IMPLEMENTING INDUSTRY 4.0: A STUDY OF SOCIO-TECHNICAL READINESS AMONG MANUFACTURERS IN MINNESOTA AND NORTH DAKOTA

A Dissertation
Submitted to the Graduate Faculty
of the
North Dakota State University
of Agriculture and Applied Science

By

Katherine Roth

In Partial Fulfillment of the Requirements
for the Degree of
DOCTOR OF PHILOSOPHY

Major Department:
Industrial and Manufacturing Engineering

February 2024

Fargo, North Dakota

North Dakota State University
Graduate School

Title

IMPLEMENTING INDUSTRY 4.0: A STUDY OF SOCIO-TECHNICAL READINESS AMONG MANUFACTURERS IN MINNESOTA AND NORTH DAKOTA

By

Katherine Roth

The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

DOCTOR OF PHILOSOPHY

SUPERVISORY COMMITTEE:

Dr. Kambiz Farahmand
Chair

Dr. Justin Walden

Dr. Mojahid Saeed Osman

Dr. Harun Pirim

Approved:

February 28, 2024 — Date

Dr. Kambiz Farahmand — Department Chair

ABSTRACT

The implementation of Industry 4.0 has become increasingly prevalent in the manufacturing industry since its inception. With the introduction of these newer technologies, changes in personnel and organizational structures occur. The purposeful joint optimization of social and technical factors of organizations is imperative to the successful adoption of Industry 4.0. Thus, the socio-technical system theory addresses a holistic design of human, technology, and organization subsystems of the manufacturing process and their interdependencies.

This dissertation investigates the progress made towards implementing Industry 4.0 by small, medium, and large manufacturers in Minnesota and North Dakota. The outcomes of two surveys conducted among a group in Minnesota and North Dakota are analyzed and the results are compared to national and international data. This research identifies potential challenges, as well as, advantages in the current socio-economic landscape for manufacturers that may be either impeding or encouraging the development of a competitive and sustainable manufacturing business. As well, the implementation of flexible work arrangements in the modern work environment has increased in recent years. The first survey posed questions based on a socio-technical theory framework, Industry 4.0, and productivity outcomes. Insights were provided as to how regional manufacturers were utilizing the socio-technical design framework to integrate Industry 4.0 into the organizational design and extract value, such as increased productivity. The joint optimization of social and technical factors within an organization is necessary for the successful adoption of hybrid work environments. The outcomes of the second survey conducted among a group of small, medium, and large manufacturers in Minnesota and North Dakota were assessed the level of socio-technical readiness among regional manufacturers. The survey posed questions based on socio-technical design, digital maturity, organizational learning, responsible autonomy, leadership, communication strategies, and reduced work week schedules. Insights were provided as to how these critical factors support sustainability initiatives, such as reduced work week schedules. As a result of the surveys, a socio-technical strengths, weaknesses, opportunities, and threats (SWOT) analysis framework to complete was proposed to guide the organization through the industry 4.0 implementation process, assess opportunities for the reduction of work hours, and facilitate the strategic enterprise-wide buy-in from employees and diverse stakeholders.

ACKNOWLEDGMENTS

I would like to express my sincere gratitude to my advisor Dr. Kambiz Farahmand for the invaluable guidance, support, and training he provided throughout this research. I am very grateful to Drs. Mojahid Saeed Osman, Harun Pirim, and Justin Walden for invaluable instructions, sharing knowledge on relationship models and computer science methodologies, being committee members, and reviewing this thesis. I want to sincerely thank Dr. Yadav Om for providing invaluable advice and insights on the socio-technical theory. I would like to thank Curt DeKoett for providing statistical support throughout the dissertation process.

DEDICATION

This dissertation is dedicated to my parents and family for their continuous encouragement and support.

TABLE OF CONTENTS

ABSTRACT iii

ACKNOWLEDGMENTS v

DEDICATION vi

LIST OF TABLES x

LIST OF FIGURES xii

LIST OF ABBREVIATIONS xiv

LIST OF EQUATIONS xv

LIST OF APPENDIX TABLES xvi

1. INTRODUCTION 1

1.1. Research Rationale 9

1.1.1. Research Questions 10

2. LITERATURE REVIEW 11

2.1. Industry 4.0 Adoption Differences Among Small, Medium, and Large Manufacturers 13

2.1.1. Reviewing The Nature of Small, Medium, and Large Manufacturers—The Changing Environment and Current Skills Gaps 20

2.1.2. Adopting Socio-Technical Design in the Industry 4.0 Context 21

2.1.3. Organizational Learning in the Socio-Technical Design Context 23

2.1.4. Reducing Work Week Schedules in the Socio-Technical Design Context 27

2.1.5. Practicing Responsible Autonomy in the Socio-Technical Design Context 29

2.1.6. Leading in the Socio-Technical Design Context 31

2.1.7. Understanding the Impact of Industry 4.0 in the United States and Worldwide 34

2.1.8. Integrating Industry 5.0 into the Industry 4.0 Context 37

2.1.9. Implementing Industry 4.0 by Utilizing a Socio-Technical SWOT Analysis 41

2.1.10. Evaluating Digital Transformation – A Socio-Technical Assessment Model 48

3. RESEARCH METHODOLOGY 57
3.1. Purpose of Study 57
3.2. Research Questions and Hypotheses 59
3.3. Research Design 61
3.4. Target Population and Sample 61
3.5. Population 61
3.6. Sample Study 62
3.7. IRB Approval/Exemption 62
3.8. Data Collection 62
3.9. Data Validity 63
3.10. Data Analysis 63
3.11. First Survey 70
3.12. Second Survey 72
3.13. Ethical Considerations 74
3.14. Summary 74
4. RESULTS 75
4.1. Results for Manufacturers – First Survey 75
4.2. Results for Manufacturers – Second Survey 102
5. WEB SCRAPING AND INNOVATION RESEARCH STUDY 141
5.1. Background 143
5.2. Research Methodology 143
5.3. Results 146
5.4. Quantitative Analysis 155
5.5. Support of First and Second Survey Results 155
5.6. Limitations of the Study 157

5.7. Contribution of Web Scraping Research 157
5.8. Recommendations for Future Study 158
5.9. Conclusion 158
6. DISCUSSION 160
7. CONCLUSION 174
REFERENCES 178
APPENDIX A. DATA FROM FIRST SURVEY 196
APPENDIX B. DATA FROM SECOND SURVEY 200
APPENDIX C. DATA FROM WEB SCRAPING PROJECT 207
APPENDIX D. SURVEY RESULTS OF ARCHITECTURE, ENGINEERING, AND CONSTRUCTION INDUSTRIES 220
APPENDIX E. SURVEY RESULTS OF BUSINESS, FINANCIAL, SALES, AND LOGISTICS INDUSTRIES 232
APPENDIX F. SURVEY RESULTS OF COMPUTER AND INFORMATION TECHNOLOGY INDUSTRY 238

LIST OF TABLES

Table Page

1. Proposed Socio-technical SWOT Analysis Framework Based on Davis et al. 44

2. Legend for the First Socio-technical Survey Tool 49

3. Legend for the Second Socio-technical Survey Tool 50

4. All Minnesota and North Dakota Manufacturers Surveyed 81

5. Small Manufacturers in Minnesota and North Dakota Integrating Industry 4.0 (Q12) 83

6. Medium-sized Manufacturers in Minnesota and North Dakota Integrating Industry 4.0 (Q12) 85

7. Large Manufacturers in Minnesota and North Dakota Integrating Industry 4.0 (Q12) 87

8. Minnesota Manufacturers Surveyed 89

9. North Dakota Manufacturers Surveyed 91

10. The relationship between Q3 and Q12 for MN and ND Manufacturers........................... 93

11. The Pearson and Polychoric Correlation Coefficients for Q3 by Q12 for MN and ND Manufacturers 94

12. The Relationship between Q3 and Q21 for MN and ND Manufacturers 95

13. The Pearson and Polychoric Correlation Coefficients for Q3 by Q21 96

14. The relationship between Q12 by Q21 for all MN and ND Manufacturers 97

15. The Pearson and Polychoric Correlation Coefficients for Q12 by Q21 98

16. All Small Manufacturers from Minnesota and North Dakota Surveyed 115

17. All Medium-sized Manufacturers from Minnesota and North Dakota Surveyed........... 116

18. All Large-sized Manufacturers from Minnesota and North Dakota Surveyed............... 117

19. Socio-technical Construct Comparison of all Manufacturers Surveyed......................... 119

20. Comparison of Digital Maturity Level (Q4) with Reduced Hourly Work Week Schedule (Q15) 120

21. Comparison of Productive Learning Type (Q11) to Responsible Autonomy (Q21)...... 122

22. Minnesota and North Dakota Production Companies – Second Survey 125

23. Pearson and Polychoric Correlation Coefficients for Q15 by Q13 – Second Survey 126

24. Minnesota and North Dakota Production Companies – Second Survey 127

25. Pearson and Polychoric Correlation Coefficients for Q15 by Q16 – Second Survey 128

26. Minnesota and North Dakota Production Companies – Second Survey 129

27. Pearson and Polychoric Correlation Coefficients for Q15 by Q21................................ 130

28. Minnesota and North Dakota Production Companies – Second Survey 131

29. Pearson and Polychoric Correlation Coefficients for Q14n by Q13 – Second Survey 132

30. Minnesota and North Dakota Production Companies – Second Survey 133

31. Pearson and Polychoric Correlation Coefficients for Q14 by Q16 – Second Survey 134

32. Minnesota and North Dakota Production Companies – Second Survey 135

33. Pearson and Polychoric Correlation Coefficients for Q14 by Q18 – Second Survey 136

34. Minnesota and North Dakota Production Companies Q14 by Q21 – Second Survey 137

35. Pearson and Polychoric Correlation Coefficients for Q14 by Q21 – Second Survey 138

36. Minnesota and North Dakota Production Companies Q14 by Q24– Second Survey..... 139

37. Pearson and Polychoric Correlation Coefficients for Q14 by Q24 – Second Survey 140

38. Number of Manufacturing Websites Using Keywords Associated with Cyber-physical Systems.. 146

39. Industry 4.0 Categories and Keywords Searched in Web Scraping Project 148

40. Number of Manufacturing Websites Using Keywords Associated with the Nine Industry 4.0 Categories 149

LIST OF FIGURES

Figure Page

1. Proposed Framework for Socio-technical Design of Industry 4.0 Implementation with Industry 5.0 Resiliency and Socio-Technical SWOT Analysis 46

2. Example of the Socio-technical Relationship Model used with the First Survey Data 52

3. Example of Socio-technical Relationship Model Used to Test the Level of Socio-technical Joint Optimization within an Organization 52

4. The Relationship Model of the Acceptable Range of ‘S’ Value to Observe Increased Productivity Per Employee Based on Socio-technical Design 52

