teaching and research to drive innovation and digital skill set building guided by appropriate AI policies.

Keywords: higher education, generative AI, teaching models, innovation, AI policies, academic integrity policies

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Workshop

"Innovative Pedagogy:

Unleashing the Power of Artificial Intelligence in Higher Education"

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This conference workshop spotlights the transformative role of Artificial Intelligence (AI) in higher education, with a keen focus on faculty-driven advancements in teaching. Attendees will gain insights into AI applications that enhance instructional strategies, facilitate personalized learning experiences, and foster student success. Engaging discussions and practical demonstrations will empower faculty members to harness AI tools effectively, promoting effective integration into diverse curricula. Join us for an illuminating session where educators can explore the frontiers of AI-driven pedagogy, exchange best practices, and collectively shape the future of teaching in higher education.

Potential Topics of Discussion:

1. **Content Generation:** AI tools can assist in generating lesson plans by providing relevant content, learning materials, and resources aligned with specific learning objectives and curriculum standards.
2. **Automated Lesson Planning:** AI can analyze curriculum requirements and learning objectives, suggesting comprehensive lesson plans with a variety of teaching strategies, activities, and assessments.
3. **Assignment Design:** AI-powered platforms can help faculty design assignments by suggesting topics, formats, and criteria based on learning objectives, ensuring alignment with the course goals.
4. **Adaptive Learning Paths:** AI algorithms can recommend personalized learning paths for students, helping faculty create assignments that address individual learning needs and track student progress.
5. **Automated Assessment Creation:** AI tools can automate the creation of assessments, generating quizzes, tests, and exams based on the content covered in the lesson plans and learning objectives.
6. **Rubric Development:** AI can assist in creating rubrics by suggesting criteria, descriptors, and weighting based on learning objectives, ensuring consistency and objectivity in grading.
7. **Plagiarism Detection:** AI-powered plagiarism detection tools can scan student submissions for potential instances of plagiarism, supporting faculty in maintaining academic integrity.
8. **Feedback Generation:** AI can aid in generating feedback on assignments by analyzing student responses and providing constructive comments based on predefined criteria.
9. **Data Analysis for Learning Outcomes:** AI analytics can process assessment data, offering insights into student performance trends, learning outcomes, and areas for improvement, guiding instructional decisions.
10. **Time Optimization:** AI tools can help faculty optimize their time by automating routine tasks associated with lesson planning, assessment creation, and feedback provision, allowing educators to focus on more interactive and impactful aspects of teaching.

Abstracts

Abstracts

Accounting, Finance and Economics

AFE201

Building Absorptive Capacity: Economic Development and Growth in Select Oil-Producing Economies

Siamack Shojai

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Abstract

Oil-producing countries enjoyed a capital surplus in the early 1970s because of a sharp increase in the oil price. However, they faced many bottlenecks, such as inadequate port facilities to unload cargo and a shortage of skilled and unskilled labor. Countries like the United Arab Emirates (UAE) and Qatar have enjoyed billions of dollars of oil and gas revenues in the past decade and have developed their economy rapidly. The UAE's per capita GDP increased from $27,090 in 1975 to $53,758 in 2022. According to the International Labor Organization, the UAE's population is estimated to be 9.3 million in 2021, comprised of 665,145 nationals and 8.7 million expatriates, mostly temporary contract workers. The government mainly employs nationals and expatriate workers are mainly employed by the private sector, including multinational firms. Indigenous labor shortages question the sustainability of economic growth and further development of the UAE in the long run. The country has built absorptive capacity, defined as the amount of investment (gross capital formation) as a percentage of the GDP that can be employed at a reasonable expected rate of return (Adler, 1965) by employing a relatively abundant expatriate labor force.

This paper uses the incremental capital-output ratio to measure absorptive capacity in the UAE and other oil-producing countries. It compares the sustainability of the absorptive capacity of oil-producing nations with that of non-oil-producing economies. The Ordinary Least Square estimates of semi-elasticity of investments indicate that countries like EUAE and Qatar face challenges sustaining rapid economic growth and development.

AFE202

How Extreme Cryptocurrency and Oil Movements Affect Insurance Tokens: A Cross-Quantilogram Study

Ulrika Lesie Nyamsi Nkouemkeu Shriya Anand

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Abstract

This study explores the complex dynamics of decentralized finance (DeFi) by investigating the substantial effects of oil shocks and cryptocurrency markets on the price distribution of insurance tokens. Using cross quantilogram analysis we found two interesting result. First, a resilient response of insurance tokens to the studied events, showcasing their adaptability within the DeFi ecosystem. Second, the quantilogram reveals distinctive patterns in tail dependencies, shedding light on potential risk dynamics of token economics. This research contributes a comprehensive understanding of how insurance tokens respond to and are influenced by these events. The insights derived from this analysis are poised to navigate the risk dynamics of DeFi insurance tokens amidst the turbulence of cryptocurrency markets and oil shocks, offering valuable guidance for market participants, regulators, and stakeholders in the ever-evolving landscape of decentralized finance.

AFE302

A Data Envelopment Analysis Approach to Rank a Set of Mutual Funds and Mutual Fund Companies

Richard Muszynski III

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Abstract

Mutual funds have become an increasingly popular investment tool for many investors. These investors view mutual funds in high regard because of the diverse selection of stocks, bonds and other securities that reduce the overall risk of losing capital. Since there exists a plethora of mutual funds from which to choose, the investors' goal of selecting mutual funds that match with their beliefs or expectations becomes an ever-daunting task. We provide insight about which mutual funds an investor should invest in by using a nonparametric linear-programming approach called data development analysis (DEA). The goal of the present paper is to analyze and rank a set of mutual funds across several mutual fund companies by implementing the additive DEA model (Charnes *et al.,* 1985). We demonstrate why standardizing data is crucial in order to create equal weighted factors that may rank mutual funds. After ranking the set of mutual funds for each mutual fund company, we then rank mutual fund companies by taking averages, medians, and standard deviations of the efficiency scores of individual mutual funds of each company. We conduct 90 iterations for various input and output variables in order to determine the overall average, median, and standard deviation of all potential variable combinations, and we determine the companies that offer the most consistent performing mutual funds and ones that are highly regarded, i.e., the mutual funds that produce the highest average rate of return.

AFE304

Social Media and Sustainability Reporting: Observations From Kuwaiti Listed Companies

Kameleddine Benameur, Ayman Haddad, Mohamed Elian

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Abstract

This paper assesses whether social media is an effective way for organizations to engage with stakeholders and define the contents of sustainability reporting in Kuwait. The authors investigate the organizations that use social media for this purpose, and that their level of interaction. They also investigate these interactions to identify whether they are more focused on gathering divergent socio-political views or on forging a consensus on specific issues.

The authors call for further research to complement this exploratory study with statistical analyses and to examine how organizations use comments and replies from users, as well as the impacts of sustainability reporting on companies' performances.

Overall, this paper provides valuable insights into the potential of social media as a stakeholder engagement mechanism for sustainability reporting. It is expected to have a positive value-added for researchers and practitioners interested in this topic.

AFE402

Financial Contagion and Machine Learning: The Forest in the Trees

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Abstract

Employing an empirically defined dataset detecting international financial contagion, this paper utilizes machine learning via a Random Forest algorithm to provide a proof-of-concept for predicting the spread of contagion. Focusing on capital flows, direction of trade, regional, and other idiosyncratic features, this paper finds that a forecast accuracy of over 70% is possible. Ultimately, the largest barrier to improving the forecast accuracy is a matter of reliable, consistent international data.

AFE403

The Network Effect on Tokenization of REITs: Investors Centrality, Liquidity, and Performance.

Ajim Uddin, Yao Sun

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Abstract

As a novel and noteworthy fundraising model, crowdfunding in recent years has continued to spread and flourish all over the world, and has led to evolutionary development in FinTech and real estate areas. Despite its expanding scope and profound influence, however, research examining the dynamics of tokenization and crowdfunding in real estate investment trusts (REITs) remains scarce. To fill this gap, this study utilizes network analysis techniques to understand the roles played by investors network on the success and liquidity of REITs. This study also provide a roadmap and best practices for token economics and real estate startups in terms of designing and launching new REITs tokens.

AFE504

The Effects of Sports Betting on Casino Gambling and Lottery

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[1]University of Alabama in Huntsville, Huntsville, USA. [2]University of Nevada, Reno, USA

Abstract

In May 2018, the Supreme Court overturned the Professional and Amateur Sports Protection Act, allowing every US state to legalize sports betting. As of December 2023, 38 states have legalized sports betting. We provide panel regression evidence of the effects of sports betting on casino gambling and lottery revenues. To model the variables of panel regression we utilize change point analysis. Our findings show that, on average, onsite sports betting is associated with an increase in casino revenues; however, online sports betting is associated with a decrease in casino revenues. Online sports betting revenues are positively associated with lottery revenues. Alternative specifications include analyzing slot handle and instrumental variable estimation.

AFE602

AS 3101's Impact on Financial Reporting on Goodwill Impairment

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Abstract

The objective of this study is to determine whether AS 3101 has any material impact on financial reporting on goodwill impairment. This is a pilot study to explore the proper procedure to identify effective methods to measure such impact by examining the Critical Audit Matters (CAMs) reported by the Dow 30 companies for the fiscal years of 2019 and 2018. We are using the DOW company annual reports because only the large accelerated filers were required to report CAMs for the fiscal year ended June 30, 2019.

On June 1, 2017, the Public Company Accounting Oversight Board (PCAOB) promulgated the new auditing standard AS 3101: The Auditor's Report on an Audit of Financial Statements When the Auditor Expresses an Unqualified Opinion. This new standard requires auditors to include CAMs in an unqualified opinion. As of November 30, 2019, the PCAOB observed that 189 annual reports contained an average of 1.7 CAMs. Specifically, 88 CAMs were on goodwill and other intangible assets, 64 on revenue recognition, 43 on taxes, and 40 on business combinations. Thus, it appears that one of the most reported CAMs was on goodwill and other intangible assets. However, our focus of this research is solely to examine the effect this new standard has on the reporting of goodwill impairment.

We will compare the amounts of the goodwill impairment reported for fiscal years before and after the effective date of AS 3101. In addition, we will make a ratio comparison of goodwill impairment over total assets.

Abstracts

Big Data and Business Analytics

DATA101

Predicting Software Developer Salaries in the United States Using Unconventional Variables

Akshaj Kabthiyal, Julia Costa Severo, Joao De Alvarenga Ferreira

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Abstract

With the job outlook in the Software Development industry expected to grow 26% from 2022 to 2031, understanding the factors influencing their salary is critical for talent acquisitions and individual career development. Leveraging the 2023 Stack Overflow Developer Survey dataset, this research employs rigorous data analysis, including outlier handling, feature engineering, and machine learning modeling.

Through the incorporation of unconventional variables like LanguageHaveWorkedWith, DatabaseHaveWorkedWith, and PlatformHaveWorkedWith, our study highlights the necessity of incorporating our insights into existing models. This unique approach not only enhances existing models but also underscores the critical influence of these lesser-explored variables on salary estimations.

Our results shed light on the importance of these unconventional variables, providing an improved understanding of the industry's salary drivers. While presenting promising outcomes, the study acknowledges limitations within the dataset, inviting future development to refine and extend these models for more accurate predictions.

This research holds substantial implications for talent acquisition strategies, industry trends, and individual career growth within the software development field, pointing towards avenues for further exploration and improvement in salary prediction models.

DATA104

What's Happening at Prospect Press

Beth Golub

Prospect Press, Burlington, VT, USA

Abstract

Learn about current and upcoming Business Analytics (BA) texts from Prospect Press. Of particularly note, Prospect Press will be releasing "Introduction to Sports Analytics Using R" in 2024. Other key BA-related titles include "Python for Data & Analysis," "Big Data Technologies for Business," and "Database Systems: Introduction to Databases and Data Warehouses."

Prospect Press is a special-purpose publisher created to serve the Information Systems (IS) curriculum. In recent years, Prospect Press has been increasing its BA offerings as the overlap between the IS and BA programs has been increasing. Also, consider stopping by our exhibit at NEDSI and/or visit our website https://www.prospectpressvt.com/.

DATA105

How Advanced Information Technologies Are Transforming Agriculture

Eric Stein

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Abstract

This work explores the impact digital technologies are having on farming by revolutionizing agricultural practices and fostering more sustainable and efficient food production systems. We explore the application of Industry 4.0 technologies such as IoT, data analytics (AI and MI), and distributed sensor networks to enhance crop yields, improve quality and optimize resource use. We focus this research on what is commonly referred to as indoor farming, which includes modern greenhouses and vertical farms. We begin with a review of the concept of digital transformation and the emergence of Industry 4.0 architectures and technologies. We then look at the unique characteristics of indoor farms, and why they are considered modern "plant factories." Next we look at the primary control systems that govern the production of indoor crops such as lettuce and how digital twins can be created to enable the implementation of Industry 4.0 methods. Frameworks are provided to show the alignment between digital technologies, the business model, and the value chain of an indoor farm. We illustrate the application of these ideas via a case study of a greenhouse farm that uses robots, AI and MI to grow strawberries. We close with reflections on the challenges and opportunities offered by applying advanced IT systems to agriculture.