5. The Relationship Model of the Socio-technical Readiness and Industry 4.0 Adoption 53

6. The Relationship Model for Achieving a Reduced Daily Work Hour Goal Using the First and Second Survey Results 53

7. Example of the Reduced Daily Work Hour Goal Relationship Model in Use 54

8. Socio-technical Constructs Researched 58

9. Socio-technical Research Framework 60

10. Data Gathering 100

11. Analysis and interpretation 100

12. Summarization…………………………………………………………………101

13. Testing………………………………………………………………………..101

14. Iterate and Amend……………………………………………………………102

15. Q21 Responsible Autonomy comparison to Q22 Organizational Learning……………123

16. Q22 Organizational Learning Compared to Q13 Reduced Daily Work Hour Goal....... 123

17. Q21 Responsible Autonomy Compared to Q9 on Productivity and Innovation 124

18. Bibliometric Analysis of Keyword Co-occurrence within Industry 5.0 Context from Ghobakhloo et al 142

19. Current Status of Industry 4.0 Utilization Deduced from Sampled Minnesota and North Dakota Manufacturers 150

20. Web Scraping Results for Keywords Associated with Cyber-physical Systems. 151

21. Web Scraping Results for Keywords Associated with Big Data 151

22. Web Scraping Results for Keywords Associated with Cyber Security 152

23. Web Scraping Results for Keywords Associated with Cloud Computing 152

24. Web Scraping Results for Keywords Associated with Additive Manufacturing 153

25. Web Scraping Results for Keywords Associated with Advanced Robotics 153

26. Web Scraping Results for Keywords Associated with Modelling and Simulation 154

27. Web Scraping Results for Keywords Associated with Industry 4.0 154

LIST OF ABBREVIATIONS

SME ....Small and Medium-sized Enterprise

SWOT ....Strengths, Weaknesses, Opportunities, and Threats

AI ....Artificial Intelligence

LIST OF EQUATIONS

Equation Page

1. Pearson Correlation Coefficient as Provided by SAS Institute Inc. 65

2. Polychoric Maximum Likelihood Method of Simultaneous Estimate by Olsson, 1979.. 67

3. Polychoric Maximum Likelihood Method of Simultaneous Estimate by Olsson, 1979.. 67

4. Case 1: All Parameters are Estimated Simultaneously - Polychoric Maximum Likelihood Method of Simultaneous Estimate by Olsson, 1979 68

5. Polychoric Maximum Likelihood Method of Simultaneous Estimate by Olsson, 1979.. 69

6. Case 1: Variance/Covariance - Polychoric Maximum Likelihood Method of Simultaneous Estimate by Olsson, 1979.. 69

7. Tetrachoric Correlation Coefficient Provided by Olsson, 1979 70

LIST OF APPENDIX TABLES

Table		Page
A1.	Data from First Survey	197
B1.	Data from Second Survey	201
C1.	Data from Web Scraping Project	208
C1.	Data from Web Scraping Project (continued)	214
D1.	First Survey for Architecture, Engineering, and Construction industries – All Business Sizes - Pearson Correlation Coefficient	220
D2.	First Survey - Polychoric Coefficient of Industry 4.0 Integration (Q12) Relationship with Increased Productivity (Q21)	221
D3.	First Survey - Architecture, Engineering, and Construction by Business Size	222
D4.	First Survey – Polychoric Coefficient for Architecture, Engineering and Construction Industries for Q3 and Q12 Relationship	223
D5.	Relationship of Q3 and Q21 for the Architecture, Engineering, and Construction Industries	224
D6.	Polychoric Coefficient for the relationship of Q3 and Q21 for Architecture, Engineering, and Construction Industries	225
D7.	Second Survey - Architecture, Engineering, and Construction	226
D8.	Pearson and Polychoric Coefficients for Second Survey – Architecture, Engineering, and Construction	227
D9.	Second Survey – Architecture, Engineering, and Construction	228
D10.	Second Survey – Architecture, Engineering, and Construction Q14 by Q21	229
D11.	Second Survey – Architecture, Engineering, and Construction – The Relationship of Q14 by Q24	230
D12.	Pearson and Polychoric Coefficients for Second Survey – The Relationship of Q14 and Q24 - Architecture, Engineering, and Construction	231
E1.	First Survey – The Relationship between Digital Technology Integration (Q3) and Industry 4.0 Integration (Q12) - Business, Financial, Sales, Logistics	232
E2.	First Survey – The Relationship between Digital Technology Integration (Q3) and Industry 4.0 Integration (Q12) - Business, Financial, Sales, Logistics	233

E3. First Survey - The Relationship between Industry 4.0 Integration (Q12) and Increased Productivity (Q21) - Business, Financial, Sales, Logistics 234

E4. Second Survey – The Relationship between Q14n and Q5 – Business, Financial, Sales, Logistics 235

E5. Second Survey – The Relationship between Q15n and Q5 – Business, Financial, Sales, Logistics 236

E6. Second Survey – The Pearson and Polychoric Coefficients for the Relationship between Q15n and Q5 – Business, Financial, Sales, Logistics 237

F1. First Survey – The Relationship between Digital Technology Integration (Q3) and Industry 4.0 Integration (Q12) – Computer and Information Technology 238

F2. First Survey – Pearson and Polychoric Coefficients for Digital Technology Integration (Q3) and Industry 4.0 (Q12) – Computer and Information Technology...... 239

F3. First Survey – The Relationship of Industry 4.0 Integration (Q12) and Increased Productivity (Q21) - Computer and Information Technology....................................... 240

F4. First Survey – Pearson and Polychoric Coefficients of the Relationship of Industry 4.0 Integration (Q12) and Increased Productivity (Q21) – Computer and Information Technology Industry... 241

F5. First Survey – Relationship of Gathering Data (Q3) and Increased Productivity (Q21) – Computer and Information Technology Industry... 242

F6. First Survey – Pearson and Polychoric Coefficient for the Relationship of Q3 and Q21 – Computer and Information Technology Industry 243

F7. Second Survey – Relationship of Q14n and Q5 - Computer and Information Technology 244

F8. Second Survey – Pearson and Polychoric Coefficients - Computer and Information Technology 245

F9. Second Survey – The Relationship between Q15 and Q5 - Computer and Information Technology 246

F10. Second Survey – The Relationship between Q15 and Q5 - Computer and Information Technology 247

F11. Second Survey – The Relationship between Q15 and Q13 - Computer and Information Technology 248

F12. Second Survey - Pearson and Polychoric Coefficients - Computer and Information Technology 249

1. INTRODUCTION

Estimates have placed the pace of internet use from online consumers by 2030 to be once every 18 seconds or 5000 times a day (Satyro et al., 2023). Consumers are driving greater demands for mass customization, which provides a significant incentive for manufacturers to implement Industry 4.0 technologies (Dossou et al., 2022). In 2011 the manufacturing industry in Germany announced its focus on Industry 4.0 to meet these evolving market demands and to improve production accuracy, reduce inventory, operating and human resource costs, and further investment opportunities (Setyaningsih et al., 2020).

The academic literature in the field of Industry 4.0 studies focuses on increasing organizational flexibility and resilience, which may be reached through decentralization and real-time logistics. As well, sustainability, consumer empowerment, and product and service customization were studied (Pucheanu et al., 2022). Industry 4.0 requires the adequate appropriation of resources to implement successfully. The socio-technical systems theory can assist with the reduction of the reliance on resources, as well as, the adequate allocation of resources through its readiness assessment techniques, which directly supports this endeavor. (Setyaningsih et al., 2020). Assessment models, such as the socio-technical readiness surveys, that are conducted in this research, are essential to Industry 4.0 implementation (Haring et al., 2023).

Additional focuses on new application areas of socio-technical theory, such as technology platforms and the platform economy are conducted. As well, gaps in socio-technical research in predictive work have been identified (Abbas & Michael, 2022). Research topics on sustainability are also increasingly important. Socio-technical dimensions such as people, organization, and technology are directly correlated in the research to measures of critical success factors for developing sustainability (Koldewey et al., 2022).

Business size matters in discussions of Industry 4.0 adoption due to the historically limited financial resources of smaller enterprises (Sievers et al., 2021). Additional reasons for delaying Industry 4.0 integration may be a lack of employee knowledge, a hierarchical organizational structure and culture, and inadequate procedures to guide implementation in a volatile, uncertain, complex, and ambiguous digital transformation process (Gabriel et al., 2021).

The use of Industry 4.0 is becoming increasingly prevalent among industries, such as manufacturing. Industry 4.0 integration’s goals are to support more autonomous, decentralized, and responsible work teams to move toward customized production (Bastos et al., 2022). The four design principles of Industry 4.0 are connectivity, decentralized decision-making, information transparency, and technical assistance (Yildizbasi and Unlu, 2019). Industry 4.0 connects the physical and digital assets to create an artificially intelligent and decentralized organization (Guertler et al., 2023). The Internet of Things, cloud computing, and big data and analytics create the opportunity to capture and leverage real-time data from products, processes, services, and people. These multi-faceted innovations will develop long-term solutions that create stronger sustainability, human resources, and supply chains (Tortorella et al., 2022).

Additionally, the vertical, horizontal, and end-to-end integration methodologies of these new enabling technologies will aid in the implementation of Industry 4.0 systems (Salunkhe & Berglund, 2022). Vertical integration is implemented using software tools, such as enterprise resource planning and manufacturing execution system, to influence planning and manufacturing within the organization. This technology implementation may shift the hierarchical structure of an organization. The horizontal integration supports the flow of material and information between the manufacturer and the supply chain network (Yildizbasi and Unlu, 2020). The end-to-end solutions create greater opportunities for customization (Sivananda et al., 2021). Also, vertical integration focuses on the areas of information processing, products, and equipment. Horizontal integration emphasizes the connectivity to strategic partners and information flow (Chonsawat & Sopadang, 2020).

Modular production, service orientation, virtual applications, real-time capabilities, interoperability, decentralized systems and virtual applications enable the implementation of Industry 4.0 (Satyro et al., 2023). Modularity is defined as the ability for a manufacturer to instill flexible assembly through a variety of configurations to develop various products (Roy et al., 2023). Modularity, along with agility, flexibility, scalability, and interoperability synergies, aids in the digital transformation process (Haring et al., 2023).

Industry 4.0 technologies are critical to enhancing innovation and the competitive advantage of manufacturers in local and global markets through a combination of new digital technologies, products, and services (Sofic et al., 2022). Industry 4.0 is creating a more complex modern production system. The increased utilization of digital solutions generates advanced manufacturing data analytics (small data), predictive modelling, and real-time analytics to support decision-making. Yet, manufacturers are slow to adopt digital transformation strategies, which is evidenced in an overall less mature use of innovative technologies and are therefore predominantly in the earlier stages of Industry 4.0 (Clausen, 2023).

Socio-technical theory is an organizational theory that focuses on jointly optimizing the social and technical components of a work organization. Socio-technical theory was introduced by Trist and Bamford in 1951 as they studied the work-flow processes of coal miners. Socio-technical theory defines employees as a resource to develop (Pasmore et al., 2019). A trait of process maturity is where the employee is co-responsible for decision-making (Jalowiec & Wojtaszek, 2022). The theory details the social, technical, work organization, and design of internal and external factors affecting the work environment. According to this theory, a business socially comprises employee engagement, employee development, knowledge, safety, personal interests, skills, and experience. The technical elements of businesses are described as operations, processes, tools, facilities, equipment, inventory, maintenance, and information flow. The work aspects involve policies, rules, procedures, instructions, information flows, teams, employee shifts, training, planning, and integration. The design principles of goals, cyber-physical connection, information, transparency, decentralized decision-making, and employee input contribute to the joint optimization of the social and technical elements of an organization. Market demands, production processes, employee condition improvement, financial/economic environment, regulatory environment, and customization represent environmental work elements (Macron et al., 2021).

Socio-technical system design supports sustainable development within organizations. Additionally, Industry 4.0 technologies are proving to support environmental sustainability goals, as manufacturing processes are completed with improved efficiency while relying on fewer resources for total production (Javaid et al., 2022). Industry 4.0 tools are enabling technologies to assist small, medium, and large businesses with the sharing of information and collaboration between individuals, accessibility and security of the flow of data, mobility of work times and locations, and improved productivity and working conditions for employees (Cimini & Cavalieri, 2022). These newer technologies are providing improved production processes, increased productivity, reducing reliance on resources, decreasing costs, improving quality, and creating a more transparent and profitable organization (Cerne et al, 2023). Industry 4.0 serves well an organizational design that requires agility to address continuous, complex, and non-linear change. Reasons for implementing Industry 4.0 are consumer demands for customization, supply chain complexity, and globally dispersed production, competition, and labor challenges (Zhou et al., 2022)(Biglardi et al., 2023). The Oxford English Dictionary defines agility as “the ability to think quickly and in an intelligent way” (Szabo, P. et al., 2023). An agile organization responds immediately to unexpected change to adapt as demands shift. Established processes that add value in dynamic business environments are known as strategic agility. Agile organizations also have the characteristics of reconfigurability within manufacturing systems that facilitates the adoption of Industry 4.0, which leads to increased productivity. Factors that directly impact the level of SME agility are production system structure, product decomposition, technologies leveraged, and business plan (Bouchard et al, 2023).

Although non-linear and non-transitive, socio-technical design is synchronous and interactive in developing value (Kurtz et al, 2023). In jointly optimizing Industry 4.0 with socio-technical work design, observations of increased performance with the technical system and Operator 4.0, job satisfaction, increased safety, a collaborative economy and improved economic outcomes have been reported. The Operator 4.0 viewpoint focuses on the overall employee’s capacity (De Assis et al, 2022). (Margherita & Braccini, 2021). Strong technology adoption rates are also indicated with the use of socio-technical theory (Macron et al., 2021). A more recent trend focuses on the conversion to human-machine co-working and is referred to as Industry 5.0, where humans are both originators and consumers of knowledge along with machines. The onset of the Industry 5.0 smart factory is based on the needs and skills of the workers, rather than the utility of the technology (Peruzzini et al, 2023). These synergistic human-cyber relationships integrate socio-democratic and ethical factors, where human intelligence partnered with cognitive computing create value-added products and services (Bednar and Welch, 2020).

Human-centered design considers cognitive psychology, industrial design, information processing graphics, human factors, and ergonomics (Ngoc et al., 2021). There are three types of ergonomics: physical, cognitive, and organizational. Physical ergonomics focuses on the employee's movement, safety, and health. Cognitive ergonomics focuses on performance, decision-making, training, and cyber-physical interactions. Organizational ergonomics focuses on schedules, processes, communication, collaboration, and structures (e.g. flat or hierarchical organization) (Zizic et al., 2022).

Smart technologies are innately socio-technical connecting the production process and products to issues of environmental, social and economic sustainability. New research is being conducted on both user and worker perspective of smart technology, where privacy, autonomy, and the dehumanization of interactions is observed. Gray areas aligned with the human-AI interaction are language processing, social roots, cyber-physical systems, virtual reality, and augmented reality (Ngoc et al., 2021). The human-centered systemwide perspective considers the three main areas of human-centered industrial engineering, human-centered modelling, and human-centered management, which correlate directly to the socio-technical system design theory (Sgarbossa et al., 2020). The goal of human-centered design is to create decentralized organizational techniques, which simultaneously serves as a catalyst to flatten hierarchical structures (Dregger et al., 2016).

In this paper, a socio-technical framework provided by Davis et al. is used to assess the interdependent nature of work systems that support both predictive work and design (Davis et al., 2014). The socio-technical framework consists of three external factors and six internal factors. The external factors have been identified to influence the connections between technological and social aspects, including regulation, financial circumstances, and stakeholders. The internal factors of organizations can be categorized into three technological aspects: technology, infrastructure, process, and three social aspects, namely goals, people, and culture. This analysis of technical, organizational, and employee-related factors is holistic and offers insights into the correlations among the five socio-technical constructs. These constructs are data gathering, analysis and interpretation, summarization, testing, and iterating and amending. These socio-technical constructs are viewed through the lens of Industry 4.0 integration, as well as, productivity outcomes among small, medium, and large manufacturers in North Dakota and Minnesota (Davis et al., 2014).

The existing literature gap encouraged the focus of this study to assess the socio-technical dimensions of manufacturers in North Dakota and Minnesota in the context of Industry 4.0 adoption. According to the National Association of Manufacturers, as of 2019, there were 624 manufacturing firms in North Dakota. In North Dakota as of 2021 manufacturers employed 27,000. There are 6387 manufacturing firms in Minnesota that account for 320,000 employees (National Association of Manufacturers, 2023). These manufacturing firms employ 6.32% of non-farm workers in North Dakota and 11.08% of non-farm workers in Minnesota as of 2021. Additionally, due to North Dakota and Minnesota's low unemployment rates of 2% and 2.9%, respectively, as of June 2023, the assessment is also imperative of the integration of human factors through the implementation of the socio-technical theory framework to support sustainability plans (National Association of Manufacturers, 2023). The study is especially needed to assess regional competitiveness of manufacturing firms in the Industry 4.0 context using the lens of socio-technical design, which is described as the joint optimization of social and technical factors, is self-managing to embody resourcefulness, and where the employees are multi-skilled to ensure successful performance in dynamic business environments (Mitki et al., 2019).

Flexible work arrangements are also of increasing interest to the present-day workforce. In 2022, 34 percent of employed persons did some or all of their work at home and 69 percent of employed persons did some or all of their work at their workplace. On average, those who worked at home did so for 5.4 hours on days they worked and those who worked at their workplace did so for 7.9 hours. (U.S. Bureau of Labor Statistics, Accessed on 1 October 2023).

The state of North Dakota's Economic Development Foundation developed a Strategic Plan for 2017-2025, which includes a strategic vision for advanced manufacturing by assessing the critical area of entrepreneurship and innovation. This report outlines the strategic responsibilities of the state to successfully implement a vision for continued growth. These outlined goals include continuing to invest in university-based research and development conducted with the private sector that engages North Dakota in emerging technologies and work to fast-track commercialization, promote export trade, and continue investing in statewide talent strategies that address education, training recruitment and retention to support long-term sustainability goals (commerce.nd.gov, 09/25/23). Alternately, Enterprise Minnesota is a participant of the U.S. Department of Commerce's Manufacturing Extension Program and has conducted surveys illustrating several key indicators of the current status of manufacturers in Minnesota. When surveyed Minnesota manufacturing firms indicated that increasing productivity, developing company managers and leaders, effective strategic planning and implementation, and implementing and using automation were within the top ten drivers of the company's future growth (enterpriseminnesota.org, 9/26/2023). Furthermore, on a national level the United States commenced the Advanced Manufacturing Partnership and the National Network for Manufacturing Innovation in 2014 to foster continued economic growth (Trehan & Machhan, 2022).

The objective of the research is to evaluate the technical and social factors impacting modern manufacturers' ability to work in new and meaningful ways, such as through reduced work week schedules resulting from developing a culture of organizational learning, responsible autonomy, bottom-up problem solving, and promoting productivity and innovation. Reports indicate that reduced work week schedules are successfully implemented in Germany and Austria, as well as several other countries, such as in New Zealand and Japan. The overall belief is that reduced work week schedules support sustainability goals, such as employee safety, wellbeing, and job satisfaction (Gaitlin-Keener & Lunsford, 2020). Furthermore, a socio-technical analysis framework will be introduced to address the strengths, weaknesses, opportunities, and threats hindering the joint optimization of social and technical elements throughout the enterprise.

This study is grounded in socio-technical theory as described by Davis et al. where the joint optimization of technical components, such as technology, processes and infrastructure and social components of people, goals, and culture operate interdependently and efficiently (Davis et al., 2014). When either the social or technical component is unattended a less than optimal outcome is observed. This study contributes to the literature on socio-technical systems theory by measuring the regional impact of socio-technical design among small, medium enterprises (SMEs), as well as large manufacturers.

1.1. Research Rationale

Organizations may be described as systems with behaviors, structures, and functions (Doussou et al., 2022). This paper seeks to assess the socio-technical readiness of manufacturers in Minnesota and North Dakota to both integrate Industry 4.0 and instill a reduced work week goal within their organizations.

1.1.1. Research Questions

The objective of the research questions is to glean insights into the current level of socio-technical design that is integrated within an organization. This study focuses on socio-technical design framework constructs that can facilitate the successful adoption of Industry 4.0, as well as predict the dependent variables of increased productivity and reduced work week schedules. A hypothetical model is also presented to illustrate and test the correlation between socio-technical constructs and the current status of an organization's work design. The following six research questions pertain to the socio-technical readiness of small, medium, and large manufacturers in Minnesota and North Dakota in the Industry 4.0 implementation process.

1. How applicable are socio-technical design principles in the Industry 4.0 context among North Dakota and Minnesota manufacturers?

2. Is there a positive correlation between Industry 4.0 and increased productivity among manufacturers in Minnesota and North Dakota?

3. Is there a positive correlation between socio-technical design principles and increased productivity?

4. Will organizational learning have a significantly positive correlation to achieving a reduced daily work hour goal?

5. Will responsible autonomy have a significantly positive correlation to the promotion of productivity and innovation?

6. Will responsible autonomy have a significantly positive correlation to organizational learning among regional manufacturers?

2. LITERATURE REVIEW

The structure of work, technology, and design practices are ever changing, informing the use of socio-technical principles and applications. The work organization operates with goals and metrics and the aid of people of varying skills and attitudes, using a range of technologies and tools, leveraging infrastructures, holding specific cultural orientations, and following a set of processes. As mentioned previously, a work organization is a system that operates within the external environment and is impacted by regulatory frameworks, stakeholders, and the economic and financial environment. The current status of an older workforce dated industrial facilities, and environmental concerns in many areas of the world calls for the digital transformation of the manufacturing sector that is informed by a human-centered design (Gales et al., 2022).

The socio-technical analysis offered by Davis et al. outlined that the socio-technical framework includes the constructs of data gathering, analysis and interpretation, summarization, testing, and iterating and amending within the six dimensions of people, infrastructure, technologies, culture, processes, and goals. This socio-technical framework assists with predictive work and is significant in designing and overseeing project implementation. The themes of end-user engagement and team-based approaches promote sustainability (Davis et al., 2014). Badham et al. provided five descriptors for socio-technical systems as systems having independent parts, being adaptive, holding both social and technical subsystems, having multiple pathways for obtaining objectives, and overall system performance occurring through joint optimization. Cherns described nine socio-technical principles as: “(i) Compatibility: the design process must align with its objectives. (ii) Minimum critical specification: social groups should have clear objectives, but they should decide how to achieve them. (iii) Socio-technical criteria: deviations from expected norms and standards should be eliminated or controlled. (iv) Multifunctionality principle: groups should facilitate the exchange of knowledge and experiences. All groups should learn from each other. (vi) Information should be transmitted to where it is needed for action. (vii) Supporting congruence: social support systems that reinforce desired behavior should be designed. (viii) Design and human values: quality work requires opportunities that lead to a desirable future. (ix) Incomplete establishes that design is an iterative process that never stops." (Agote-Garrido et al., 2023)(Challenger and Clegg, 2011).