DATA201

The History and Future Horizons of Reject Inference

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Abstract

Credit scoring is a decision support system that utilizes analytical techniques to make decisions regarding whether credit applicants will be granted financial loans. An applicant's credit score is the result of an analytical model. The data used in the credit scoring model must include accepted applicants and rejected applicants information so the model is not biased. The problem is the outcome loan status (good or bad) of the rejected applicants is not known. Reject inference is the process of inferring the outcome loan status (good or bad) for applicants that were rejected for a financial loan. The accepted applicants, along with their good/bad loan outcome status, and the rejected applicants with their inferred good/bad loan outcome status are combined. The combined data is used to build a credit scoring model that is representative of all credit applicants.

Over the last several years there have been advancements using machine learning and artificial intelligence techniques to approach the reject inference problem. This presentation will first provide an overview of the historical statistical techniques used to perform reject inference. Then, the modern-day approaches will be discussed. Lastly, a new approach using semi-supervised learning methods will be presented

DATA202

Analysis of Hong Kong Exchange Rate Dynamics Since COVID Pandemic: a Comprehensive Study

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[1]Beijing Institute of Technology, Zhuhai, China. [2]Universidade de São José, Macau, China. [3]Stockton University, Galloway, USA

Abstract

Our comprehensive study explores the complex exchange rate dynamics in Hong Kong, concentrating on the HKD/USD and HKD/CNY currency pairs amidst the global economic challenges post-2019. In an era marked by the COVID-19 pandemic and escalating US-China

trade tensions, this research merges empirical data with fundamental theories of international finance and advanced statistical methods to dissect the factors affecting Hong Kong's

exchange rates. Central to our analysis is the region's unique Linked Exchange Rate System (LERS)[1]. We employ crucial theoretical frameworks like interest rate parity, Purchasing

Power Parity (PPP), and the Law of One Price, alongside statistical models such as ARIMA for forecasting. This comprehensive method offers a detailed perspective on how local and international economic forces interact, influencing Hong Kong's currency value during these uncertain times.

Keywords: Hong Kong, Linked Exchange Rate System, Interest rate parity, Purchasing Power Parity, Law of One Price, ARIMA, forecasting.

DATA203

Impact of Major Financial Factors on Bitcoin Prices at Times of Uncertainty

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Abstract

Abstract: The decentralized nature of cryptocurrencies makes them appealing choices for investors around the world in times of uncertainty. COVID-19 and recent global conflicts have been instrumental in causing some uncertainty in financial markets around the world. In this study, we examine the recent changes in the price of Bitcoin and explore the relationship between various financial factors and the price of Bitcoin. Previous studies were inconclusive in establishing the linear relationship between Bitcoin and different market indexes such as the S&P 500, Dow Jones Industrial Average, Nasdaq 100, Russell 2000, and Nikkei 225, and the price of commodities such as Gold and Oil before, during, and after the COVID-19 pandemic. To address the issue of uncertainty due to the volatility of stock markets and its effect on the Bitcoin price, we examine the relationship between the popular measure of the stock market's expectation of volatility based on the S&P 500 index (VIX) and Bitcoin. Various non-linear analytical methods are used to examine the effect of the above indexes, commodities, and measures of financial uncertainty on Bitcoin prices. Different periods such as weekly and monthly data from Oct 2010 to December 2023 are used in this study.

Key Words: Cryptocurrency, Market Volatility, Commodities, and Financial Indexes.

DATA204

Modeling Stock Returns With Laplace Family Distributions- a Concise Decision

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Abstract

Investment in stocks and shares aims to seek potential gains while weighing the risk of future needs, such as retirement and children's education. Analyzing the behavior of stock market returns and making predictions is crucial for investors to mitigate investment risk. Traditionally, normal variance models have been used to describe stock market returns. However, these returns exhibit characteristics such as skewness, higher kurtosis, heavier tails, and a higher center than the normal distribution. The Variance-Gamma distribution is the most sought-after distributions for modeling asset returns and has been extensively discussed in the financial literature. In this paper, we explore the other Laplace family, such as Asymmetric Laplace, Skewed Laplace and Kumaraswamy Laplace including Variance-Gamma to examine their fit with the weekly returns of the S&P 500 Index and it's eleven business sector indices. We use Nelder-Mead optimization method for direct maximization of the log-likelihood function to estimate the parameters. We rank the performance of the distributions across all stock indices and the empirical study concludes that the Kumaraswamy Laplace distribution outperforms other distributions, including the Variance-Gamma distribution, when it comes to modeling stock returns. As a result, Kumaraswamy Laplace can be considered a strong alternative for practitioners seeking to accurately predict returns and mitigate investment risk.

Abstracts

Cyber Security, IT, IS, and Emerging Technologies

CYIT104

The Impact of AI on Healthcare: Security and Privacy Concerns

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Abstract

The integration of AI in healthcare is fundamentally reshaping the industry, particularly in the efficient management of electronic health records. This involves the extraction and analysis of patient health data, enabling timely interventions, especially in emergency situations using remote monitoring. The utilization of AI technology brings significant benefits to both healthcare providers and patients. Patient treatments can be enhanced through continuous monitoring and analysis using remote sensors, while providers can save substantial time and cost by eliminating redundant management expenses and processes. However, the deployment of AI in healthcare introduces inherent security and privacy challenges. The evolution of AI-driven devices has seen significant growth over the last two decades, generating a wealth of information, including health records, pictures, voices, financial transactions, locations, and conversations. As most wearable sensors are connected to the internet, these devices remain vulnerable to information security risks. Simultaneously, the vast amount of collected data raises valid concerns about privacy. This research aims to systematically review the current landscape of security and privacy concerns arising from the utilization of AI in healthcare.

CYIT201

Exploring Emerging Technologies for Occupational Health and Safety Practices Improvement

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Abstract

This research addresses the imperative responsibility of organizations for the occupational health and safety (OHS) of workers, focusing on the deficiencies present in their OHS management systems. Currently, these systems face issues such as incomplete information, manual forms, lack of communication and data visibility, and unclear roles and responsibilities. Automation of this system significantly helps with overcoming such deficiencies. Emerging technologies, such as Blockchain, Internet-of-Things and Augmented Reality, are notable tools for providing this automation by diminishing the absence of immutability and traceability throughout the processes. They not only reduce the errors but offer the trust and privacy requirements for the processes.

This study explores the potential of the key technologies for revolutionizing OHS practices by shedding light on their capabilities to drive positive change in the dominion of workplace health and safety. The ISO 45001 standard is explored explicitly as a well-established and widely embraced international guideline to signify the areas of technological implication in OHS management systems. To this end, a systematic literature review is conducted to provide a rigorous and evidence-based synthesis of the previous research on the application and benefits of emerging technologies for implementing OHS management systems in the context of ISO 45001 elements.

The study results compile a framework that empowers organizations to identify areas of technological adaptation for health and safety enhancements. The proposed framework also offers organizations a guide for streamlining their regulatory compliance processes while fostering a culture of safety to protect their workforce physical and mental well-being.

CYIT203

Navigating Privacy Concerns in the Age of Connected Cars

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Abstract

In recent years, the advent of smart devices has sparked intriguing debates around privacy norms. The auto industry is revolutionizing customer experience through autonomous features like built-in navigation, mobile device synchronization, and contact storage. However, this transformation raises concerns among regulatory bodies regarding customer data safety. This study delves into the need for privacy regulations in the use of such devices regarding the existing regulations like Health Insurance Portability and Accountability Act (HIPAA) in the context of health data protection and data protection laws like GDPR. We will investigate the varying levels of privacy protection in the automobile industry. One major challenge lies in communicating complex privacy policies to users. Addressing the difficulty users face in comprehending privacy policies for vehicles that collect biometric data and location information is paramount. Auto dealers need to recognize the importance of security issues related to the data collected by vehicles. We also examine the often-overlooked aspect of post-purchase data management. How should users handle their data when selling a car, and what measures can be implemented to wipe sensitive information? What types of data are collected in the unfortunate event of a car crash, and what are the implications for privacy? Understanding the relevant privacy policy becomes crucial, and this study aims to outline actionable steps for users and industry players and to contribute to the development of a robust framework that ensures user privacy in an increasingly interconnected world.

CYIT301

Understanding Cryptocurrency Investment: Insights from American Investors

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Abstract

The cryptocurrency market has experienced a significant influx of individual investors in recent years. This surge in interest necessitates a comprehensive examination of the characteristics, behaviors, and biases exhibited by these investors, given their profound implications for both policymakers and financial institutions.

This research focuses on American investors and leverages empirical data to illuminate the determinants of cryptocurrency investment choices. Our findings establish a compelling link between overconfidence and participation in cryptocurrency investments. Specifically, our study identifies that overconfident investors exhibit a higher propensity to engage in cryptocurrency investments compared to their underconfident counterparts.

Gaining an understanding of the cryptocurrency investor profile, their behavioral inclinations, and the influential role of overconfidence in shaping investment decisions can serve as a guiding resource for policymakers and financial institutions seeking to regulate and engage with this emerging asset class. This research delivers an indispensable perspective for stakeholders aiming to navigate the evolving cryptocurrency landscape with precision.

CYIT302

Perspectives on the Evolution of a Transformative and Empowering Metaverse

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Abstract

When it comes to a Metaverse, there is a vision being pursued by engineers, scientists, and technologists of widely available access to lifelong educational opportunities, of improved and more cost-effective health care, of access to new forms of entertainment and social interactions, and of increasing productivity, efficiency, and competitiveness.

The vision is of an immersive three-dimensional remote communications experience with spatial audio and even tactile feedback, enabled by edge and cloud-computing, virtual and augmented reality, block chain immutability, security, and 5G+ wireless communication technologies that have emerged over the last several years. In essence the Metaverse presents a new transformative capability that can enable new dimensions of creativity, innovations, and fruitful interactions that can gracefully unfold without geographical or physical limitations.

The presentation will develop the notion of how the Metaverse spans the physical and virtual worlds, and inherently provides and interoperable fabric that enables a users' avatars to wander freely throughout different domains. The presentation will show that the metaverse is a logical extension of the evolving IoT with some additive key technologies. The presentation will discuss how many of the underlying technologies used in the IoT are harmonized and integrated with emerging technologies to realize a dramatically new outcome that we are calling a Metaverse.

The presentation will conclude with some focus on the technical challenges in wireless communications and edge computing, which are the enabling big bangs needed for a graceful and rapid unfolding of a high performance metaverse! It is coming sooner than we think!

CYIT401

Aquaculture/Seafood Use Case Development for Edge With Cybersecurity and Federated Learning

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Abstract

Food insecurity is a huge problem worldwide. Both in the USA and Africa, the fisheries supply chain may be at risk. The SEEDS Institute and the Green Reef Foundation are committed to addressing such challenges by seeing that critical knowledge management is not lost in this process. Federated learning can be used to collect and share best practices, which may help fishery communities develop a more resilient knowledge base of field operations.

Specifically, the quality control of aquaculture and fisheries design for knowledge management is a critical community, workforce skill where efficient processes are critical to knowledge transfer for future generations. The challenge of fisheries and fish farms is to address the food supply chain challenges without losing critical best practices that emerge from implementations.

Thus, this work discusses some technology enabling approaches that promote data sovereignty with federated learning outcomes in a secured cybersecurity manner near the source of data or (Edge). Such an international effort of open source technology may bridge efforts of closing the digital divide between industrialized and developing countries. Federated learning is a means of logging best practices and sharing with fisheries knowledge communities. At a high level, we will imply how tools of edge computing may be helpful. There will be some discussion of how Skupper.io facilitates this, and related aquaculture/seafood uses cases of fish waste management and water desalination as loosely coupled considerations to investigate for federated learning outcomes.

CYIT404

Minority Entrepreneurship and Culture: A Text Mining Analysis

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Abstract

There is a growing interest in the study of minority entrepreneurs due to the critical role these entrepreneurs play in developing small businesses and driving economic growth. Past studies of entrepreneurs and their characteristics concentrated on individuals from the same cultural background (Cohen et al. 2019). There was little emphasis on entrepreneurs who were minorities and shared different values and ideas from those who belonged to the mainstream culture. Minority sub-cultures strongly influence entrepreneurs' intentions, values, business conduct, and decision-making. In this paper, we propose a text-mining framework to identify the characteristics of minority entrepreneurs from unstructured text and multimedia content. In this study, we analyze the characteristics of minority entrepreneurs from the African American, Hispanic, and Asian communities using text mining analysis.

Our study consists of three major phases. First, we collect the success stories, business case study materials about these entrepreneurs, media comments, and speeches given by these entrepreneurs. In the second step, we will use relation extraction and sentiment analysis to extract the keywords and phrases representative of entrepreneur characteristics. In the third step, we cluster the extracted keywords to existing entrepreneur characteristics factors and construct new factors based on the extraction results according to the keyword's co-occurrences and semantic similarity between keywords. Our study contributes to the knowledge of data analytics in entrepreneurship studies by showing how text-mining techniques can be used to study minority entrepreneurs from unstructured data.