Socio-technical theory is connected to ethical factors, as well as technical-economic factors (Yue et al., 2020). Socio-technical systems are recognized by the U.N. as imperative to Sustainable Development Goals (Rojas et al., 2022). The socio-technical theory provides insights to support an organization's need for both social and technical organizational standards to ensure the successful interoperability of Industry 4.0 technologies with human factors. This method creates new business models for new communication and information technology implementation through instituting a high coordination effort (Orzes et al, 2018). Implementing organizational development involves diverse stakeholder participation, is organizationally-led, improves skills, communication, introspection of leadership and culture, and encourages continuous improvement (Blake and Mouton, 2001).

Important concepts to Socio-technical theory are responsible autonomy, autonomous groups, self-regulation, and participant design as part of the digitization process (Thomassen et al., 2017). Socio-technical systems design includes incompletion, in which continuous improvement is fostered (Davis et al., 2014). Another manner of conceptualizing incompletion is as continuous "design-in-use" where insights are collected from a variety of stakeholders, such as workers (Gales et al., 2022). The framework for applying socio-technical design may differ based on variables such as the size of the business. Participative design is a democratic process of integrating the norms and values within the organizational culture into a system's design. The employee is the participant and provides direct input regarding the design, length of participation in the design process, the significance of the input, and the level of decision-making (Ahmad et al., 2022). The three principles guiding socio-technical design per Bastidas et al. are trustworthiness and trust among stakeholders, technical design correlations with organizational context, and access to resources and solutions that directly align with organizational culture. Designing socio-technical work organizations also considers the assessment of competencies, developing cross-disciplinary leaders and defining the tasks of the Industry 4.0 technologies (Bastidas et al., 2023). Furthermore, the socio-technical skill of team fluidity is essential for successfully implementing Industry 4.0 (Nayernia et al., 2022). Additionally, a study conducted by Marcon et al. found that joint optimization of the social and technical aspects will lead to greater technology adoption rates (Marcon et al., 2021).

Socio-technical attributes encourage team responsibility (Kaminiski, 2022). Organizational learning is achieved through the empowerment of employees, creating responsible autonomy observed at both the individual and team levels. Responsibility is the foundation for control, which is found in skill discretion and task authority (Enehaug, 2017). Sharing autonomy is an operational concept that sustains the dynamic relationship between individual autonomy and collective behavior (Heininger et al., 2023).

2.1. Industry 4.0 Adoption Differences Among Small, Medium, and Large Manufacturers

A prerequisite to ensuring the entire supply chain is operating efficiently to meet changing consumer demands is through the integration of the information and communication technologies of Industry 4.0 (Pech and Vrchota, 2020). The key design principles of Industry 4.0 are interoperability, predictability, real-time data analysis, system intelligence, and flexibility

(Nayernia et al., 2022) (Peruzzini et al., 2023). The cyber-physical information flow processes are information acquisition, information analysis, decision selection, decision implementation, and innovation (Heininger et al., 2023). Studies have shown that small and medium-sized enterprises resist sharing data within the supply chain due to data security and negotiation power (Nayernia et al., 2022). Common descriptors of small businesses are low-profit margins, limited training and staff development, informal quality control, narrow customer base, lack of negotiating power over suppliers, lack of long-term plans and strategies, and limited resources and capacities (Minshull et al., 2022). Competitive disadvantages that SMEs have in comparison to large enterprises are a lack of technological infrastructure, lack of advanced manufacturing technologies, lack of management knowledgeable of Industry 4.0, and lack of standard procedures. A recent study by Pech and Vrchota reported that small and medium-sized enterprises utilize technologies commonly for the purpose of analysis, collecting data, and cloud storage (Pech and Vrchota, 2020).

The relative advantages provided by Industry 4.0, the compatibility of manufacturing equipment and processes to intended technology use to drive collaboration and integration, top management support, and competitive pressure are key selling points in support of its adoption (Shahzad et al., 2023). The presence of a digital infrastructure and the personnel's level of knowledge to process and understand data are instrumental to Industry 4.0 adoption as well (Khourshed et al., 2023).

There are estimates that 400 million small and medium-sized enterprises exist worldwide (Haring et al., 2023). Small, medium, and large businesses choose to adopt Industry 4.0 for a variety of reasons. These reasons include increased productivity, customized software, increased customer care, and reduced labor requirements. Small, medium and micro-sized businesses vary among the multitude of socio-economic contexts offered throughout the world. Waste reduction and increased productivity may be observed by increasing productivity through tools, such as Industry 4.0 (Qureshi et al., 2023). Often the Industry 4.0 integration plans are focused on production processes without regard to the entire work system and resource connectivity (Cerne et al., 2023). Businesses located in rural markets are typically smaller and have a higher concentration of solopreneur and micro-businesses (Jones et al., 2020). According to a Price Waterhouse Cooper report, the Industry 4.0 integration leads to a greater than 10% outcome in both the improvement in efficiency and a reduction in operational expenses (Bag et al., 2021). As well, industrial organizations that undergo a digital transformation may be more resilient to global crises (Neuhuttler et al., 2023).

McDermott et al. conducted a study of small, medium, and micro enterprises in the west of Ireland in 2022. The popular tools indicated to be helpful in this study by survey respondents were automation, smart processes, automated inspection, and cloud computing. The aims for adopting Industry 4.0 within small, medium, and micro enterprises were improved customer experience, reduced costs, improved long-term outlook for the business, improved product and service quality, increased profits, and increased capacity (McDermott et al., 2022). Automation may address both cognitive and manual activities, such as manual work, manual control, control activities, judgment and decision making (Stern & Becker, 2019).

The study also found that having the right equipment or software solution, having knowledgeable employees, having consultancy support, and having an adequate budget were critical success factors. A factor that the study considered as indicating a lack of Industry 4.0 adoption was the absence of leadership vision tethered to innovation through the use of new technologies (McDermott et al., 2023).

Obstacles may exist to adopting Industry 4.0, such as increased unemployment generation, data vulnerability, and challenges to device interconnection. Short-term risks to adopting new technologies include lack of employee expertise and short-term strategy (Kumar et al., 2021). A recent study conducted on the impacts of Industry 4.0 on industrial employment indicated as employees become familiar with digital transformation the less likely they are to expect substantial changes to workforce levels (Shuttleworth et al., 2022). An additional challenge may be a narrowly defined product portfolio in which to automate (Haring et al., 2023). Moeuf et al. reported that small and medium businesses have the potentially downside characteristics of local management, short-term strategy, lack of expertise, non-functional organization, limited resources, short-hierarchical lines, and lack of methods and procedures, which are challenges to adopting Industry 4.0. The study suggested simplifying the utility of a tool, such as a cloud computing platform for big data analysis to "offset a lack of technical competency, which is characteristic of the small and medium enterprise context". Another characteristic highlighted in the report by Moeuf et al. is that small and medium-sized businesses are innovative, entrepreneurial, and studious. Relaying the importance of data and orienting the small and medium-sized manufacturing operator toward leveraging data for regular operational use are catalysts for Industry 4.0 adoption and require the application of socio-technical theory design principles, as they imply continuous improvement processes. Implementing Industry 4.0 for these business sizes requires a leader specifically assigned to the Industry 4.0 project, who will engage in the necessary communication, have the necessary skills, factor in training versus consulting, and ensure the simplification of Industry 4.0 tools (Moeuf et al., 2021). The implementation of Industry 4.0 will require the organization to leverage Intrapreneurship to convey needed creative and innovative internal resources (Gupta & Jauhar, 2023). An agile process that is specific and structured may align well with smaller enterprises and support aptitude building (Minshull et al., 2022). The employees are invaluable to contributing knowledge and problem-solving strategies, which allows for the integration of both human or worker data and machine data to create greater operational efficiencies (Peruzzini et al., 2023).

Managing the Industry 4.0 transformation in small and medium-sized enterprises (SMEs) differs compared to large enterprises. As mentioned above, small, and medium-sized enterprises tend to focus on short-term strategies and objectives. Flexibility is used when assessing new opportunities and challenges. Processes may not be in place compared to more organizationally mature large enterprises. Additionally, in comparison, large companies often strategize digital transformation throughout a larger architectural footprint. Systems are implemented to acquire vast amounts of data and initiate data valorization projects to leverage insights from the data acquired (Brodeur et al., 2022). The digital transformation in the large business focuses on business processes, integrating agility, improving work-balance, and increasing operational efficiencies overall (Cotrino et al., 2020). Success factors for small and medium-sized businesses that were highlighted by Brodeur et al. are aligning Industry 4.0 with business strategy, leadership, aligning along a hierarchical line, conducting a study prior to Industry 4.0 projects, managing communication, teamwork and team composition, employee training and knowledge management, organizational culture and change management, project management, and continuous improvement strategies. Continuous improvement strategies foster the development of employees’ agility to learn new tools and processes (Brodeur et al., 2022). New technologies, such as AI are lacking in transparency and have abridged innovation timeframes leading evermore to the necessity of organizational flexibility (Neuhuttler et al., 2023). Organizations instilling the strategy of continuous improvement are focused on both developing employee commitment and motivation, as well as operating more efficiently (Oudhis & Tenglad, 2020).

Knowledge management is defined as a continuous management of all types of knowledge and requires a comprehensive strategy inclusive of the elements of policy, implementation, monitoring, and evaluation. Knowledge management supports the organizational growth in the areas of skills and capacity building (Smuts & der Merwe, 2022). The production of organizational knowledge is heightened with the utilization of Industry 4.0 as it allows for opportunities to share, creating sustainable, safe and educated society (Satyro et al., 2023).

Throughout the process, self-evaluation translates into the capacity to execute and manage Industry 4.0 transformation, assessment of financial abilities, employees' expertise and experience in Industry 4.0 technologies and projects, internal project management and continuous improvement processes, resistance to change, and external resource availability. The company's management and key employees should be actively engaged in the evaluation process and communicate openly the results with the SME management (Brodeur et al., 2022). Industry 4.0 technological solutions will differ among small, medium, and large businesses. Implementation standards among groups will vary. Research has also shown that small and medium-sized businesses are often suppliers for larger businesses that are operating on Industry 4.0 principles. Digital transformation applied to logistics will realize efficiency gains along the entire supply chain (Tubis & Grzybowska, 2022).

Furthermore, the differences impacting Industry 4.0 implementation outlined between SMEs and large businesses are as follows. SMEs have barriers to accessing financial resources, advancing manufacturing technologies, research and development, standards, and strategic partnerships with universities and research institutions. Moreover, SMEs utilize software that is tailored and therefore not standardized. Additionally, there are few knowledge carriers, and the leader is responsible for decision making. The SME organization is informal and simpler. The SMEs' human resources operate in a variety of domains. The SMEs' industry knowledge and experience are very specific. They are dependent on collaborative networks. Large businesses make decisions through boards of advisors and internal and external consultants. Large businesses exhibit contrary characteristics to SME traits (Tubis & Grzybowska, 2022). The deficit in resources hinders SMEs from participating in advanced value co-creation. Creative solutions exist for SMEs, such as mergers and acquisitions, inter-enterprise collaboration, and industry-university research cooperation, which represent open innovation ecosystem's value co-creation models (Li et al., 2022). Open innovation allows manufacturers to diversify and expand through connecting with innovative ideas, utilizing innovation inputs, and informing its supply chain to optimize its use (Madhavan et al., 2022). With regards to the open innovation ecosystem, this setting is characterized by its invitation to a diverse set of collaborators to provide insights and solutions to real organizational problems (Riquet et al., 2022). Open innovation allows consumers to participate in the design process of products, since the boundary between the consumers and designers works collaboratively to meet customization requirements (Yao et al., 2021). Open innovation also may expedite the innovation process while creating knowledge-sharing opportunities, decreasing costs, and targeting effectiveness. One study found the impetus for innovating in Industry 4.0 stemmed from the market force of substitution through the new market entries of content modifications with products and innovations (Kohnova & Salajova, 2023).