Abstracts

Decision Support Systems (DSS), Machine Learning, and Artificial Intelligence

DSS101

Sentiment Analysis of Artificial Intelligence Applied in the Hospitality

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Abstract

Companies in the hospitality industry are adopting artificial intelligence (AI) for many advantages in efficiency, technology, and customer experience sector. The implementation of AI in the hospitality sector is a move in this direction. Potential obstacles in the smooth adoption of AI technology in the hospitality industry must be carefully studied. The present study identifies the critical success factors (CSF) of AI technology in hospitality implementation based on sentiment analysis. Initially, 20 CSFs are identified through expert opinion and extensive literature review. Finally, prioritization based on their criticality is technical advancement in the field of AI as hospitality industry lags behind adoption of AI technology. The study concludes that *technology and business & marketing* are the most critical barriers to implementing AI in the hospitality sector. While e*fficiency and customer experience aspects* are the other identified critical barriers. The managerial implications of the findings that could help practitioners and industry experts in the effective implementation of AI technology in the supply chain sector are also discussed.

DSS103

Incentives for AI-Enabled Knowledge Sharing and Learning

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Abstract

Artificial Intelligence (AI) has become pervasive, revolutionizing various organizational functions and significantly enhancing operational efficiency. This transformative role positions AI as a critical tool, particularly in knowledge sharing and learning domains. Its contributions to knowledge management (KM) processes, through automating procedures, providing cognitive insights, and fostering cognitive engagement, underscore its significance. However, a research gap persists in understanding the nuanced impact of incentives on AI-powered knowledge sharing and learning activities.

We address this research gap by examining the role and design of incentives in the context of AI-powered knowledge activities. Two primary research questions guide the investigation: (1) what types of incentives and designs effectively motivate knowledge workers in knowledge sharing and learning? and (2) for which types of AI systems are incentives most impactful? To answer these questions, we develop an analytical model focusing on knowledge sharing and learning, exploring incentive designs that facilitate meaningful interactions between knowledge workers and AI systems.

Through analytical derivations and numerical experiments, we study the role and impact of incentives and their designs in motivating workers to contribute to the AI system and derive knowledge from it. The findings are expected to highlight the effectiveness of incentives that reward workers for providing inputs to the AI system and actively engaging in the learning process. These incentives significantly contribute to enhancing the AI system's quality and utility in generating valuable outputs. Beyond practical implications for practitioners aiming to optimize their AI implementations, this research lays the groundwork for future exploration in this dynamic domain.

DSS105

Curing Generative AI Hallucinations with Data Provenance

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Abstract

Public awareness of large language models (LLM) increased in December 2022 with OpenAI's ChatGPT. Shortly thereafter, LLMs began fabricating content to support seemingly reasonable statements. Dubbed "hallucinations," these problems can pollute legal briefs with non-existent case law, support medical studies with non-existent science, or sway the public with news of fictional events. Retrieval augmented generation and other techniques designed to counterbalance the phenomenon are insufficient. Efforts are underway to stop inventing history by retaining more training details, but the challenge of accuracy remains. Documentation of the origin of data from its inception, including the source of changes along the way, is necessary to trust LLM outputs, especially in certain disciplines. Preservation of cultural heritage, which exists in the intersection between memory (meaningful individual and collective reminiscences over time) and history (reconstruction of events, ideas, and people based on primary and secondary sources), requires careful consideration of data provenance. By offering easy access to contextually relevant information, LLMs have the potential to create highly personalized learning experiences to meet a traveler in their present point of view and transport them to the past with an immersive experience connecting multiple points of view across time. Using an LLM in conjunction with imagery, computer vision tools, and multiple points of view, we are developing a tourism capability connecting historical data to places of cultural significance on Ireland's Dingle Peninsula. By focusing on data provenance to maintain the integrity and richness of cultural heritage, our insights have broader implications for data provenance in LLMs.

DSS202

Using Fuzzy AHP for Investigating Barriers to the Development of Smart Mobility in Montreal

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Abstract

Mobility is a vital issue for residents and local governments, and it has an impact on sustainability, economy, and lifestyle. Smart mobility focuses on real-time data accessibility. Public Accessibility of real-time data helps smart mobility players to provide efficient, safe, sustainable, and high-quality transportation services. This research aims to investigate and prioritize smart mobility barriers in the city of Montrèal to help decision-makers, policy planners, and smart mobility players to establish effective approaches for safer, smarter, and modern transportation systems in Montrèal. In this research, firstly, 39 smart mobility barriers are identified using an integrative literature review. Secondly, the list of barriers modified by experts from the public, private, and multinational sectors to be compatible with mobility system and infrastructure in Montrèal. Lastly, the Fuzzy Analytical Hierarchy Process (AHP) method is used to prioritize identified barriers. Results show that financial barriers have a major impact on smart mobility development in Montrèal followed by “legal & regulatory”, “technical & technological”, “administrative”, “information & awareness”, “others”, “social”, “policy”, “environmental”.

Keywords: Smart Mobility, Fuzzy AHP, Smart Mobility Barriers, Prioritization, Montrèal.

DSS204

Estimating Optimal Tour Length in Irregular Geometric Areas With Fewer Nodes

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Abstract

Estimating the optimal length of a tour becomes crucial in situations where precise route details are not required, but the overall distance or cost of the tour is essential. This concept finds practical application in various fields such as public transportation systems, traveling repairperson services, home health care routing, Amazon Flex delivery operations, and courier services. Such approximations are particularly advantageous when rapid decisions are needed from decision-makers concerning the cost or length of the optimal tour. For example, consider a situation where a disaster relief manager must determine whether a single-vehicle tour is sufficient to efficiently cover all necessary locations. In most real-world cases, the number of stops on the tour is relatively small, often fewer than 100. Furthermore, the geographical areas covered frequently exhibit irregular, non-standard shapes. Therefore, it becomes crucial to derive a reliable approximation for estimating the optimal tour length when dealing with fewer than 1000 nodes distributed non-randomly within an irregularly shaped area. This research employs machine learning methods to predict the optimal length of the Traveling Salesman Problem (TSP) tour in scenarios involving a limited number of nodes.

DSS301

Assessing Waste Management Performance in Korea: Neural Network and Gray Incidence Theory

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Abstract

This study delves into the waste management performance in South Korea by employing a combination of neural network and gray incidence theory analyses. Leveraging secondary data from the Waste Management Statistical Center of South Korea spanning the years 2012 to 2021, the study focuses on eight cities, evaluating nine key waste performance criteria. The primary objectives are to identify the top-performing cities, ascertain the critical performance criteria, and suggest areas for improvement.

Through the application of advanced analytical techniques, the research aims to unravel nuanced patterns within the dataset, revealing insights into the dynamic landscape of waste management across the selected cities. The neural network analysis offers a robust method for uncovering complex relationships among variables, while gray incidence theory provides a framework for measuring the degree of similarity between different sets of data.

The findings of this study contribute to a better understanding of the waste management landscape in Korea, offering policymakers and stakeholders valuable insights into which cities excel in waste management practices. Furthermore, the identification of key performance criteria sheds light on aspects that demand immediate attention and improvement. The study concludes with practical suggestions for enhancing waste management strategies in the underperforming cities, aiming to facilitate a more sustainable and efficient waste management system throughout the region.

DSS302

Integrating Bert and Deep Reinforcement Learning for Dynamic Product Attribute Recommendation

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Abstract

Personalized product attribute recommendations are pivotal in enhancing user experience and increasing sales. This study introduces an innovative approach by hybridizing Bidirectional Encoder Representations from Transformers (BERT) with Deep Reinforcement Learning (DRL) to create a dynamic session-based personalized product attribute recommendation system. Our model capitalizes on BERT's state-of-the-art natural language processing capabilities to deeply understand and extract meaningful features from product descriptions and user queries. These features, encapsulating the nuances of user preferences and product attributes, form the backbone of our recommendation strategy. The core of our system lies in the application of DRL, which accurately and dynamically navigates the complex decision-making process of real-time product recommendation. By defining each user session as a unique sequence of states, our DRL model learns to recommend product attributes that are not only contextually relevant but also adapt to the evolving interests of users within a session. This session-based focus, enhanced by the temporal understanding of user behavior, allows for responsive, agile, personalized recommendations. Significantly, this research bridges the gap between recommendation systems based on attention mechanisms and reinforcement learning, offering a dynamic solution that harnesses the strengths of both techniques.

Abstracts

Education, Curriculum, and Cases

EDU101

Incorporating the Voice of Customer (VOC) Into the Design of a Business Analytics Course

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Abstract

Designing for quality involves integrating customer satisfaction into products and services to gain a competitive advantage. Quality Function Deployment (QFD) offers a method to incorporate the voice of the customer into the design of a product or service. This study aims to illustrate how integrating the voice of the customer into the design of 'Data Analysis for Business,' a core business course, at a medium-sized private comprehensive college, has improved students' perceptions of learning effectiveness, job readiness, and discipline relevance.

The approach considers the needs of various customers, guiding the selection of focus areas and course materials based on these needs. As all departments in the business school are considered customers, this approach fosters teamwork and cross-functional communication. In essence, voices of student and faculty across all disciplines are included in the design process.

EDU201

Revisiting “How Business Schools Lost Their Way”

Neil Desnoyers

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Abstract

The 2005 article by Bennis and O’Toole (HBR, 2005) titled “How Business Schools Lost Their Way” argued that business schools had become “[t]oo focused on ‘scientific’ research”. In the 19 years since the article was published, has the business school ship continued on the route of scientific research? Or has it plotted a new course? From 1970-71 through 2020-21, the number of business degrees awarded annually grew at more than twice the annual rate of the total number of higher education degrees awarded. (Natl Ctr for Educational Statistics, 2022) As a country, are we getting our money’s worth? Fuchs and Kirchain (DOI: 10.1287/mnsc.1100.1227) laid out a case that the combination of manufacturing offshore and technology selection have an impact on how much – if any – research is completed in the U.S. Will this eventually impact the management positions for which business schools prepare graduates?

EDU202

Integrating Skills for Undergrad Business Students in the Digital Age: a Multidisciplinary Review

Haleh Karimi, Amy Fairfield, Frank Raymond, Alisha Harper

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Abstract

This manuscript delves into a multidisciplinary literature review, examining the interplay between technical and soft skills for undergraduate business students across the core business disciplines of finance, accounting, economics, technology, and management. By synthesizing existing research, this paper provides an in-depth analysis of the skill sets that today's students are developing and the evolving demands they will encounter in their future professional endeavors. As the digital era transforms industries, this review extends its focus to the development of digital skills. The discussion encompasses digital literacy, proficiency in emerging technologies, and adaptability to digital platforms, emphasizing their significance in preparing students for the modern workplace. The paper introduces a forward-thinking perspective by exploring the potential impact of generative artificial intelligence (AI) on the skill sets of undergraduate business students. It delves into how generative AI is expected to influence routine tasks, decision-making processes, and innovative practices, shaping the skill requirements of tomorrow's professionals. A focal point is the application of connectivism, a contemporary learning theory utilized in online education, with a proactive discussion on reshaping business education for the digital era.

EDU203

A Study on First-year Retention: Evidence from One of the Most Diverse Higher Education Institutions

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Abstract

First-year retention is one of the pivotal indicators of student success in higher education. Existing research shows that it is a very challenging effort to retain first-year students in institutions with a high minority student population. In this study, we use the data collected from one of the most diverse four-year regional universities in the United States to explore the impacts of the first-year students' demographic status, academic performance, and financial condition on the first-retention outcome. Specifically, we employ a regression analysis to identify and estimate the impacts of the above-mentioned factors on first-year retention, and then conduct a comparative analysis on the performance of the alternative machine learning models in forecasting first-year retention. These machine learning models are Artificial Neural Network, Decision Tree, Random Forecast, Support Vector Machine, and Naive Bayes. We find that on a campus with a minority-dominating student population, minority students' first-year retention turns out to be higher than that of white students; students' academic performance in the spring semester of their first-year college has more significant impact on their returning decision after their first-year study; in-state students have higher retention than their out-of-state counterparts; students living on campus are more likely to return after their first-year study. We adopt a Bayesian-based evaluating method to evaluate and compare the forecasting performance of the above-mentioned machine learning models. Our results show significant differences in these algorithms' forecasting performance.

EDU301

Building an Introductory Analysis Course in the Management Curriculum

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Abstract

This study details the development of an introductory analytics course, Foundations of Analytics (FOA), for undergraduate business students majoring in Management in a four-year public university in the USA. It discusses the challenges and issues that stem from the nature of the management program.

FOA is a required core course for management majors at the university. The primary course learning expectations include comprehending and applying basic analytics concepts and techniques to solve simple business problems, using standard computer software to perform fundamental data analysis, and interpreting analytical results for business decision-making.

FOA introduces business analytics from three perspectives: descriptive, predictive, and prescriptive. It utilizes a variety of pedagogy, e.g., extensive hands-on lab exercises (Excel, Tableau, SPSS), emphasizing the interpretation of computer reports, minimizing the use of math or statistical formulas, etc. The course provides students with the opportunities to connect and apply their existing knowledge to new materials and contexts and helps them develop a deeper understanding and engage in higher-level thinking tasks.

The biggest challenge for teaching this course relates to students' educational backgrounds, perceptions, attitudes, and learning expectations toward business analytics. Most management students have an aversion to statistics and lack sufficient quantitative skills.