2.1.1. Reviewing The Nature of Small, Medium, and Large Manufacturers—The Changing Environment and Current Skills Gaps

The constructs of management, operations, and technology readiness directly correlate with the readiness of an organization to implement Industry 4.0 technologies (Ali et al., 2022). According to a recent study, Industry 4.0 is observed more with manufacturers in the B2B market than the B2C market (Kanovska and Bumberova, 2021). The nine fields of Industry 4.0 are cyber-physical systems, internet of things, big data, cyber security, cloud computing, additive manufacturing, advanced robotics, modelling and simulation, and augmented virtual reality (Peruzzini et al., 2023). These innovative technologies also include blockchain, digital platforms, autonomous vehicles, synthetic biology, artificial intelligence, machine learning, and analytics (Asiimwe & de Kock, 2023).

It is often cited as a barrier that small and medium-sized enterprises have limited skills that relate to the Industry 4.0 context. The socio-technical systems readiness survey assessments can assist with preparing the employees for the information that will need to be gathered, analyzed, and shared to utilize the newer communication and information technologies optimally (Setyaningsih et al, 2020). Employees will be required to develop new skillsets to manage the utilization of cyber-physical systems, the Internet of Things, cloud computing, enterprise resource planning, radio frequency identification, and social product development as key technologies in the manufacturing setting.

The Internet of Things is supported by cloud and edge computing, which allow process storing and interconnection (Trehan & Machhan, 2022). Cloud computing is very reliable, scalable and is offered at a low cost, which is a significant pathway for providing accessibility to the implementation of Industry 4.0 to small and medium-sized businesses (Liu et al., 2021). One report indicated that cloud storage and computing are the most adopted technologies used by SMEs. Additional technologies and practices that are imperative for employees to understand are enterprise resource planning systems, manufacturing execution systems, real-time key performance indicators, and a knowledge management system. Observation and data collection are required activities to integrate Industry 4.0 (Roy et al., 2023).

2.1.2. Adopting Socio-Technical Design in the Industry 4.0 Context

The work organization operates with goals and metrics and the aid of people of varying skills and attitudes, using a range of technologies and tools, leveraging infrastructures, holding specific cultural orientations, and following a set of processes. A work organization is a system that operates within the external environment and is impacted by regulatory frameworks, stakeholders, and the economic and financial environment. The socio-technical framework assists with predictive work, such as determining productivity outcomes and labor scheduling, and is significant in designing and overseeing digital project implementation. The themes of end-user engagement and team-based approaches promote sustainability. Socio-technical system design involves the concept of incompletion, which requires continuous improvement (Davis et al., 2014). The concept of incompletion or an 'unfinished system' affords the organization the ability to pivot to address new short-term demands, as well as assess and advance the socio-technical system once new demands become new operational conditions (Maguire, 2014). Bastidas et al described the socio-technical design of tasks as a linear process of "planning tasks, testing tasks, embedding tasks, and enabling tasks", which relates to the operational process outlined by Davis et al (Bastidas et al., 2023). The digital transformation process allows manufacturing SMEs the ability to become more flexible, agile, and responsive to customer needs. Digital transformation can be integrated in design, planning, manufacturing, research and development, and service activities (Dutta et al., 2021). The structure of work, technology, and design practices are ever changing, informing the use of socio-technical principles and applications.

Challenges to adopting Industry 4.0 among SMEs have been reported as a lack of employee knowledge and training capabilities on quality issues, financial constraints, cyber security, resistance to change, organizational culture, large data volume, integration of digital tools in infrastructure, data quality, and data ethics (Malin et al., 2023). Additional challenges to Industry 4.0 implementation have been reported as poor existing data, lack of employee skills, and lack of technological infrastructure. Manufacturers may also lack government support and be unclear of the economic benefits (Alsaadi, 2022). Smart or digital retrofitting has been a cost-effective solution employed by SMEs to provide advantages to successfully adopting Industry 4.0. The practice requires the utilization of software, such as artificial intelligence, machine learning algorithms, neural networks, digital twins, cloud systems, and remote maintenance (Pietrangeli et al., 2023).

Cross training employees to understand skills from divisions outside their own strengthens internal capacities to conduct continuous research, analysis and decision making, which are integral skills to developing employee adaptability (Sony & Mekoth, 2022). As well, the type of digital maturity of an organization provides an indication of how innovative and responsive to customer requirements the SME is likely to be (Dutta et al., 2021). The level of organizational focus on social factors, such as training and management support also provides advantages to adopting Industry 4.0. Economic factors such as employee innovation and perceived usefulness also support Industry 4.0 adoption rates. The technical subsystem of holistic internal cooperation, effective use of knowledge, techniques, equipment, and facilities also support digital transformation (Zemlyak et al., 2022).

Project teams representing a diversity of stakeholders may work to ensure that human factors are integrated due to the team's specific work knowledge that will contribute to socio-technical design (Choi et al., 2022). An iterative approach in developing cross-trained employees is commencing in a specific area within the organization and scaling across divisions. This allows the organization to cautiously build internal capabilities of employees to work with data and to interpret this successfully while quickly creating successful outcomes (Harland et al., 2022). The socio-technical theory emphasizes joint optimization, however, when the conditions create an imbalance that optimizes social and technical factors without interaction, unpredictable and unplanned outcomes may occur (Tortorella et al., 2022). Therefore, in the formation of predictive work the identification of social aspects or human factors will require consideration at all three phases of conceptualization, design, and implementation of Industry 4.0 into the existing organization. To carry out this socio-technical framework the design must follow a pattern of "defining the technology, identifying the affected humans, identifying the technology, task scenario analysis and impacts, and outcome analysis" (Neumann, 2021). This implementation process involves data gathering, analysis and interpretation, summarizing the findings, testing the results with stakeholders, and iterating and amending.

2.1.3. Organizational Learning in the Socio-Technical Design Context

Learning is the creation and management of the acquisition of knowledge, skills, and attitudes, which aims to continuously improve employee performance (Gamero, 2018). Organizational learning occurs when new knowledge is integrated into the organization therefore being co-leveraged with current institutional knowledge to enhance systems, routines, rules, and procedures (Haraldseid-Driftland et al., 2023). Organizational agility requires employee adaptability, which is fostered through a socio-technical design of work that encourages organizational learning and employee empowerment for task discretion. The socio-technical design continues to evolve with the integration of a human-AI operations model, which calls for updated methods of analysis, organizational learning, and autonomy (Fischer et al., 2023). The four major skillsets of AI are perception, understanding, acting, and learning, which expand the logical foundations of input, processing, and output of typical IT systems. AI's attributes contribute to continuous self-optimization, which is ideal for a human-AI collaborative environment (Garrel & Jahn, 2022). Socio-technical workplace design must also consider skills, aptitudes, and control strategies within the human-AI dynamic to include assessments of strategic contributors to collaboration beyond the human-AI duality, collaborations on the shopfloor, impacts of time on collaboration, developed processes for shared control and responsibility, and develop holistic organizational work concepts (Weiss et al., 2023).

A four-step process for transforming work was identified as the 1) developing production-oriented skills, network, and jobs, 2) devise future-centric work designs, 3) create short, medium, and long-term idea models to test, and 4) engage the new idea model and encourage creativity within the practices and culture of the organization (Gratton, 2022).

Organizational learning strengthens preparedness to anticipate and solve problems, as well as navigate change. Long term strategies that involve curating and leveraging data instill an orientation towards learning. Activities contrary to developing a culture of organizational learning and continuous improvement are resistance to change, cultural lock-in, and assumed continuity. Activities in support of a cultural of organizational learning are knowledge sharing, employee engagement, and productivity transparency (Chinoperekweyi et al., 2022).

Principles for jointly optimizing both social and technical aspects of an organization call for continuous learning to be instilled in the strategic vision. Feedback is provided for the individual and organizational perspectives to contribute to the ongoing development of the social aspects (Fischer et al., 2023). Modern socio-technical system design involves democratic dialogue, which encourages democratic interrelation of stakeholders. Democratic dialogue moves away from the one-directional communication and encompasses two-way dialogue, which is a participatory design process. It is important to note that a close knowledge with the work organization fosters the collaboration and solution focused model of democratic dialogue (Thun et al., 2022). The eight learning principles of using a collaborative approach, creating collaboration across levels of stakeholders and contexts, high flexibility that accommodate time, ensure usability and easy access, highly relevant for context, create space for reflection, create awareness for adaptive capacities, and share examples of good practice were also reported in a recent study (Haraldseid-Driftland et al., 2023).

Productive organizational learning encourages an organization to improve, learn in a productive manner, and engage in organizational inquiry on behalf of the organization. When operational problems arise, employees inquire and recommend new methods of solving them. The development of an organization that values employee learning is a first step to creating autonomy. When productive organizational learning is combined with responsible autonomy and employee control, an environment of socio-technical sustainability is created (Enehaug, 2017).

The socio-technical process of meta-design supports collaborative learning through the design process where system users are designers. The design of the design process itself is considered, due to the technical and social aspects, a greater inclusive socio-technical system. End users are thus designers rather than passive users of the socio-technical system (Cabitza et al., 2020). Five meta-design principles are support for cultures of participation, mechanisms to support empowerment for adaptation and evolution at use time through user-driven adaptability, a procedure model of seeding, evolutionary growth, and reseeding, semi-structured modeling, and a walkthrough-oriented facilitation (Fischer, 2011).

An enabler to integrating Industry 4.0 within the organization is shared learning, which is found concurrently with activities, such as shared trust, shared visual understanding, and shared user perspectives (Thun et al., 2022). Change agents may also be in place to ensure ongoing education, training, and communication for facilitating a culture of organizational learning (Loh and Koh, 2004).The actions of creating cultures of participation, empowering adaptation, fostering growth, and structuring communication contribute to creating this condition (Fischer & Herrmann, 2011). The competitive advantage of successfully recruiting the best talent may also lie in providing meaningful, challenging, and enjoyable employment.

Also, continuity is observed through organizational learning, which engages employees to improve task completion, job performance, and preventative work. Employees that exert control illustrate greater skill discretion and task authority, which are the foundation of responsible autonomy (Enehaug, 2017). When assessing events or projects the level of employee job control is critical to ensure the diversity of organizational design. Job control leads to employee engagement, which supports continuous learning and coping strategies to respond to disruptions and challenges in workflow processes. Holistically, the professional development of employees who operate under an increased range of mobility leads to increased agility (Gobers, 2023). Socio-technical work design focuses on improving the diversification of task options rather than minimizing them (Fischer et al., 2023). Sgarbossa, F. et al reported that research found a positive correlation between job rotation and job satisfaction (Sgarbossa et al., 2020). Industry 4.0 technologies will alter work strategies, potentially with permanence, therefore understanding the human factors involved, such as employee experience is critical to averting feelings of reduced autonomy, lessened competence, and counterproductive work behaviors (Grosse, 2023).