EDU303

Methods for Synchronous Teaching and Interaction in Online Courses

Bhupinder Sran, Moustafa Ahmed, John Weber

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Abstract

As the number of students taking online courses has grown, universities are trying to implement practices to increase the success of these students. Online courses involve mostly asynchronous interaction between faculty and students. The result can be a lower level of student engagement, which in turn can affect student performance. To increase student engagement in online courses, many faculty have focused on using synchronous methods to add another dimension to their teaching and interaction with students. These methods have ranged from one-on-one meetings to live office hours to live lessons.

In this presentation, we will discuss several methods that faculty have used to implement synchronous communication and teaching in online courses at a small university in the Northeast. We will describe the methods, discuss the advantages and disadvantages of each along with a presentation of best practices.

EDU401

Incorporating Ethics and Professionalism in an Entry-Level PR Course Through Real-Client Engagement

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Abstract

The realm of Public Relations (PR) is often perceived through the lens of media strategies and campaign effectiveness, with ethics and professionalism serving as the less visible backbone of practice. Recognizing the gap between theoretical knowledge and practical application, this project encapsulates the experiential learning journey undertaken in an entry-level PR course designed to integrate ethical practice and professional development. The purpose of the project was to move beyond traditional pedagogies, employing a hands-on approach where students engaged with real clients, confronting authentic ethical dilemmas and professionalism in practice. This reflective analysis shares the author's experiences in orchestrating this pedagogical shift, emphasizing the challenges and breakthroughs encountered in guiding students through the nuanced landscape of ethical PR practice. The course structure, centered around a client-based project, demanded that students navigate the dual responsibilities of adhering to ethical standards while satisfying client expectations. This approach aimed to instill a strong ethical foundation and a sense of professionalism that transcends classroom walls, preparing students for the multifaceted PR industry. Preliminary findings suggest an enriched understanding among students of the ethical considerations inherent to PR work and a heightened sense of professional identity. The culmination of this initiative presents a replicable model for PR educators seeking to embed ethical consciousness and professionalism within the curriculum, thereby shaping future practitioners equipped to uphold the integrity of the PR profession.

Abstracts

Healthcare Analytics

HEL102

The Predictive Factors of Hospital Bankruptcy: A Longitudinal Analysis

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Abstract

In recent years, the operational viability of numerous hospitals across the United States has faced challenges due to the intricate landscape of regulatory, reimbursement, and workforce issues. This has resulted in a significant upswing in healthcare-related bankruptcies, as emphasized by the Polsinelli Financial Distress Index, revealing a 305% increase since 2010. Despite earlier attempts by researchers to propose explanatory methods for predicting bankruptcy, such as Altman's discriminant multivariate analysis and Ohlson's "O-Score" nine-factor linear factor model, these models have not undergone extensive testing. Addressing this gap, this study develops an explanatory and predictive logistic model for hospital bankruptcy, utilizing only 7 financial and hospital-level variables and drawing on data from 3,196 hospitals spanning the period from 2008 to 2021. The outcomes showcase superior performance on 5 out of 7 commonly used metrics in the confusion matrix, as well as presenting practitioners with a robust tool for both assessing and predicting financial distress in the healthcare sector.

HEL302

Polypharmacy Risk in Working-Age Women: Role of Multimorbidity Patterns & Care Coordination Factors

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Abstract

We present research that examine effects of two care coordination components- physician-specialty mix, and continuity of care index (CCI) on polypharmacy burden (simultaneous use of 4-plus medications in recent 3-months) in working-age adult women (18–64 years) having different multiple chronic conditions (MCC) patterns. We analyzed panel 64,295 adults women (Texas residents) with MCC for their polypharmacy regimen during Jan2012-Dec2013 by estimating mixed-effects multilevel logistic models controlling for individual's health and utilization factors, and community-level social determinants separately for four MCC patterns groups (metabolic, cardiovascular, musculoskeletal, renal-autoimmune patterns were derived using exploratory factor analysis on six-years 2008-2013 claims history of a baseline cohort of 250,058 women). We found that women visiting general practitioners (GPs) exclusively, compared to women often visiting GPs, had polypharmacy risk about 13% lower within metabolic group and about 31% lower within cardiovascular group. Women often visiting specialists had 6% and 9% higher polypharmacy risk within metabolic and musculoskeletal groups respectively. Women exclusively visiting specialists had 20% higher polypharmacy risk within musculoskeletal group but 38% lower within renal-autoimmune group. Polypharmacy risk increased by 9–22% for every 10 percent-point increase in CCI across all MCC groups. Finally, concurrence of additional MCC patterns increased polypharmacy risk by a factor of 1.19–2.24 for metabolic group, by 1.07–2.44 for cardiovascular group, 1.11–2.76 for musculoskeletal group, and by 1.78–2.90 for renal-autoimmune group. This study strengthens the need for general practitioners to serve as focal care-coordinators and development of guidelines to manage polypharmacy in working-age women MCC patterns.

HEL303

Exploring the Relationship Between CMS STAR Ratings and Patient Satisfaction in Hospitals

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Abstract

The Centers for Medicare and Medicaid Services (CMS) utilize a five-star quality rating system, known as the Star Rating Program, to assess the experiences of Medicare beneficiaries with their health plans and healthcare systems. Within this program, a hospital's overall rating includes an evaluation of its patient satisfaction survey scores. This research investigates the connection between the CMS star rating and patient satisfaction scores, pinpointing the survey questions that provide the most significant insights into a hospital's overall quality. This valuable information aids healthcare facility management and guides CMS in improving their annual survey questionnaire to generate meaningful outcomes.

HEL304

Readmission and Length of Stay of COPD Patients: A Longitudinal Analysis Using HCUP – NRD Data Sets

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Abstract

Chronic diseases account for a significant cost and burden for the US healthcare system. As a chronic condition, chronic obstructive pulmonary disease (COPD) is one of the leading causes of mortality worldwide. Although some studies analyzed the association between LOS and unplanned readmission for COPD patients within limited datasets, only a few studies employed longitudinal and nationwide data sets. In this context, the primary objective of this study is to examine the impact of LOS on the 30-day readmission of COPD patients at the national level using the Healthcare Cost and Utilization Project (HCUP) database between 2010-2020 in a longitudinal approach. Obtaining a further understanding of the relationships between LOS and readmission rates of COPD patients may provide insightful knowledge for policy and decision-makers.

Abstracts

Legal, Ethical, and Social Issues

LEG101

Policies for Funding of Service Providers in Subsidy Welfare Programs

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Abstract

The U.S. federal and state governments run various voucher-based subsidy programs to make essential services available to low-income families. In this paper, we delve into the operational dynamics of such programs, the effectiveness of which depends on the interplay between the government service agencies and the private service providers. Providers are motivated to participate in these programs through financial incentives allocated by service agencies, in exchange for reserving capacity to beneficiaries. With this approach, service agencies aim to maximize the positive societal impact of voucher programs by ensuring the accessibility of services for beneficiaries. In our study, we characterize optimal fund allocation policies for service agencies to providers such that total social impact of the subsidy welfare programs is maximized. Our analysis incorporates factors such as demand uncertainty, total provider capacity, price of service, cost of serving beneficiaries, and the limited budget of the service agency. We show that, under certain operational settings, providers do not require incentives to participate in subsidy programs. We identify the conditions where funding becomes necessary to incentivize provider participation and specify the optimal investment levels required for each provider type. Notably, our results show that larger amounts of funding do not necessarily result in increased provider participation. Our research contributes to the understanding of subsidy program operations, offering valuable insights for policymakers and service providers. Proposing a novel approach to voucher-based subsidy program operations, our aim is to make essential services more accessible for low-income families and individuals.

LEG102

The Impact of Government Policies on Aviation and Air Connectivity in Africa

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Abstract

Improving air connectivity is not smooth, especially in the intra-Africa market due to the slow transition to liberalizing the air transport market. This paper examines the critical role government policies play in shaping the aviation sector in Africa and their subsequent impact on air connectivity. In this study, we provide different demand scenarios for air transportation in 10-year period, and accordingly predict the new market structure formed by both state-owned and foreign carriers.

LEG103

Rethinking the Role of Organizational Justice in Influencing Perceived Performance:

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Abstract

That employees reciprocate conditions of perceived fairness experienced in the workplace with favorable attitudes and behavior is well established in organizational justice research. However, the research appears limited in its ability to address when and how these effects occur. The current research sheds light into how employees' perceptions of organizational justice may influence critical organizational outcomes. Specifically, we argue that organizational identification, the perceived belongingness with an organization, will mediate the impact of all three facets of organizational justice (i.e., distributive, procedural, and interactional) on perceived firm performance Furthermore, we examine whether the impact of the justice dimensions on organizational identification varies at different levels of the service climate, defined as the shared sense of policies, practices, and procedure that are experienced while performing the job. For our theoretical foundation, we integrate research on social identity theory and social exchange theory. Our conceptual model is empirically tested by a survey based on a sample of 246 employees working in various industries. Analyses indicate a partial mediation effect of organizational identification and that the service climate positively moderates the effect of procedural justice on organizational identification. Contrary to the stated prediction, the interaction of interactive justice and service climate is negative. Findings also reveal asymmetric effects of the three justice dimensions on organizational identification. This research advances knowledge at the intersection of organizational justice and organizational identification literature and encourages that there could be subtle differences the way different justice dimensions play out.

Abstracts

Marketing and Consumer Behavior

MKT201

Using Multidimensional Scaling Toward a Prevalence-Severity Theory of Human Trafficking

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Abstract

Human trafficking research has underutilized the UN's concept of "Severity" (i.e., victim suffering). The reason may be "Exploitation Creep" (Chuang, 2010), wherein all human trafficking is regarded as "slavery." However, some researchers (e.g., Weitzer, 2014) regard severity as a matter of degree. For instance, Murray et. al's (2015) "Victim Intervention Marketing" offers five levels. Severity only describes part of the trafficking phenomenon. "Prevalence" (number of victims) is equally important.

To explore the relationship between prevalence and severity, we used MDS and correlations from a convenience sample of 59,000 human trafficking victims from 28 countries (for n > 100 cases). The data source was the Counter Trafficking Data Collaborative, a UN affiliate.

Results: The downward sloping MDS trendline and correlations indicated that countries with higher prevalence scores had more "Willing Assimilator" employees ($r = .45$, $p < .05$), fewer "slaves" ($r = -.42$, $p < .05$), fewer "Trapped and Robbed" (e.g., abductees), and less favorable prevention (i.e., "awareness") scores ($r = -.37$, $p = .054$). This suggests that a social marketing effort to reduce human trafficking prevalence can have two effects. First, it can reduce the number of workers who accept woeful terms (i.e., Willing Assimilators). However, the downside is it may increase the number of slaves ($r = -.77$, $p < .01$, for Willing Assimilators and "Trapped and Robbed"). Perhaps traffickers sometimes replace Willing Assimilators with abductees—slaves, when prevalence declines. Finally, no nations scored high in both prevalence and severity. These findings hold implications for theory development in social marketing against human trafficking.

MKT203

Consumer Privacy Expectations and the Impact on Buying Intentions

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Abstract

Abstract

Purpose – Based on past research and attitudinal theories, this study intends to investigate the effect of attitudes about data privacy protection and disclosure and the perception of corporate data privacy performance on future purchase intention. Additionally, it seeks to understand the relationship between purchase behavior intensity, personal data privacy concerns and purchase intent.

Design/methodology/approach – A total of 271 usable surveys were gathered from United States consumers and analyzed by two multiple linear regression models and correlation analysis.

Findings – The results show that attitude (data privacy protection and disclosure responsibility) and perceptions about corporate data privacy performance predict purchase intention. Furthermore, past purchase behavior intensity and personal data privacy concerns influence purchase intent.

Originality/value – This study extends the current data privacy literature by understanding how data privacy expectations (attitude) and data privacy performance perceptions impact purchase intent and are influenced by personal data privacy concerns and purchase behavior.

MKT302

Toyota Model for Global SMEs

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[1]Charisma University, Bilings, MT, USA. [2]Beijing Institute of Technology, Zhuhai, China. [3]Universidade de São José, Macau, China. [4]Stockton University, Galloway, NJ, USA

Abstract

To be amended. Submit as is to make the deadline of 12/29.

MKT304

Inventory Disclosure and Donor Behavior

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Abstract

We conducted a behavioral experiment to investigate the impact of inventory disclosures on donor willingness to donate. We invited participants to make in-kind donation decisions for a charity's wish list under various scenarios for two similar items (one more expensive than the other). Depending on the treatment, the inventory level (high or low) for each needed item would be disclosed to potential donors, or not. We find that the right inventory disclosure can significantly affect donor decisions. We also find that, when acting as managers of the charity's wish list, the majority of participants wanted to disclose inventory information regardless of inventory level.

Abstracts

Operations Management/Operations Research

OMOR101

Optimizing Marketing Resource Investment Strategies Under Distributional Uncertainty

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Abstract

We model marketing effort allocation strategies for a risk-averse firm that is about to release a new product to a population of mutually independent, geographically dispersed customers. Each strategy is a collection of costly resource investment decisions (e.g., one-on-one engagement time, customized promotion discounts) aimed at increasing customers' conditional demand (i.e., demand under a positive purchase decision). Unfortunately, resource investment would yield conditional demand that grows at a decreasing rate (law of diminishing returns). To complicate matters, the firm only has a rough prior estimate of each customer's purchase probability. In view of the worst-case set of purchase probabilities within a described ambiguity set, the firm's goal is to determine the minimum cost investment strategy that will probabilistically guarantee them a certain aggregate demand threshold. We model the problem as a distributionally robust chance-constrained integer nonlinear problem, and propose an exact decomposition algorithm based on sequential mixed integer linear programming. Numerical experiments yield several practical insights as well as illustrate the tradeoff between the size of the ambiguity set and the optimal promotion investment cost.