2.1.4. Reducing Work Week Schedules in the Socio-Technical Design Context

Industry 4.0 tools are enabling technologies to foster the support of communication and the sharing of information and collaboration between individuals, accessibility, and security to the flow of data, mobility of work times and locations, and improved productivity and working conditions for employees (Cimini & Cavalieri, 2022). As well, flexible work arrangements are a result of trust as a management control strategy (Abgeller et al., 2022).

According to studies of the four-day work week, the results indicated improved employee morale, engagement, and increased productivity (Campbell, 2023). The benefits of flexible work hours are also reduced turnover and absenteeism, increased work-life balance, greater motivation, increased training opportunities and staff qualifications, workplace mobility, and time savings due to lessened travel (Kostadinova & Vladkova, 2022). An increase in job and life satisfaction directly correlates to increased productivity due to the employees' assigned meaning to the tasks. (Ferrara et al., 2022). According to a study conducted by Laursen the autonomy to select work schedules was the most important form of its definition to young workers (Laursen, 2021). AI is increasing in pervasiveness within work systems across industries. Benefits of AI are process improvements and innovation. When developing AI, a socio-technical context must be maintained to ensure that trust is built in through the creation of transparency of the decision-making process and data policies (Werens & von Garrel, 2023).

Employee engagement is essential in strategic planning to achieve desired productivity outcomes when following a four-day work week schedule. When employees view the company as a brand, social interaction is increased among employees, and happiness inspired at work all positively influence employee performance (Chakraborty et al., 2022). Furthermore, according to a survey respondent of a study conducted by Whiteoak and Sullivan it was stated that family culture is contrary to change, which holds a significantly different meaning other than an employee culture that views the organization as a brand (Whiteoak, 2022).

An earlier study reported by Enehaug showed that the reduced daily work hour goal initiated better coordination and cooperation through the re-scheduling of work shifts. These factors served as a coping mechanism for the employees (Enehaug, 2017). Whiteoak and Sullivan also conducted a socio-technical analysis of a manufacturing firm in Australia to assess the option of instilling a reduced work week goal or other alternative work arrangements. Three main recommendations resulted, which were to integrate a bottom-up approach to job crafting, explore micro-efficiencies, and value quality over quantity in work design as methods to achieve a reduced work week goal (Whiteoak, 2022). Creating time for high-quality focus, collaboration, and reducing distractions and inefficiencies is essential (Pang, 2020). Prioritizing working hours and ensuring the brain functions at its best support collective efficiency (Abildgaard, 2019).

Socio-technical theory encourages that as the workflow process is more simplified to incentivize employee involvement that the tasks are enriched to create a more varied and humane working environment. The goal is that this strategic action espouses innovation in the organization and results in increased productivity. The ability to oversee unexpected events and deal with problem solving for the employee is also addressed in this activity (Klemsdal et al., 2017). As an example, a study of modern socio-technical theory when applied develops opportunities to reduce the frequency of repetitive jobs in an organization, such as through integrating interventions such as the creation of semi-autonomous teams (Vermeerbergen et al., 2021). This study outcome is in line with the socio-technical concept of responsible autonomy and autonomous work groups (Guest et al., 2022).

2.1.5. Practicing Responsible Autonomy in the Socio-Technical Design Context

An employee's responsible autonomy is a core value of the socio-technical design process (Flinchbaugh et al., 2016). As outlined by Yadav et al. the socio-technical criterion described by Cherns discussed as eliminating or controlling variances as close to the point of origin as possible refers to allowing employees to learn from mistakes, if applicable, and involves the freedom to conduct 'self-inspection' (Yadav et al., 2017). The socio-technical system theory notes that responsible autonomy describes the collective learning of employees to ensure skillsets are developed to promote a more independently self-governed work organization. Sustainability is supported by employees' autonomy and control of workplace conditions, in other words self-leadership (Amble, 2013). Furthermore, autonomy represents the employee's freedom, independence, and discretion to determine methods of completing work and choice in selecting work schedules (van Kleeff et al., 2023). Work design considers both the physical and mental aspects to ensure the feasibility, safety, and relevancy of tasks to promote job satisfaction and personal development (Stern & Becker, 2019). Studies have found that employee training, empowerment and job-enrichment partnered with 'worker task capability' and 'flexibility in staffing' are connected to the successful implementation of Industry 4.0 (Das and Jayaram, 2007).

The goal of Industry 4.0 is to gain autonomy, decentralization, responsibility, and teamwork (Tortorella et al., 2022). To achieve responsible autonomy leadership takes a significant role in creating a work environment that supports flexibility in an employee's place and time of work. When employees find meaning in their work and have the ability to customize technology, increased productivity is observed (Fischer et al., 2023). Designing a socio-technical organization jointly optimizes both technical and social systems, which aligns with the employee's values thereby creating greater trust and job satisfaction (Liscio et al., 2023). Primary job characteristics that are desired are described as encompassing skill variety, task meaning, task identity, autonomy, and feedback (Kwiotkowska & Gebczynska, 2022). Research illustrates that improving an employee's autonomy and task discretion correlates directly to perceived benefit of flexible work arrangements (Tortorella et. al, 2023).

The meaning of work may be derived from an employee's motivation to determine their tasks physically and cognitively. Several job crafting practices exist, such as amending task boundaries and the quantity of tasks completed. In terms of cognitive crafting, the task boundaries and perception of work are open to change by the employee. An additional aspect of job crafting is defining the social interactions and frequency thereof in the workplace setting. Reasons for job crafting include employee control, meaning, socialization, and employee self-identity, which are all significant factors during a period of digital transformation. Learning algorithms may divert employees to strengthening their focus on the development of the social aspects within the socio-technical work organization. Social aspects include the people, culture, and goals and may be focused on redefining the meaning of work. (Perez et al., 2022).

One method of completing work, such as creating cross-functional diagrams of processes and resources, helps to identify the root cause of factors impacting workflow times and identifying the relationships influencing outcomes that occur (Alsakka et al., 2023). Cross-functional diagrams encourage the design of adaptation, dynamic cooperation, and work distribution (Pacaux-Lemoine et al., 2022). To support employee autonomy cross-functional diagrams aid in providing discretion to design workflows to jointly optimize both technical and human factors, which assists with managing work demands and therefore reduces the potential for employee burnout. The mapping of interrelated activities and resources jointly by management and employees assists with accurately setting productivity goals, employee appraisals, and reduced work hours (Delaney & Casey, 2023). A digital leadership will encourage the creative use of technology to espouse employee motivation, productivity, and efficient resource allocation, thus strengthening organizational capacity (Shin et al., 2023).

2.1.6. Leading in the Socio-Technical Design Context

As businesses respond to increased product and service customization requirements, the upskilling of employees to manage digital technologies will be valuable (Achieng, 2022). The World Economic Forum's report on the future of work highlights these ten job skills: creativity, emotional intelligence, analytical thinking, active learning, judgment and decision making, interpersonal communication skills, leadership skills, diversity and cultural intelligence, technology skills, and embracing change (Szabo, P. et al., 2023). Developing cross-functional teams allows for a bottom-up leadership approach where employees lead communication efforts to effectively integrate digital transformation. This communication structure is agile as it allows for the diffusion of operational information and innovation for the purpose of creating value and supporting an organization's most successful strategic objectives within the internal and external subsystems of a socio-technical system (Leso et al., 2022)(Whiteoak, 2022). The bottom-up leadership style, also considered a self-organizing manufacturing system, is a decentralized approach to problem-solving as it involves diverse communication sources (Maltseva et al., 2022). The employees are integral to the production process and can therefore leverage in-depth their industrial knowledge to impart qualitative and quantitative data to contribute to continuous improvement and knowledge creation (Colombari & Neirotti, 2023). In digital transformation employees' roles may change to incorporate tasks that are more engineering in nature, such as process control or continuous improvement, which will require a mindset of ongoing training (Waschull et al., 2022). As well, another critical soft skill in Industry 4.0 is an agile mindset (Lima et al., 2023). This mindset allows the organization to weather external market forces that are supported by Industry 4.0 (Kohnova & Salajova, 2023).

Communicating as an organizational unit across departments and teams allows employees to identify areas of improvement that lead to greater operational efficiencies. This strategy provides an antecedent to moving to a reduced work week schedule (Whiteoak, 2022). A flexible organization activates the involvement of a variety of teams, units, and organizations for which the system design will be utilized (Haraldseid-Driftland et al., 2023). A digital leadership that understands that as the employee base becomes more decentralized, methods of long distant employee motivation and coordination will be crucial to performance success (Hirsch-Kreinsen, 2023). Mutually transferring knowledge across all organizational levels will elevate the employee to the role of knowledge worker (Davies et al., 2017). Allowing for the continuous facilitation of employee training and feedback strengthens employee engagement and therefore operational effectiveness (van Kleeff et al., 2023).

Leadership characteristics such as promoting self-awareness, listening, serving those on the team, helping people grow, coaching versus controlling, promoting safety, respect, and trust, and promoting the energy and intelligence of others are critical skills. (Project Management Institute, 2017). To maintain a high-level of employee trust, the development of standard operating procedures to guide the implementation of Industry 4.0 is essential. Standard operation procedures represent the technical subsystem of a socio-technical system. They provide a useful guide for an organization to prioritize processes carrying out digital transformation. The work processes, systems architecture and data formats are then assessed to strategize the purpose for digital integration, data use, employee use, and return on investment (Budde et al., 2022). When an organization holistically agrees upon these organizational procedures, a greater propensity for the robust adoption of Industry 4.0 is ensured (Liu et al., 2022).

Employee learning is a continuous process to maintain, as it fosters a sustainable growth advantage of trained personnel. Opportunities for employees to learn and encourage each other to learn, as well as provide feedback will support new technology adoption (Chaudhuri et al., 2023). A flat organization rather than a hierarchical leadership structure provides a suitable environment for digital transformation as this represents an employee base with greater engagement and responsible autonomy. These organizational characteristics espouse a flexible, agile, learning, innovative, and communicative culture. Organizations that have exhibited a contrary structure have experienced lower levels of technology adoption. According to the socio-technical systems framework provided by Davis et al., the six internal subsystems of people, culture, goals, processes, infrastructure, and technology are all equally important to strategically build internal capacity within to ensure successful interoperability and dynamic performance (Sergei et al., 2023). Dynamic performance anticipates external opportunities and threats, assumes opportunities, and achieves competitive advantages through continuous improvement and the reconfiguration of intangible and tangible organizational resources (Bag et al., 2021).

Organizational flexibility may be observed in the contexts of part or product and process, which may be completed utilizing a variety of equipment, processes, and resources. Flexibility is achieved through the aggregate planning among various operational functions (Salunkhe & Berglund, 2022).

2.1.7. Understanding the Impact of Industry 4.0 in the United States and Worldwide

According to a study conducted by Michulek and Gajanova, publications on the topic of Industry 4.0 were assessed during the 2016-2022 timeframe. The number of total publications on the topic of Industry 4.0 during the 2016 -2022 on the Web of Science database is trending as follows:

1. Germany – 2450
2. Italy – 2,318
3. China – 1,515
4. USA – 1,220
5. India – 1,198
6. Great Britain – 1,277
    a. England – 1,064
    b. Scotland – 121
    c. Wales – 69
    d. Northern Ireland – 23 (Michulek & Gajanova, 2023).

A separate study utilized the Web of Science Core Collection to assess the academic literature published in 2018 on the topics of artificial intelligence, big data and the internet of things to identify the top 20 countries researching these fields. In the order of the number of significant contributions from most to least frequent on the topic of artificial intelligence, they found that China, USA, Korea, India, England, Italy, Spain, Australia, Germany, Japan, Taiwan, Canada, Iran, France, Brazil, Saudi Arabia, Malaysia, Turkey, Netherlands, and Pakistan were the academic research presence in the field. With regards to the United Kingdom of Great Britain and

Northern Ireland, they found that England had the most publications, followed by Scotland, then Wales, and finally Northern Ireland (Mizukami and Nakano, 2022).

Furthermore, another study conducted a cluster analysis of the 33 European Union countries and classified groups of countries according to similarities in Industry 4.0 performance. Cluster 1 represented France, Portugal, Malta, Slovenia, Luxembourg, Austria, Spain, Cyprus and Italy. Cluster 2 represented Belgium, Germany, Netherlands, Sweden, Norway, Denmark, Finland, and Lithuania. Cluster 3 represents Bulgaria, Greece, and Romania. Cluster 4 represents Hungary, Turkey, Latvia, Poland, Macedonia, and Serbia. Finally, Cluster 5 represents Croatia, Slovakia, Czech Republic, Estonia, UK, Ireland, and Iceland (Atik and Unlu, 2019).

Moreover, fifteen countries throughout the world have initiated industrial plans to move Industry 4.0 forward within their respective geographic and economic contexts. The countries and their initiatives are as follows:

- Australia – Industry 4.0 Testlabs
- Belgium – Made Different
- Denmark – Manufacturing Academy of Denmark (MADE)
- France – Industrie du Futur
- Germany – Germany: Industrie 4.0
- Italy – Impresa 4.0
- Japan – Society 5.0
- The Netherlands – Smart Industry
- People’s Republic of China – Made in China 2025
- Portugal – Industria 4.0
- Singapore – Research, Innovation and Enterprise 2020 Plan

- South Korea – Manufacturing Industry Innovation 3.0
- Spain – Industria Conectada 4.0
- The United Kingdom – The Future of Manufacturing
- The United State of America – Advanced Manufacturing Partnership (Yang, F. and Gu, S., 2021).

More recently the Office of the European Union has published a report in 2023 titled "Analytical insights into the global digital ecosystem" (Calza et al., 2023). The shared insights provided by the EU's Joint Research Center highlighted the following items.

1. The digital profile of China, the largest competitor of the U.S., indicates that dynamic data, artificial intelligence, autonomous systems, robotics have a significant presence. As well, in the U.S. the infrastructure, cloud computing, artificial intelligence, and dynamic data are key. In the E.U., infrastructure, cloud computing, dynamic data, and artificial intelligence are leading investments. In the rest of the world, infrastructure, cloud computing, dynamic data, semiconductors, and power electronics are key investments.
2. It is interesting to point out that in the U.S.'s digital profile that dynamic data is focused on less than that in the China, E.U., and the rest of the world. Also, the U.S. does not include in its digital profile a significant investment in the Internet of Things.
3. In contrast, China's digital profile includes infrastructure, cloud computing, and the internet of things as far lesser investments at 5%, respectively.
4. The E.U. displays the highest strategic value, which suggests a strategic position in the network of Research & Innovation activities, such as patent applications, in autonomous systems. This may be due to the fact that the E.U. players display an intense collaboration with players located outside the E.U., implying that the E.U. may be in the position to act

as bridge or as bottleneck controlling the flow of knowledge through this specific network representation of the global digital ecosystem.

5. China dominates the autonomous system category in terms of the level of engagement. The strategic position of China is lower, which may indicate fewer Research & Innovation activities, such as patent applications.
6. The engagement level in the U.S. is slightly greater than in the E.U. However, the strategic position is at least half of the E.U. This may indicate fewer patent applications. The rest of the world illustrated aggregately far less strategic positions and engagement activity than the E.U., China, and the U.S.
7. The U.S. leads in the Industry 4.0 fields of infrastructure/cloud computing and cyber security. U.S. businesses place a close second in the integration of artificial intelligence to China.
8. In the U.S. the organizations leveraging Industry 4.0 are primarily businesses, followed by research institutions and universities. There is a nominal representation by government organizations.
9. In contrast China has more businesses leveraging Industry 4.0 than the U.S., European Union and the rest of the world.
10. As well, there is significantly more representation of Industry 4.0 usage among China's research institutions, universities, and government agencies. (Calza et al., 2023).

2.1.8. Integrating Industry 5.0 into the Industry 4.0 Context

Industry 4.0's purpose coordinates distributed information and communication technologies with operational technology within a cyber-physical system allowing a human operator to ensure the ability to mass customize and personalize through intelligence (Michulek &

Gajanova, 2023). Industry 4.0's emphasis is lacking a focus on the promotion of social aspects and the consideration for environmental conservation (Ghobakhloo et al., 2022).

Industry 5.0 is the continued development of Industry 4.0 to one that is sustainable and resilient and that emphasizes digital sustainability, environmental awareness, and human-centeredness. As an example, smart quality management focuses on research and innovation as a human-centered role. (Bajic et al., 2023). Sustainability has been defined as meeting the present organizational needs without jeopardizing the future requirements. Sustainability in the Industry 4.0 context are the economic, ecological, social, and corporate social responsibility factors. This aim is achieved through the 6R approach of reducing resource dependency, reusing end-of-life products and components, recycle waste materials into materials, redesigning recovered materials and resources for new product lines, recovering products at the end of the stage, and remanufacturing or restoring products for future use (Dossou et al., 2022).

Industry 5.0 has also been described as that it "reflects the value of humanistic care and integrates human subjectivity and intellect with the effectiveness, artificial intelligence, and accuracy of robots in industrial production, accomplishing the progression toward the symbiotic ecosystem" (Michulek and Gajanova, 2023). The Triple Bottom Line is the term used to describe the aim of measuring performance in Industry 5.0 around environmental, social, and economic goals (Dossou et al., 2022).

The circular economy represents this pull towards sustainability, as it is described as a practice of retrofitting industries to improve reusing, remanufacturing, and the reduction of waste resources. Fundamental to this initiative is to "preserve and enhance natural capital", "optimize resource yields" and "foster systems effectiveness" (Varbanova et al., 2023). The circular economy has been referred to as "a business model focusing on the entire economy" as it focuses on perpetuating the solutions (Dossou et al., 2022).

Industry 5.0 focuses on integrating cognitive computing and the Internet of Things and, according to a report on Europe's industrial future, it should be viewed as a continuous evolution of Industry 4.0. Industry 5.0's imperative is to move away from the techno-centricity and the digital divide that has marred Industry 4.0 and transition to energy transition technologies, smart materials, and cognitive artificial intelligence. Industry 5.0's focus on elevating the importance of social factors in the use of Industry 4.0 technologies eases the digital divide and facilitates equitable development.

Five key characteristics define Industry 5.0. They are as follows: sustainable development and performance-driven competitiveness, human resource centered strategies inform the digital transformation, value chain expansion using standards and effective technologies, an emphasis on stakeholder engagement throughout innovation cycle, technology management, and sustainability management, and innovation with a core alignment with environmental sustainability (Espina-Romero et al., 2023).

Sustainable industrial development has been described as building digital transformation competency, eco-innovation (environmental and social), stakeholder collaboration and integration, sustainability orientation and performance management, sustainable value network composition, and corporate and technology governance (Ghobakhloo et al., 2022). The socio-technical systems theory is also a potential enabler for Industry 5.0 researchers to explore, as this agenda aligns with the theory's core impetus of jointly optimizing both social and technical factors of the work organization.

Data researchers implement smart manufacturing systems in Industry 5.0. To carry out the integration they must understand the workflow processes to select the appropriate data to analyze and model, such as through the real-time big data collection and processing methods of edge computing in order to prepare small data sets to identify significant information (Bajic et al., 2023). The following countries have published the most academic research on measuring the sustainable performance of SMEs that are undergoing digital transformation – Italy, China, Finland, Indonesia, and the UK (Melo et al., 2023). The following countries are ranked as to the level of contribution of published content on the topic of Industry 5.0.

1. China
2. India
3. USA
4. Italy
5. Great Britain (Michulek & Gajanova, 2023).

The number of total publications on the topic of Industry 5.0 during the 2016 -2022 on the Web of Science database is trending as follows:

1. 2016 – 1
2. 2017 – 0
3. 2018 – 2
4. 2019 – 10
5. 2020 – 21
6. 2021 – 58
7. 2022 – 201 (Michulek & Gajanova, 2023).

The key enabling technologies of Industry 5.0 that have inclusive, sustainable, value-sensitive, and universal design attributes have been noted as cognitive artificial intelligence, extended reality, human interaction and recognition technologies, cognitive cyber-physical systems, industrial smart wearable, intelligent energy management systems, intelligent or adaptive robots, dynamic simulation and digital twin, and smart product lifecycle management (Agote-Garrido et al., 2023).

2.1.9. Implementing Industry 4.0 by Utilizing a Socio-Technical SWOT Analysis

When focusing on the implementation of Industry 4.0 in the small and medium-sized enterprise context, it is imperative to consider the "how", "what", and "why" scenarios of the future development of the smart manufacturer. (Grefen et al., 2022). The Industry 4.0 integration will have impacts throughout the entire organization, such as with the production, administration and control, human resources, and inventory and warehouse management departments. Understanding the strategic and tangible benefits with regards to resource utilization, expenditures, risks, and scheduling is essential (Loh and Koh, 2004).

A SWOT analysis is the review of the strengths, weaknesses, opportunities, and threats of an organization to understand the formal position of the organizational structure both internally and throughout the supply chain network external to the manufacturer. Examples of items to be assessed include internal and external support, knowledgeable staff, technological infrastructure available, collaborative partnerships, skill development, and employee engagement (Mian et al., 2020). Also, successful Industry 4.0 implementation will be reliant on internal management skills, value chain readiness, and internal technological maturity (Roy et al., 2023).

A business model canvas, which was created by Osterwalder and Pigneur, is a helpful strategic planning tool and will be created after the completion of the socio-technical SWOT analysis by the organization. The business model canvas serves as a guide to understanding how the organization creates, delivers, and attains value (Nuryani et al., 2023). This business development tool considers the nine core elements of an organization such as the key partners, key activities, key resources, value proposition, customer relationships, channels, customer segments, cost structure, and revenue streams (SK, 2020).

The first socio-technical survey focuses on the five socio-technical system's theoretical framework aspects. These are data gathering, analysis and interpretation, summarization, testing, iterating and amending as displayed in Table 4 (Roth and Farahmand, 2023). The second socio-technical survey focuses on the six subsystems outlined by Davis et al. These are goals, people, processes, building/infrastructure, technology, and culture that are embedded within an external environment comprised of stakeholders, financial considerations, and regulatory frameworks. The socio-technical system framework highlights areas requiring design process improvements, underlines an interrelated perspective approach, serves as a guide for systems analysis, and supports enabling forecasts on future systems operation (Davis et al., 2014). A socio-technical SWOT analysis will be developed for each of the eleven socio-technical constructs to inform the development of the business model canvas as illustrated in Table 1.