OMOR102

Quantification of International Trade Network Performance Under Disruptions in Disasters

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Abstract

Both sudden-onset and slow-onset disasters are causing disruptions to global trade, impacting the availability and affordability of commodities from agricultural to mineral ones. In this paper, we develop a multicommodity international trade network equilibrium model under disaster scenarios with distinct probabilities of the occurrence of the disasters and their impacts on the capacities associated with production, transportation, and consumption. The disaster scenarios can also affect the exchange rates. We state the governing equilibrium conditions and derive the variational inequality formulation in commodity path flow variables and Lagrange multipliers associated with the capacity constraints. For each disaster scenario, we construct an international trade network performance measure, followed by a unified performance measure that includes all the disasters and their probabilities. Robustness is then quantified as the difference between the network performance under no disruptions and the unified performance measure. An international trade network component performance indicator is also given to assess the impacts of the complete removal of trade network supply markets, demand markets, and/or transportation routes. The modeling framework is then illustrated through a series of numerical examples motivated by Russia's war on Ukraine. The work is of relevance to decision-makers and policy-makers.

OMOR104

Data Analysis of a Quality Management Research Survey

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Abstract

An empirical study has been conducted to enhance our understanding of the relationship between Quality Management System (QMS) certification efforts and operational and business performances. Although many scales used in this study underwent empirical tests for reliability and validity, it was necessary to assess their performance under the actual condition of the study. Confirmatory factor analysis has been employed since it involves inferential statistics that allow for hypothesis testing regarding the unidimensionality of a set of measures. Multiple group analyses have been carried out by segregating the data based on by firm type, such as U.S.-owned and foreign-owned firms, and firm size in terms of the number of employees. These comparisons have revealed intriguing and meaningful insights.

OMOR105

Bad Store or Bad Inventory? Decoding Multi-Location Retail Performance

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Abstract

In the retail apparel industry, managing variety effectively is crucial to a company's success. Fashion retailers with many brick-and-mortar store locations face two challenges simultaneously: they must select an appealing range of products to make or buy from garment manufacturers, and they must allocate available units of inventory across store outlets to match supply with uncertain demand in multiple markets. Yet once these decisions have been made, a further challenge remains: fairly evaluating the outcomes that are observed in different stores that received inventory allocations of varying consumer appeal. We propose a simultaneous equations model that allows for the estimation of store effects and product effects on item-level profitability. The results of this model can inform store- and chain-level assortment planning; inventory allocation; and store closing decisions.

OMOR202

A Study on Aggregate Service Levels Approximations for a Multi-Item Lot Sizing Problem

Satyaveer Singh Chauhan, Tanvir Sidhu

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Abstract

In this work, we integrate various performance measures associated with the inventory in multi-item lot-sizing problems with stochastic demand. We introduce mathematical models for the lot-sizing problem, incorporating various aggregate service levels, and propose a time-based decomposition technique based on a linear approximation scheme. Extensive computational experiments explore the performance of the approach, strategy, solution quality, and challenges.

OMOR204

Periodic Vehicle Routing Problem with Time Separation Constraints

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Abstract

We study a periodic vehicle routing problem, in which a vehicle must visit links of a network periodically. There are specific requirements on the visit frequency and the time separation between two consecutive visits to the same link. Such time separation constraints specify that the vehicle can revisit the same link neither in a too short period to avoid resource waste nor in a too long period to ensure service quality. The problem is motivated by the practical infrastructure inspection decisions where expensive inspection vehicles need to be utilized to maximum efficiency meanwhile all inspection tasks must be performed periodically to prevent disruptions to regular operations. We model this problem as an optimization problem that minimizes the cycle time of visiting all links while satisfying all frequency and time separation constraints. We develop effective solution strategies to solve the problem and demonstrate its effectiveness based on real-world data.

Abstracts

Public Administration and Policy

PUB101

Administrative Decision Variation in the State Health Insurance Assistance Program

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Abstract

The State Health Insurance Assistance Program (SHIP) is a federally funded but state administered program which provides free counseling services regarding Medicare enrollment. Because each state has the ability to administer the program to their liking, variations are vast. The Administration for Community Living (ACL), which oversees the federal funding and administration of these programs, released performance data on the efficacy of state programs' ability to reach the general Medicare eligible population and what they deemed as 'hard to reach populations' such as those who are low-income, rural, or have language barriers. Using these data and interviews collected with paid coordinators and volunteer counselors in SHIP programs across the country, this study aims to understand the differences between high performing and low performing states, and whether these differences can be attributed to administrative decisions within each state's program. Given the rapid growth of Medicare Advantage and the risks of deceptive marketing from brokers and third-party organizations, a free non-biased resource such as SHIP may be essential to providing effective health insurance coverage decision-making for seniors going forward. With this information, ACL may be able to provide lower-performing states with best practices for reaching vulnerable populations, based on lessons learned from high-performing states. Through this ACL may attempt to influence lower performing states into decision making that maximizes the impact of their SHIP programs.

PUB103

Evaluation of AI Policies in Higher Education

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Abstract

The combination of artificial intelligence (AI) in higher education necessitates a detailed evaluation of institutional policies to ensure the balanced integration of technological innovation and ethical governance. This presentation provides a comprehensive framework for assessing AI policies in higher education, encompassing various dimensions crucial for ethical and responsible AI implementation. The evaluation criteria include the identification of ethical considerations, classroom implementation, and educational impact. The multifaceted nature of this evaluation framework provides a nuanced understanding of the complexities associated with AI integration in academic settings. This abstract serves as a scholarly resource for those shaping AI's ethical landscape in higher education.

PUB104

Downsizing Community Colleges: A Data Envelopment Analysis Model

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Abstract

In response to declining enrollments, a State in the United States merged its 12 community colleges into one State Community College (SCC) with 12 campuses. Efficiency improvement is crucial for SCC to address the concern of further potential consolidation. Although there are many factors and variables that can impact efficiencies, high online course offerings and new technology lab investments can potentially influence efficiency significantly. This research investigates the impact of online course offerings and new technology labs on higher education efficiency and profitability. Data was collected from the State government and were separated by campuses who offered high online course offerings and those who did not. Similarly, the same was performed for campuses that invested in new technology labs and those that did not. Data Envelopment Analysis (DEA) models were employed to develop four types of bilateral DEA models. These models utilized a ranking variable to assess performance within two groups: campuses with high online course offerings versus those with low online course offerings, and campuses with technology lab investments versus those without. Results indicate that hypotheses predicting a positive impact of online offerings and technology investments on efficiency were not statistically supported. However, the DEA model identified two benchmark campuses that were considered efficient, while other 10 were identified inefficient. Lessons and managerial implications are discussed for future research directions, such as using different set of inputs and outputs, expanding research to other states and regions, various types of higher education institutions, and other statistical models.

Abstracts

Strategy, Knowledge Management and Organizational Behavior

SKO201

Navigating Cost Estimation Complexities in the Us Commercial Construction Industry

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Abstract

In the dynamic landscape of the US commercial construction industry, where precision in cost estimates is paramount, the selection of an appropriate cost escalation factor gains critical significance, particularly amidst the challenges posed by rising inflation. This study underscores the pivotal collaboration between academia and industry to unravel the complexities of cost estimation in the face of macroeconomic uncertainties. Our objective is to streamline conventional academic research for practical comprehension.

Through an analysis of current economic conditions and the behavior of the construction cost index, our proposal advocates focusing on holistic cost outputs that encompass the fluctuations in contractor markups. Drawing on nearly four decades of Turner Building Cost Index data, we establish a baseline forecast, projecting from 2024 to 2030 under three scenarios: best, average, and worst-case. The primary goal is to empower professionals within the construction sector, equipping them to make well-informed decisions in navigating challenges presented by economic uncertainties and their subsequent impact on cost estimation processes.

This contribution extends beyond academic discourse, metamorphosing into a pragmatic guide tailored for industry practitioners, instilling resilience and adaptability to navigate evolving economic landscapes. The deliberate simplification of language and the integration of insights from industry professionals ensure the practical applicability of our findings. The paper urges cost estimators and construction stakeholders to foster fundamental economic literacy, apply outlined forecasting methodologies for an informed approach, and actively engage in collaboration with academia. Our findings provide practitioners with a direct, data-driven process for forecasting cost escalation in future commercial construction projects.

SKO202

Struggle or Ease in Remote Work? Examining the Influence of Remote Work on Employee Well-being

Jie Li, Tamara Montag-Smit, Nabi Ebrahimi, Asil Oztekin

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Abstract

The COVID-19 pandemic has drastically impacted employee motivation and well-being, particularly with the shift to remote work. This study examines the role of remote work in shaping employee well-being and motivation, with a focus on its moderating effects on the relationship between job demands/resources and employee outcomes. Using partial least square-structural equation modeling (PLS-SEM) and universal structural modeling (USM), data collected during the pandemic is analyzed. The findings reveal that remote work presents new challenges, affecting motivation and well-being. Blurring boundaries between work and personal life negatively impacts well-being and organizational outcomes. The study explores the varying effects of remote work across job types and provides insights into organizational policies and practices to support employee well-being and performance in remote work settings. The research contributes to the understanding of remote work, Job Demands-Resources (JD-R) Theory, and employee well-being, informing strategies for work-life balance, job demands management, and motivation in remote work environments.

SKO203

The Influence of Commuting Satisfaction and Teleworking Policies on Job Satisfaction and Commitment

William Hampton-sosa, Holly Chiu

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Abstract

The 2020 COVID-19 pandemic led to the widespread adoption of teleworking, prompting extensive exploration into its advantages, consequences, and challenges. This paper delves into the ongoing debate surrounding teleworking's impact on organizational culture, with organizational leaders expressing concerns about its negative effects, while employees favor flexible teleworking policies, which lead to increased job satisfaction and organizational commitment. These factors are important precursors to enhanced job productivity and creativity.

We conducted a nationwide survey involving 230 full-time adult employees from various industries experienced in teleworking. We analyzed a model using Partial Least Squares Structural Equation Modeling (PLS-SEM), which yielded robust results. Our findings revealed a positive association between teleworking intention and both organizational commitment and job satisfaction. Importantly, job satisfaction was moderated by the flexibility of the organization's teleworking policy.

Furthermore, our research uncovered positive associations between teleworking intention and teleworking appeal, teleworking subjective norms, and teleworking perceived behavioral control. We also observed a negative correlation between commuting satisfaction and teleworking appeal. An important negative determinant of commuting satisfaction was found to be commuting distance, which is especially notable as rising living costs in major job centers drive individuals to reside farther from their workplaces.

This study contributes valuable insights into the complex dynamics of teleworking and its implications for organizational behavior, shedding light on the factors that shape job satisfaction, organizational commitment, and the appeal of teleworking in the evolving landscape of work arrangements.

Abstracts

Supply Chain Management and Logistics

SCM102

On the Integrated Production and Distribution Problem With Time Windows

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Abstract

We study a partial LP relaxation based heuristic that schedules the operations of a fleet of heterogeneous vessels in an integrated production and distribution process where the products are released for distribution at different time points. Empirical results and special case analysis on the performance of the proposed heuristic are reported.

SCM104

A Hierarchical Optimization Model for WEEE Circular Plant Operation: Evidence From Copier Recovery

Zhiqin NI

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Abstract

Despite notable progress on e-waste recycling in recent years, China is facing a certified disassembler dilemma resulting from the consistent shrinking of the formal recycling rate, low capacity utilization, a simple shredding economy of disassemblers, and consumers' limited accessibility, which poses challenges to the existing intermediation mode (Mode-P) of e-waste collection. We propose a disintermediation mode (Mode-C) with a robust bi-objective mixed-integer linear programming (BMILP) model to select residential transshipment centres (RTCs) for maximising the collection rate and the total profit under uncertainties. Based on model analysis, efficient heuristic algorithms are proposed to search for the robust efficient (RE) solutions. A case in the Chinese Yangzi River Delta is investigated to validate the effectiveness of the robust BMILP model. A high-level decision on the upper boundary of each RTC's coverage is also discussed. Our results show that compared with Mode-P, the RE solutions under Mode-C demonstrate significant improvement in terms of collection rate and capacity utilization rate, etc. However, profit in Mode-C may be higher or lower than in Mode-P depending on different considerations. This study offers a reliable and effective model for RTC location decisions under uncertainties and facilitates the transformation from the intermediation mode to the disintermediation mode.

SCM201

Analyzing the Factors for Implementation of Air-Taxi Services

Bhawesh Sah

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Abstract

Passenger transport companies are embracing innovative methods to improve their responsiveness and efficiency. One such move in this direction is the implementation of air-taxi services. Many companies worldwide are currently developing and testing air-taxi services for practical applications. However, various barriers may significantly affect the adoption of air-taxi services in the transport sector. The present study identifies and prioritizes the barriers of air-taxi implementation based on their criticality by using sentiment analysis and machine learning techniques using Twitter data. These findings demonstrate the potential of mining social media for understanding the public discourse about innovative methods such as air-taxis. The study concludes that customer perception and the environment are the most critical barriers in implementing air taxi services. The research implications of these findings can help practitioners and policymakers effectively implement air-taxis in the public transportation sector.

SCM202

Food Price and Transportation Impacted by Diesel Price and Truck-Driver Availability

Jasmine Chang, Jim Shi, FUQIN ZHOU

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Abstract

Food price has been witnessed to be increasing considerably in the wave of inflation. As two main driving factors in the context of food transportation, the rising diesel prices and the prevailing shortage of truck drivers have posed threating challenges, leading to a substantial surge in transportation costs, subsequently contributing to higher food market prices. Based on collected data consolidated from multiple sources, this study conducts a comprehensive regression analysis to elucidate the impact of diesel price and driver availability on food price. To this end, we have curated a panel dataset encompassing key variables such as diesel prices, truck driver availability, and food prices for the most popular food commodities pre-, amid and post-pandemic of the COVID-19. Employing fixed effects regression, this paper specifically investigates the extent to which the surge in fuel prices and truck-driver availability has contributed to the overall increase in food prices in the U.S. fresh food market. The experiment results show that the rising diesel prices and more shortage of truckers' availability have a significant positive impact on food prices margin. The contributions of this study are multifold. First, our study enriches the food price literature by specifically considering the fundamental root factors, truck-driver availability and diesel price. Secondly, this study provides data-driven empirical evidence confirming the positive association between food prices and diesel prices and driver availability. Thirdly, in the presence of pandemic, the food price sensitivity to diesel price and driver availability obtained from this study renders useful guidelines for policy implications.

SCM203

Effects on All the Three Levels of Supply Chain Due to Disruptions Caused by Public Policy Changes

Kaverinathan Dhanapal, Shravya Dharba

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Abstract

Recent research underlines the crucial role of public policy changes like tariff changes causing supply chain disruptions. Despite a wealth of literature on supply chain disruption, resilience, and recovery mechanics, to the best of our knowledge, there is no state-of-the-art analysis on the effects of supply chain disruptions due to public policy changes on the three levels of the supply chain. The paper explores the relationship between public policy modifications and supply chain management, specifically in Latin American countries. Supply chain management literature and insights from industry reports exploring the research topic of 'nearshoring' support the relevance of this topic. Further, this article's theoretical foundations are the mercantilism theory, supply chain risk factors, and supply chain risk management literature. The primary research question examined by this article is, 'Do protectionism-based public policy changes in tariffs that originate elsewhere in the globe ultimately affect different levels of the supply chain in Latin America?'. Our conceptual model postulates the relationship between macro risk factors due to public policy changes and the three levels of the supply chain. Systematic Literature review is the methodology used to identify support from existing research publications relevant to Latin American Countries. In addition, current events are also cited, along with evidence from existing research literature, to support our conceptual model proposed in this article.

SCM204

A Reinforcement Learning Approach to Reduce Operational Costs in a Supply Chain

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Abstract

We use reinforcement learning (RL) to minimize operational costs in a centralized supply chain. In our model the supplier's yield is random (due to possible production problems) with non-zero lead-times for production and transportation to its retailers. A retailer can also receive emergency shipments from another supplier at a higher cost in case their primary supplier cannot fulfill the entire demand. Proximal Policy Optimization (PPO) algorithm of the OpenAI's stable_baselines3 library was used to determine the optimal production and distribution policy for the supplier.

SCM301

Artificial Intelligence and Machine Learning Impact on Global Supply Chains

Pedro Reyes[1], John Visich[2], Patrick Jaska[3]

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Abstract

Throughout history, technology has been an influential driver for changes in the global supply chain management environment. Global supply chain management environments have always been information-intense for collecting and processing data for the end purpose of disseminating information that ultimately determines its capabilities, productivity, delivery performance, and overall competitive performance. The evolving relationship with information has been characterized by innovations that have transformed how information is transmitted, stored, and ultimately used. The impact of changing relationship to knowledge and skill development, and supplanting of expertise, particularly concerning information that is heavily processed with minimal input by humans, such as artificial intelligence and machine learning (AI/ML) processing information and turning it into knowledge, and in some context decisions. This study explores the changing landscape of AI/ML in the global supply chain workforce, and how future studies should consider the "what" and the "how" we teach global supply chain knowledge and skill development to the workforce.

SCM302

Supply Chain Integration Through Supplier Satisfaction: Canada, Mexico, and the United States

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Abstract

In the supply chain the supplier is expected to meet the performance requirements of the customer through customer service (internal facing) and customer satisfaction (external facing). Through customer service activities the supplier creates customer satisfaction. In this research we flip this model around by investigating the performance requirements the customer should meet to satisfy 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 we used a survey to collect data from Canada, Mexico, and the United States. We present preliminary findings that compare the importance of the categories and the items within each category for each country and identify similarities and differences between each country.

SCM303

Blockchain in the Supply Chain

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Abstract

Companies in the supply chain industry are adopting blockchain technology for many advantages in privacy & security, efficiency & transparency, technology and leadership factors. The implementation of blockchain technology in the logistics sector is a move in this direction. Potential obstacles in the smooth adoption of blockchain technology in the supply chain must be carefully studied. The present study identifies and the critical success factors (CSF) of blockchain technology in logistics implementation based on sentiment analysis. Initially, 20 CSFs are identified through expert opinion and extensive literature review. Finally, prioritisation based on their criticality is a subsidy supported by the government. The study concludes that *Leadership & Technology factores* are the most critical barriers to implementing blockchain in the supply chain sector. While, e*fficiency and Security & Privacy aspects* are the other identified critical barriers. The managerial implications of the findings that could help practitioners and policymakers in the effective implementation of blockchain technology in the supply chain sector are also discussed.

SCM304

Towards Achieving Circularity in Solar PV Supply Chain: A Real Application

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Abstract

Globally, the solar photovoltaic (PV) supply chain has emerged as a significant driver of the global clean energy transition, contributing significantly to the achievement of sustainable development goals. The transformation stems from the intrinsic value supported by the principles of the circular economy. The integration of the circular economy principles into the solar PV supply chain assumes paramount importance in optimizing energy efficiency, prolonging the operational life of solar panels, mitigating waste generation, curtailing value depreciation, and ultimately realizing overarching sustainability objectives. These key factors can be achieved through the realization of circular economy targets. Stakeholder assessment of the feasibility of each target is a complex, multidimensional problem involving strategic decisions. Unfortunately, the existing literature lacks a holistic study that addresses the multidimensional assessment of the feasibility of circular economy targets with respect to solar PV stakeholders. In line with this, two-stage online surveys were conducted to collect data from experts. This study aims to evaluate the feasibility of solar PV stakeholders to achieve circularity targets using hybrid MCDM methods through survey data. The findings are discussed with the managerial implications of the strategies of solar PV stakeholders in achieving circularity targets under sustainability.

Keywords: Circular economy, solar PV supply chain, sustainability

SCM305

The Efficacy of Legal Contracts in the Lock-in Situation of Supply Chain Relationships

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Abstract

This study examines how suppliers protects themselves against abusive behaviour from customers when they dedicate their asset to the customers which put them in a lock-in situation. The research model describes a mediating relationship where asset dedication from suppliers drive them to establish a legal contract with customers as a protective mechanism to ensure that they will be benefited from the relationship with the customers. However, in this study, we bring in the interpersonal relationship between the managers of the supplier and the customer. Specifically, we test how the conflict between the two managers influence the interorganizational relationship. Using a dataset of SMEs managers from suppliers the results show the mediating effect of legal contracts in the positive indirect effect of asset dedication on benefits that the suppliers gained from the relationship with the customers. Furthermore, the conflict between managers of the suppliers and customers shows a significant moderating effect on the relationship between legal contracts and the benefits that the suppliers gained from the relationship with the customers as such that the stronger the level of the conflict the stronger the positive relationship between legal contracts and the benefits that the suppliers gained from the relationship with the customers. This finding suggest that legal contract is more needed and delivers a higher value in a toxic environment of the relationship between suppliers and customers, which provides an insightful practical implication.

SCM403

Designing a Renewable Jet Fuel Supply Chain: Leveraging Incentive Policies

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Abstract

This study addresses the growing interest in Renewable Jet Fuel (RJF) production as a means to mitigate the aviation sector's carbon footprint. Despite the global attention RJF has garnered in the past decade, challenges persist due to the dispersed nature of its supply resources and higher production costs compared to conventional jet fuel. Employing Mixed Integer Linear Programming (MILP), we present a comprehensive design of a corn-stover-based RJF supply chain network. This model optimizes the supply chain configuration and identifies operational decisions necessary to meet RJF demand at airports. To facilitate RJF commercialization, four incentive programs covering supply chain costs are evaluated, utilizing agricultural statistics districts as designated supply regions. The study's applicability is validated through the design of the supply chain in the Midwestern United States.

SCM503

Design, Digitizing, Executing Lean/Agile Smart Manufacturing Facilities for Global Supply Chain

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Abstract

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 propose 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.

Key Words: Factory Planning, Digital Factory, Linked Cell, IoT Intra Factory

SCM504

The Impact of Extreme Weather Event on Firm Market Value

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Abstract

The increasing frequency of extreme weather events due to global climate change has profound implications for the production and operation of supply chains. However, the influence of extreme weather on corporate financial performance, particularly in terms of stakeholder value, remains uncertain. This study conducts an empirical analysis of the impact of the 2021 flood event in Henan Province, China, on the stakeholder value of local companies and their supply chain partners. Employing the event study method, our findings reveal that local companies experienced a median shareholder value reduction of 1.05% in the week following the flood. Suppliers witnessed a positive contagion impact, reflected in a median stock price reaction of 0.21%. Conversely, customers experienced a greater negative contagion impact with a median stock price reaction of −1.00%, which, however did not have a significant competition impact for competitors. Furthermore, we explore the role of corporate social responsibility (CSR) in the impacts of the Henan flood event. We find that high-CSR has caused local companies to experience a non-significant negative stock market reaction. Additionally, CSR strengthen the contagion impact of the Henan flood along the supply chain. These results emphasize the need for companies to address the direct impacts of extreme weather, while both upstream and downstream entities should consider contagion effects and market opportunities during such events. The study suggests that while establishing close ties through CSR, supply chain organizations should remain attentive to the contagion impact of extreme weather along these connections.

SCM505

Unintended Consequences of In-Kind Humanitarian Donations: The Problem of Material Convergence

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Abstract

Following a disaster that results in a humanitarian crisis, media coverage of the event is frequently followed by surplus donations of goods to charitable organizations. This flow of donations, a post-disaster phenomenon termed *material convergence,* often consists of large quantities of unsolicited and unwanted items that disrupt the distribution of more urgently needed goods. In this study, we conduct two experiments to evaluate whether this problem can be mitigated by media reports on the benefits of donating cash instead of goods. We find that such reports can significantly increase the proportion of cash donations, potentially reducing the material convergence problem.

SCM602

A Comprehensive Framework to Supply Chain Resilience and Sustainability

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Abstract

In the current global business landscape, in which uncertainties and disruptions such as pandemics and geopolitical tensions are significant, the necessity of resilient supply chains is essential. Organizations are increasingly recognizing the need to fortify their supply chains to rapidly adapt and succeed in the face of such unforeseen challenges. Supply chain resilience is defined as proactive planning and design to anticipate and adapt to unexpected events, which is crucial for gaining these competitive advantages. The strategic application of supply chain capabilities at different stages can enhance resilience systematically over time. While existing literature has explored various dimensions and capacities of resilience, a significant gap can be found in the absence of a holistic framework that ties together these facets, including collaboration, information exchange, visibility, transparency, and sustainability aspects.

This research presents the *4M Resilient Sustainable Supply Chain Framework*, which is developed through an extensive review of prevailing strategies for enhancing supply chain resilience. Building upon existing literature, this framework identifies and addresses the limitations in current supply chain resilience models, including insufficient emphasis on agility as well as the limited applicability to small and medium-sized enterprises (SMEs). This novel model not only comprehensively addresses internal and external factors contributing to disruptions but also forges unique connections between supply chain resilience and sustainability factors. This framework represents a significant contribution to the field, offering organizations a comprehensive guide to navigating dynamic environments while embracing sustainability and providing organizations with a tool to manage environmental, social, and governance (ESG) impacts.

Abstracts

Sustainability

SUS101

Fundraising Appeals: Lessons From Social Marketing

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Abstract

The Non-Profit Sector, a $1 trillion "industry" that represents 5.4% of GDP and generates over 12 million jobs has received little research support in terms of model-building. New York City alone hosts close to 200,000 nonprofit organizations. Nonetheless, although nonprofits and CSR programs play a critical role in contemporary society, the sector is in dire need of support. Fundraisers face mounting challenges as more and more social causes compete for the same dollars. The once criticized "marketization" of nonprofits seems today more desirable, and the need for developing a comprehensive model of giving behavior has never been greater. On a macro level, donations are shaped by income and information. Effective nonprofit organizations rely on a network of support, fiscal leveraging, and proper communication to obtain funds through well-planned strategies and processes. One question remains "what should nonprofits offer to get donations?" Surveying over 600 respondents, using their alma mater, the ASPCA, St. Jude's Hospital for Children, a hypothetical local homeless shelter, and their church as references, we tested which appeal works best to communicate an NGO's message, considering pride, pity, PR, personal interest, and pleasure as driving motives. The model reflected a predictive ability of almost 50% which can be improved if we added peer references; all criteria were statistically significant; the sheer pleasure of giving was the strongest driver, an underlying motivator in the donate decision, but different social causes responded differently to alternate fundraising appeals. Determining which appeal works best is key to success. Ignoring the key drivers in the decision to donate may lead to being both ineffective and inefficient.

SUS103

Decarbonizing Lib Production: The Circular Economy Approach to Cobalt Management

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Abstract

The escalating demand for electric vehicles (EVs) as a strategy to curtail greenhouse gas emissions is simultaneously driving an increase in battery production, raising new environmental challenges. Notably, the manufacturing of batteries introduces additional climate burdens. In this context, our study applies the Natural Resource Dependence Theory (NRDT) and Discrete Event Simulation to explore the potential for achieving net-zero emissions within the cobalt circular supply chain of EV lithium-ion batteries (LIBs). We specifically examine the effects of recycling, repairing, and repurposing strategies on the dependency dynamics within the natural resource ecosystem. Through a detailed simulation, we analyze the impacts of these practices under various scenarios, providing insights into the sustainability and feasibility of transitioning towards more environmentally responsible EV battery production methods. According to the results of the simulation, it was concluded that recycling alone is not sufficient to achieve net zero targets and that we need to move up the circular economy hierarchy to reduce the environmental impact of the LIB production supply chain.

SUS203

Optimizing Microgrid Design With Peak Shaving

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Abstract

This paper proposes a model to optimize the design and operations of the microgrid planning problem. Driven by the need for renewable energy sources, the concept of microgrid that consists of distributed energy resources such as microturbines, fuel cells, and photovoltaic panels has gained much attention in recent years. The proposed model focuses on peak shaving and carbon reduction while considering both initial investment cost and operational cost. The reliability of the microgrid and power trading are analyzed. The model is tested with numerical simulations and real case studies. The results demonstrate the efficiency and effectiveness of the model in achieving optimal energy management.

SUS303

Co-Optition in Sustainability Initiative

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Abstract

Sustainability is important yet costly for most companies. This paper explores the dynamics of co-opetition, that is, cooperation among competitors, in sustainability initiatives. We study the strategic interaction of two competing brands' participation in the initiative by considering their market shares, consumer segments, and loyalties, as well as the change in profit margin and investment costs when participating. We characterize the circumstances where co-opetition may take place, which is mainly driven by the big brand. However, when one brand becomes too big, the possibility of co-opetition vanishes. A Prisoners' Dilemma, as well as two distinct multi-equilibrium outcomes, may arise, though some may be circumvented or intervened to attain the desired co-opetition outcome for the social good. The non-monotone nature of the profits in market factors implies that both the direct effect of the parameters and, more importantly, the indirect effect of the rival's strategy should be taken as a whole when contemplating one brand's best response to market changes. In our multi-brand extension, we find that one new type of multi-equilibrium outcome may occur but more importantly full cooperation among a large number of competitors is unlikely to happen.

Abstracts

Teaching and Innovative Education

TCH302

The Hunger Chain: A Competitive Simulation for Teaching Supply Chain Management

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Abstract

We present an online instructional game called the Hunger Chain, designed to offer students an engaging, action-based, competitive simulation for experiential learning on various topics. This game serves as a tool for instructors to foster students' understanding of panic orders and hoarding (shortage gaming), decision dependencies (supply chain competition), and the effective and equitable allocation of limited supplies (supply rationing).

Undergraduate Student Poster Abstracts

POST101

It's All in the Eyes: How Augmented Reality (AR) is Changing Consumer's Behavior

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Abstract

Consumers are strongly dependent on product information to influence their behavior and to make informed purchase decisions. The continuous advancement of technology has significantly increased the speed, quality, and quantity of information dissemination. Augmented Reality (AR) with its spatial computing technology, provides marketers with a wide variety of creative and immersive possibilities to promote product experiences by blending digital content with the real world. AR enables consumers to easily navigate and have access to personalized product information at home while minimizing the risk of encountering unexpected changes in shape, size, and functionality. Moreover, the interactive nature of this integration creates excitement, enhances a sense of luxury and comfort, and stimulates consumers' engagement… facilitating decision-making.

Key Words: Augmented Reality (AR), Decision-Making, Consumer Behavior

POST102

University Spirit Wear Sales: Drivers and Outcomes

Nicholas Conway, Nicholas Cross, Ashton Nicholas Kao, Nicholas Theroux

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Abstract

Advertisement is crucial for student spirit apparel sales. In order to evaluate how a university bookstore looking to increase apparel sales should advertise to current students, we developed a survey that assessed student attitudes and behaviors towards brands and sports. From this data set, we were able to identify which types of athletic events drive purchasing, which student demographic groups purchase different types of athletic apparel, and which student demographic groups align with particular athletic apparel brands.

POST103

Sustainable Practices at the Dining Halls in Bridgewater State University and Heilbronn University

Isabelle Darcy

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Abstract

Sustainability Practices at the Dining Halls in Bridgewater State University and Heilbronn University of Applied Sciences: Comparisons and Suggestions

Ms. Isabelle Darcy, Student, Bridgewater State University

Abstract

Sustainability is becoming increasingly crucial in higher education. Universities like Bridgewater State University and Heilbronn University of Applied Sciences are actively taking steps to improve their operational sustainability. This research aims to identify the shared sustainable practices employed in the dining halls of these two universities, located on opposite sides of the globe. Analyzing client-supplied data and conducting interviews with managers and staff will allow for a comprehensive comparison of the schools, with a specific focus on identifying missed opportunities for further sustainability improvements. This research will offer the universities logical and achievable suggestions for filling these sustainability gaps, thereby contributing to the enhancement of their practices.

POST104

Investigating Relative Efficiency of Self-Storage Facilities Using Data Envelopment Analysis (DEA)

Devin Echavarria, Kyle Grund, EunSu Lee

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Abstract

This study investigates the drivers of demand for self-storage facilities and market attractiveness across New Jersey's diverse counties, using a dataset of 821 facilities and correlating urban development data from 2020 to 2023. Key variables influencing Net Rentable Square Feet (NRSF) per capita were identified through regression analysis and subsequently analyzed via Data Envelopment Analysis (DEA) to assess the operational efficiency of the self-storage industry county-wide. Findings indicate a marked reliance on self-storage correlated with urban densification and demographic changes, and efficiency scores reveal varying levels of industry success in meeting these demands. The insights gained provide urban planners and the self-storage industry with a data-driven basis for strategic development in the evolving urban landscape.

POST107

Changes in Global Trade Policies and Their Impact on International Relations

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Abstract

In the current global trade environment, changes in trade policies have become a crucial topic with significant implications for international relations. Understanding how the trade policy changes of each country affect international economics and politics is a key task in the fields of international trade and diplomatic studies. This study will answer the following research questions: What are the current trends and major changes in global trade policies? How do changes in trade policies impact international economics and politics? Therefore, this study explores the current trends in trade policies worldwide, identifies key changes in these policies, and how alterations in trade policies influence the international economic system and political relationships. A case study investigates changes in trade policies in specific countries or regions to examine their impact on international economics and politics. The research results aim to explain the complex impact of global trade policy changes on international economics and politics. Changes in trade policies present new challenges and opportunities for relationships between nations, the global economic system, and political exchanges. In the conclusion, reflections on how these trends may influence future international relations and trade are provided, along with policy recommendations.

POST109

A Longitudinal Study of Global Warming Discussion on Social Media

Suhong Li, Connor Emery

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Abstract

Over the past few years, a rise of global warming and climate change concern has caused spikes in concern regarding our changing environment as well as what it means for the future. This study analyzes 12 years of data from twitter/X, focusing on changes in the climate change conversation, using the three stages of the COVID-19 pandemic: pre, during and post pandemic. Employing natural language processing techniques such as word clouds to visualize word frequency, big player analysis in order to determine top influencers, and topic modeling to uncover prevailing themes, we identify the dynamic nature of climate change conversation. Additional aims for this project include identifying real and fake tweets and the ability for a machine learning model to accurately identify these tweets from climate change discussion. All analyses for this study were completed in an HPC environment through access granted by the National Science Foundation's CAREERS Cyberteam grant and the University of Rhode Island.

POST110

Examining the Impact of Income and Spending Habits Across Gender Under Food Price Inflation

Tram Lu, Sanjeev Jha

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Abstract

This study aims to examine the effect of income post-tax and spending habits on grocery shopping on males and females in the context of food price inflation. The initial idea to develop this study came from my experience in the workplace. During my school year, I was fortunate to work in the Bear Necessary Market - a program designed to support and provide non-perishable food and essential stuff for students with food insecurity. This year, more students came to the market for food supplies due to the unaffordable expensive food items in grocery stores, which raised my interest in starting a study about food price inflation. Taking a small real-world problem and expanding it to the country level, I seek to understand how male and female experiences are different in times of high food price inflation, influenced by their income after tax and grocery spending habits factors.

POST111

Comparing Machine Learning Algorithms in the Context of Antiviruses

Reese Martin, Robby Pava, Sushma Mishra

Robert Morris University, Moon Twp, USA

Abstract

The following information presents a comparative study of three major machine learning algorithms and the impact they can have on antivirus detection and response. The three algorithms reviewed in this study are decision trees, support vector machines, and neural networks. We have analyzed how these ML approaches effectively impact antivirus's ability to locate and adequately block incoming malware. Decision trees are able to process noisy data with high levels of accuracy. Support vector machines are efficient in predicting future trends. Neural networks are able to detect malware through voice/video transmissions along with being previously trained on data. Through our analysis we have concluded that neural networks are the ideal and most adaptive algorithm for use within antivirus software. Each of the algorithms have limitations that can cause them to not detect malware or create false positives/negatives as discussed in the paper. But through the use of multiple methods of machine learning the limitations of each method can be overlooked. This paper does not discuss the use of more than one algorithm at a time. All of the information in this paper have been externally gathered. We lacked the proper resources to test these theories. Implications are drawn, and future research directions are discussed.

POST114

Italian Fashion Trends: How Consumer Behavior Concepts Effect International Decision-Making

Maya Parady, Megan Ranucci, Nadia Abgrab Noormohamed, Cassandra Onorato

Salve Regina University, Newport, USA

Abstract

Italian fashion is a captivating industry that plays a major role in the European economy by meeting market demands and understanding the ever-changing world of international consumer behavior. From boutique entrepreneurs to large upscale designers, Italian fashion houses must understand buyer attitudes, lifestyles, motivations, and perceptions, and the impact on purchasing decisions. Deep knowledge of current consumer desires and emerging market trends allows organizations to position themselves for strong brand recognition and sustained revenue growth. Businesses can then leverage the knowledge of consumer buying preferences to reflect marketing strategies and tailor fashion campaigns to influence future behavior.

Key Words: Consumer Behavior, Fashion, International, Attitudes, Lifestyles, Motivations, Perceptions

POST115

Using AI Chatbots to Collect Secondary Source Data on Sustainability Information Systems

Ziqiao Qin, Thomas Abraham

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Abstract

In the rapidly evolving digital era, there is an increasing need to explore efficient methods to collect and analyze data. This paper investigates the utility of AI chatbots, ChatGPT and Bard, as tools to collect secondary source data on Sustainability Information Systems (SIS) compared to traditional manual methods. Through systematic data collection and analysis of 2022 BYD's CSR Report, we discovered that AI chatbots have the potential to streamline the data-gathering process, reduce human-induced errors, and provide a more interactive and dynamic experience for researchers. However, manual methods are still essential when human judgment is required on nuances and text needs to be clearly cited. In general, at the current stage, manual methods are still indispensable. The Manual method combined with an AI Chatbot is the best. There is still much room for improvement in artificial intelligence chatbots to enrich the depth and breadth of SIS research.

POST116

Social Robots, Consumers, and UX: A Field Study of a Commercial Social Robot in Education

Camaren Rogers, Nicholas Brown, Anshu Arora, Amit Arora

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Abstract

Many marketers are introducing artificial intelligence (AI), especially social robotics into the realm of understanding consumer journey and behavior. Social Robots are becoming more and more mature, and increasingly adopting varying service roles in the marketplace, e.g., schools and universities (education), hotels and airports (tourism), and hospitals and health clinics (healthcare). Industry is looking out for commercial applications of social robots in public spaces for enhancing consumer experiences and improving human-robot interaction (HRI) situations. However, there is a dearth of literature focusing on user experience (UX), consumer needs, and consumer satisfaction resulting from commercial applications of social robots in public places and surroundings. This research examines three types of consumer experiences with social robots: (1) knowledge capture, (2) information delegation, and (3) interactive / social experience in commercial applications of social robotics. The authors build on robotic role theory for integrating sociological and psychological scholarship to human-robot interactions. Further, the authors discuss policy and managerial avenues for exploring commercial applications of social robotics by employing the methodology for an exploratory field study involving a commercially available, social humanoid robot at a school / university in education setting. The study delineates future research opportunities aimed at enhancing consumer or user experiences (UX) for commercial, social robotics using robotic role theory.

POST117

The Impact of Real Estate Investment Tokens on Climate Change

Megha Saju, Ajim Uddin

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Abstract

This research investigates the intersection of blockchain technologies, real estate investments, and climate change, focusing on the environmental impact of Bitcoin mining and non-fungible tokens (NFTs), as well as the vulnerability of Real Estate Investment Trusts (REITs) to climate-related risks. The study applies cross-quantilogram and rolling window causality approaches to investigate the asymmetric dependence structure and directional predictability arising from the carbon footprint of Bitcoin mining and the distinctive practices of Eastern and Western REITs regarding climate change. The results show an asymmetric directional impact of Bitcoin and climate change on REIT token prices. Nevertheless, the dependence structure varies substantially between REITs. The findings also reveal that any change in REITs distinctly affects climate change indices, and the magnitude and direction of causality change across lag structures. These results emphasize the need for further investigation into the specific dynamics linking climate change and the resilience of REITs, particularly the integration of Real Estate Tokens in sustainable development and environmental returns.

POST118

The Artificial Intelligence of Video Game Design

Devon Tolbert

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Abstract

This research analyzes the implications of AI in video game design, the associated security risks, and whether game making could become autonomous. I begin with a literature review to identify how various AI tools can be employed in different aspects of game design to develop a conceptual model changing these tools together. I then use this conceptual model to develop a theory testing experiment. The proposed experiment will create a game called Chronicles. The theoretical model details each phase of the game design process from prototype development to the final game balancing aspects. Although I was unable to complete the experiment because the expected timeline is at least 30 weeks, through the experimental design process, I have identified a number of companies who have developed AI tools that could be chained together in order to automate game development, making game design faster and more efficient in the not-too-distant future.

POST119

Climate Change Impact on the American Northeast Agricultural Supply Chain

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Abstract

In the past decade the global market has been impacted by an increasing number of supply chain disruptions. From environmental crises, international pandemics, war and natural disasters, more emphasis than ever is being placed on managing risk within the supply chain. Businesses not only need to identify the risks they are exposed to, but also the nature of the risk (man-made or natural) as well as the magnitude and frequency of those risks. Some risks are slow to develop, and mitigation plans can be created before they adversely affect the firm. However, other risks can suddenly erupt with little to no warning, leaving organizations little time to react, unless they have a contingency plan in place. Risks will also vary by industry sector and geographic location, though disruptions in other industry sectors and geographic locations can also cause disruptions. Identifying the risks to a firm and the appropriate strategies to offset the risks is an important area of supply chain research. This research is focused on the effects of climate change, natural disasters and COVID-19 on the agriculture supply chain within the New England area. Through the use of a survey instrument, we collected data from farmers in New England and we will present those results in our poster session.

Masters Student Poster Abstracts

POST201

Blockchain Adoption in Counterfeit-Affected Reverse Supply Chains: An Evolutionary Game Approach

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Abstract

In a post-pandemic context, businesses seek supply chain efficiency. Reverse logistics, vital for sectors like semiconductors, faces security risks, especially unauthorized access to end-of-use products. Blockchain's decentralized and immutable nature offers a secure ledger for transactions and product data, aiding in counterfeit detection. The study models a reverse supply chain with OEMs and platforms, evaluating blockchain adoption scenarios through an evolutionary game. Findings underscore the importance of cooperation, government intervention, and consumer campaigns in encouraging blockchain adoption. The uncertified market's influence, resilience-driven strategies, and potential disruptions in cooperation are also explored, emphasizing the critical role of prompt responses and awareness campaigns.

POST202

Exploring Online MBA Program Feasibility Through Student Surveys

Olivia Ball, Kathleen Ferris

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Abstract

Over the past few years, online MBA programs have gained considerable traction. Graduate students have become particularly interested in pursuing degrees that allow for schedule flexibility. Currently, Bridgewater State University offers an MBA program with a mix of course modalities. Students may take courses in person or online. Looking to garner graduate student feedback, Bridgewater State University's Department of Management and Marketing conducted an MBA student survey in the spring of 2023. Results showed that most students worked full time, and 53 percent responded that more online courses would have helped them complete their degree in a timelier manner. Looking to maximize their student experience, the Department of Management and Marketing wanted to explore the opportunity to offer a fully online MBA program. To further assess student sentiment, another graduate student survey was conducted in the fall of 2023. Students were asked to provide feedback regarding their experiences with online courses and respond to questions about their preferred course modality in the required MBA curriculum. The survey data demonstrates the feasibility of a fully online MBA program and highlights the students' consensus of preferred course modality. The results of the survey provide pertinent information that will allow the Department of Management and Marketing to improve the MBA program, in alignment with student feedback.

POST203

Bridging the Attention Span Gap for Generation Z in Higher Education

Susan Kumari Basel, Ellen Belitzky

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Abstract

With growing technology and overwhelming stimulation from digital gadgets and social media (Oaten, 2022), student attention span can be a concern for effective instruction. Students build preferences for interactive and engaging learning. Traditional methods are less equipped to cater to changing dynamics of students (American Psychological Association, 2019). Current research on traditional lecture and interaction-based pedagogies in higher education has limited identification and adaptation to innovative student engagement strategies. Apart from lecture centric classes, this research will investigate a longitudinal approach which can offer deeper concepts of student dynamics. Addressing captivating stimuli, the study will explore how gamified learning, micro-learning modules (Clark & Mayer, 2011) and interactive methods can grasp student attention and enable deep learning. Developing student cognitive skills through mindfulness practices (Karadjova-Kozhuharova & Baker, 2023) can help traverse the plethora of digital information. Accepting and adapting innovative approaches, instructors can bridge the attention gap and showcase creative abilities of students. A major paradigm shift is required; students will change from using social media as a distraction to leveraging its power as a catalyst for interactive learning.

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POST204

Simplifying Profits With Purpose: Exploring Esg Ratings and Their Reliability

Suraj Chatakondu, Ellen Belitzky

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Abstract

ESG investments, focused on Environmental, Social, and Governance factors, are reshaping the landscape of Investment. This study dives into the mechanics of ESG investments, exploring how rating agencies integrate environmental consciousness, social responsibility, and strong governance into scoring decisions (Elena, 2019, Serafeim, 2018).

While challenges persist such as limited availability of data, the quest for standardized metrics (Florian Berg, 2022), and deceptive practices like greenwashing pose serious threats. Our work tries to understand the methodology followed by various rating agencies, understand the metrics used and finally explain if their ratings are reliable in showcasing the reality of companies (Allesandro Del Vitto, 2023).

As global consciousness veers toward sustainability, ESG investments emerge as a potent pathway, aligning financial objectives with a purpose-driven impact on the world. This research is focused on exploring a simplification of the ratings for common investors and shedding light on the inconsistencies along with the reliability of the ratings.

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POST205

Technology Integration Opportunities for the Alzheimer's Association

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Abstract

Research has focused on algorithms to identify patterns and early indicators of Alzheimer's disease, enabling more accurate and early diagnosis. The Centers for Medicare and Medicaid Services (CMS) do not propose a particular assessment tool because there is no universally preferred screening method that satisfies all needs in detection of cognitive impairment. To provide guidance on cognitive assessment and when further testing is needed, the Alzheimer's Association convened experts to develop recommendations. The Alzheimer's Association Medicare Annual Wellness Visit Algorithm for Assessment of Cognition is such a tool (Cordell et al., 2013). Application of algorithms in electronic health records may also identify cognitive decline earlier for those at risk and in need of longitudinal assessment (Dubois et al., 2021). This study aims to identify opportunities for technological integration to support developed research and patient assessment tools with emerging technologies such as artificial intelligence, machine learning, and data analytics. Partnerships with tech companies for developing applications that aid in diagnosis, monitoring, and caregiver support may be forthcoming.

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POST206

Beyond Conventional Tactics: Targeted Marketing and Causal Inference Models

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Abstract

In the domain of recommender systems, this study examines an unconventional approach that extends beyond customary practices. The uplift model is a method for simulating a marketing campaign's incremental impact. Comparing two groups - one receiving a campaign and the other receiving none - allows one to determine the campaign's incremental effect. The objective for the uplift model is to find customers who respond to the campaign to reduce the campaign's cost (Reiman, 2020).

This study uses transactional data and should contain a mix of random customer subsets of target and control groups from previous iterations of campaigns. Two Model Technique is used with a random forest algorithm to maximize predictability for target and control groups (Goldenberg et al., 2020). As a result, probability scores are used to classify 4 types: Do-Not-Disturbs, Lost Causes, Sure Things, Persuadable (Rossi, 2017). The aim is to find which customers match the single category of content Persuadable, when forecasting uplift score and choosing a section based on the highest score. The result of the study provides the prospective customer base to target in a campaign. The value proposition and implication for the marketing team is to predict the campaign maximum response rate.

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POST207

Consumer Behaviour Using Predictive Analytics

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Abstract

Today, with consumer use of technology, the internet has become a necessity rather than a luxury. Innovation and progress have given consumers global reach with the social desire to share purchase decisions on social media. Consumers are affected in many ways, particularly with an impact on buying habits (Liu, 2023). The purpose of this research is to obtain insights on consumer behavior using predictive techniques to forecast and understand how consumers are likely to act in the future with buying decisions (Osei and Abenyin, 2016). By analyzing historical data, the aim is to find patterns and trends that enable prediction of consumer preferences, buying habits, and engagement with products or services (Guo et al, 2021). The findings will help to develop understanding of consumer needs leading to increased customer satisfaction and improved products and services. Studying consumer behavior using predictive analytics can also help in developing public policies and regulations for consumers.

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POST208

Virtuous Integrative Social Robotics (VISR): Governance and Human-Robot Interaction (HRI)

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Abstract

ABSTRACT

This research conceptualizes Virtuous Integrative Social Robotics (VISR) as a value-driven philosophy for developing and designing social robots/robotics applications. It encompasses shared ethical principles highlighted as autonomy, responsibility, and transparency (ART) for social robots in the VISR context. Virtue ethics is explored as a means for programming social robots as artificial moral agents, placing human values as the basis of robot design. It is based on the 'non-replacement principle' whereby social robots should behave as a virtuous human would. Finally, this research provides managerial implications and promises to find innovative ways based on ethical decision-making and improving ethical transparency for human-robot interaction (HRI), unification, trust, and collaboration more than ever before.

Keywords: Virtuous Integrative Social Robotics (VISR); Autonomy, Responsibility, and Transparency (ART); Artificial Intelligence (AI); Design for Values; Virtuous Robots; Shared Ethics; Human-Robot Interaction (HRI)

POST209

How Does the Internet of Thing Affect Supply Chain Management

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Abstract

The Internet of Things, or IoT, is an international network that uses the web to link real items and equipment so they can be found, recognized, and managed. IoT is now a key component of supply chain management. IoT, yet opened the eyes of academics since there was a glaring void in their understanding of and study of how IoT affected supply chain performance. Consequently, by using a survey of a sample of business personnel to examine the effect of IoT on supply chain performance, this in-depth investigation attempts to close this gap. The research aims to determine how supply chain performance is impacted by customer integration and the Internet of Things. A further goal is to discover how the Internet of Things affects supply chain performance. The study evaluates the effect of the Internet of Things on supply chain efficiency. Recommendations for further research will be made at the research's conclusion.

POST210

The Effect of ESG disclosure and Diversity on Corporate Performance and Risk

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Abstract

We study Environmental, Social, and Governance (ESG) disclosure scores and corporate diversity's effect on corporate performance and risk. We measure diversity by the number of women on the corporate boards of directors and the number of female executives. We studied over 600 corporations in 2019, of which 30 percent are European, and 70 percent are headquartered in the US. We find that while the EU companies dominate the US companies with higher environmental and social scores, the US companies show higher governance scores compared to their European counterparts. We also find that in the EU, an inverse relation exists between higher ESG disclosure scores and corporate risk. In the EU and the US, we find a negative relationship between the interaction term of market capitalization and the number of women on board and corporate risk, meaning larger companies with more women on the board tend to have lower company risk.

POST211

Empowering Sustainability: The Impact of Digital Solutions on Power Utilities of Uae

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Abstract

The power utilities sector faces immense pressure to reduce emissions and adopt sustainable practices. This qualitative research explores how digital solutions are driving improved sustainability in power utilities. Semi-structured interviews with 11 industry experts provided insights into digitization's transformative sustainability impacts. The case study employs an interpretivism philosophy using an inductive approach to develop theories grounded in the collected data. The research offers useful theoretical and practical insights into the complex interplay between digitization, sustainability, and innovation in the power utilities industry. It advances the understanding of how advanced technologies can drive sustainability across carbon-intensive sectors. Findings reveal digitization enables enhanced operational efficiency, lower costs, and reduced environmental footprints. Smart meters and predictive maintenance cut waste and emissions. Integrating renewables necessitates digital twin simulations, advanced sensors, and analytics. Decentralized energy resources and storage solutions also support decarbonization. However, digitalization poses cybersecurity, cost, and adaptation risks. Stakeholder collaboration is vital to oversee this sectoral transformation. Governments should institute supportive regulations, incentives and sustainability mandates. Ultimately, digitalization unlocks immense potential for power utilities to bolster sustainability via optimized asset management, automated processes, data-driven decisions and customer engagement. Yet proactive policies and mitigation of digitization risks are essential for securing utilities' digital sustainability future amidst the renewable energy transition.

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