Implementation tools supporting the development of real-time data schema involved and the interoperability levels observed assist with resource management and optimization (Namugenyi et al., 2019). Socio-technical system (STS) surveys will be issued using a five-level Likert scale from *Extremely Unlikely* to *Extremely Likely* to calculate Pearson and Polychoric Correlation Coefficients. Feedback from employees, customers, suppliers, bankers, friends in other organizations, consultants, government reports, and association meetings is reviewed in the socio-technical SWOT analysis in the first business phase and in subsequent technology, resilience and innovation phases to ensure the instilling of socio-technical joint optimization of both technical and social factors throughout the Industry 4.0 implementation process and to conduct additional statistical analyses (Daft, R., 2021). Feedback from employees populate the internal strengths and weaknesses columns; feedback from both internal and external parties populates the opportunities and threats columns. These survey results inform the development of a digital socio-technical scorecard in an enterprise resource planning software to visually represent the organization’s current socio-technical status and to automate this project management assessment tool (Bradford, M., 2015) (Schwalbe, K., 2006).

Table 1. Proposed Socio-technical SWOT Analysis Framework Based on Davis et al.

Socio-technical Construct: Processes	Socio-Technical Survey Question	Strengths	Weaknesses	Opportunities	Threats
	Q20	5 (Please describe – i.e. standard operating procedure creating)		4 (Please describe – i.e. updated standard operating procedure provides new guidance to employees encouraging responsible autonomy)	
	Q6		4 (Please describe - cross-functional diagrams created infrequently)		5 (Please describe – competitors may be reaching more suppliers with clearly presented data)
	Q5...etc.	5 (Please describe – i.e. infographics provided to employees on key performance indicators)		4 (Please describe – i.e. opportunity to create learning module from information to support continuous learning)	
	Total	10	4	8	5

The emphasis on the individual's tasks is core to the socio-technical perspective (Haring et al., 2023). As well, assessing the data collected during this timeframe is imperative to verify if it reveals new information to facilitate a response (Pech and Vrchota, 2020). An expertise in project management, change management, an adaptive culture, a clear business plan and vision, management support, skilled staff, testing, process simplification, appropriate software development, effective communication, continuous monitoring, and a performance evaluation of the system are also critical factors to implementing newer technologies. Requesting, collecting, and measuring user input is also essential to verifying the alignment to the organization's strategic and tangible requirements (Loh and Koh, 2004).

A study provided by Liu et al. illustrated a reference framework for SMEs to implement digital transformation with IoT and cloud computing. The implementation flow begins with addressing the business model to define product features then moves to the technical requirements and addresses the innovation. (Liu et al., 2021). Manufacturing networks that utilize collaborative business models have more flexible Industry 4.0 implementation opportunities (Grefen et al., 2022). Figure 1 is based on the Industry 4.0 implementation model for SMEs by Liu et al, however, it has been modified by the author to include the elements of the Socio-Technical SWOT analysis, which incorporates the two socio-technical survey tools, and the organizational resilience phase to dually consider Industry 4.0 and Industry 5.0 strategies.

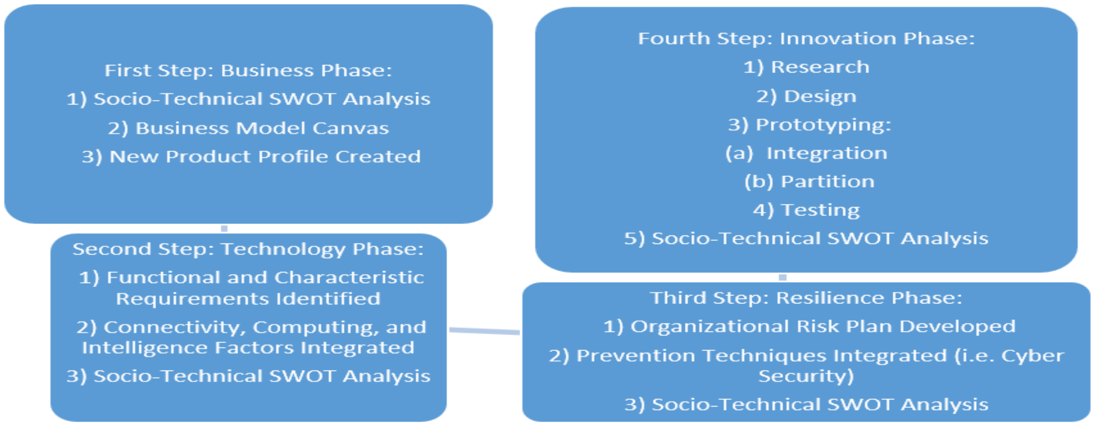

Figure 1. Proposed Framework for Socio-technical Design of Industry 4.0 Implementation with Industry 5.0 Resiliency and Socio-Technical SWOT Analysis

The phases provide technical requirements that may be defined as functional (e.g. monitoring motion) and characteristics (e.g. assessing real-time data). In the technology phase the connectivity, computing, and intelligence of the Industry 4.0 solution are considered within a step. The third phase of resilience focuses on building organizational resilience. The resiliency initiative begins with the employee identifying non-routine operational occurrences and using their training and leadership skills to resolve issues. Organizational risk plans and prevention techniques address resilience capacity building. The technological focus for building resiliency will involve a decentralized peer-to-peer network with the full integration of secured information transfer capability across departments, levels, and processes using smart platforms (Zizic et al., 2022). Therefore, resilience is about operational recovery issues, as well as adaptation and operational efficiency topics (Agote-Garrido et al., 2023).

The innovation phase first starts with the steps of research, design, and prototyping. Research entails understanding the end-user requirements; designing expresses the problem and identifies problem solutions; and prototyping is the process of creating the minimum viable solution for the end-user. The innovation principles of integration and partition are employed, where partition intends to separate the functions or services from products and foster the growth of the one that has the most potential to develop into a viable new commercial opportunity. Partition in technology refers to dividing software into various modules to increase the beneficial outcomes. The integration principle of innovation implies that there is a new configuration of functions or services to create a new process or product thereby. (Liu et al., 2021). The testing phase occurs after prototyping and is the process of learning and iterating to find the right combination of elements for a market-ready solution that is technologically and economically feasible. This is followed by the socio-technical SWOT analysis to determine the joint optimization of social and technical elements in the innovation stage.

Innovations may be in the form of a technological or business application or both. Innovations are often customer-oriented and are therefore most often externally motivated (Grefen et al., 2022). Representing a series of function blocks that verify the Industry 4.0 implementation process are the functional requirements, intermediate functional requirements aligning with the automation requirement, the characteristic requirements, and lastly the function blocks expressing the hardware requirements (Liu et al., 2021). Resources expended to create these function blocks should closely align to the core value proposition of the organization's business model and must be iterated to ensure continuous competitive advantage in the market. Defining, measuring, analyzing, improving, and controlling and designing is therefore an ongoing process (Dossou et al., 2022). A bottom-up design approach will identify the specific software components to correspond with the macro-level IT architecture requirements (Grefen et al., 2022). Lastly, ensuring employees embrace a mindset of environmental consciousness during the digital transformation may promote organization-wide carbon reduction initiatives, as well as lead to the promotion of green innovation (Gao, 2023). A socio-technical survey is conducted and the user feedback assessed for contributions to the implementation process.

2.1.10. Evaluating Digital Transformation – A Socio-Technical Assessment Model

"Technology is the most powerful shaping force on the planet and its individual impact is most evident in human factors" (Peireira et al., 2023). The academic research is supported with the proposal of modeling the interdependencies of the factors of a socio-technical system to improve adaptability, sustainability, efficiency, employee well-being, and effectiveness. The purpose of the modeling of a socio-technical system is to design, create, and reengineer holistically and systemically at all levels of the work organization. These tools aid employee decision-making in creating successful and sustainable value within an organization in a volatile, uncertain, complex, and ambiguous external environment (Lima et al., 2023). Intentionally using the survey tools to assess the level of human-centricity in the use of cyber objects – such as the decision-making system of digital twins, control systems – such as multi-agent shop floor systems, and physical objects – such as the communication role among logistics systems will ensure that human factors are thoroughly instilled throughout the socio-technical system architecture in the Industry 4.0 context (Bhattacharya et al., 2023). As well, the surveys' use among diverse skillsets and task types will encourage a collection of primary workforce data from both men and women to assess the gender neutrality of intelligent systems in a complex socio-technical environment (Maggioli & Cunha, 2023). The mathematical models noted in this chapter may be applied across industries.

This study of socio-technical readiness and organizational attributes leading to reduced work week schedules under the conditions of Industry 4.0 should be carried out by means of periodic collection of statistical information from data retained in the first and second surveys on the socio-technical constructs of data gathering, analysis and interpretation, summarization, testing, iterating and amending, responsible autonomy, productivity and innovation, organizational learning, technology implementation, resource allocation, and bottom-up communication indicators, and with the guide of the suggested mathematical models. The socio-technical constructs account for diverse learning styles, which is significant when considering the intergenerational age of the manufacturing industry. Tables 2 and 3 below provide the legends of the socio-technical indicators for the two survey tools.

Table 2. Legend for the First Socio-technical Survey Tool

Algebraic Symbol	**Definition**
C1	Data Gathering
C2	Analysis & Interpretation
C3	Summarization
C4	Testing
C5	Iterate & Amend
S	Socio-technical Readiness
IP	Increased Productivity
I4.0	Industry 4.0 Integration
r	Pearson Correlation Coefficient/Polychoric Correlation Coefficient

Table 3. Legend for the Second Socio-technical Survey Tool

Algebraic Symbol	**Definition**
RA	Responsible Autonomy
PI	Productivity & Innovation
OL	Organizational Learning
RD	Reduced Daily Work Hour Goal
RE	Resource Allocation
T	Technology Implementation
C	Bottom-up Communication
S	Socio-technical Readiness (First Survey Outcome)
r	Pearson Correlation Coefficient/Polychoric Correlation Coefficient

The first and second survey tools will also serve to provide an avenue for the employees to feel empowered to share their knowledge and contribute to the design of their job and the essential training. Additionally, they provide an open forum that leads to directly highlighting and developing worker competencies (Ávila-Gutiérrez et al., 2021).

It is recommended that the surveys are preliminarily conducted among all employees as part of a socio-technical SWOT analysis prior to developing the business model for Industry 4.0 integration. This socio-technical assessment tool is implemented in the technology, resilience, and innovation phases. Thereafter, a continued maintenance testing timeframe for the model could emulate that of the four-day work week initiatives, such as through the Four Day Work Week Global Foundation, where a two-month orientation program followed by a six-month commitment to programmatic initiatives is instituted (Schor et al., 2022). After the two-month orientation program, the survey tools will be sent to employees a second time. After the six-month trial period, the survey tools will be sent out to employees a third time (Shpak et al., 2019). Thereafter, the collection of data through the consolidated survey tools will be conducted quarterly. Depending on the length of the Industry 4.0 implementation phase, there may be more than one survey period.

Pearson and Polychoric coefficient values will be produced from the first and second survey responses and will provide insights into the successful level of integration of the socio-technical construct, as well as the successful transition or correlation among socio-technical constructs. These coefficient values will be inputted in the mathematical models in the figures below. According to the results of the mathematical model calculation, the evaluation and prediction of the state of development of joint optimization socio-technical factors in the work organization, the socio-technical readiness to adopt Industry 4.0, and the preparedness to instill four-day work week initiatives will be determined. As well, the surveys will provide data on the stability and efficiency of the development of socio-technical factors within the firm.

Figure 2 depicts the Pearson and Polychoric coefficient formula for the first survey tool. As the coefficients are often expressed as two or three numerical values behind the decimal point, this may also be conversely translated into a percentage value. The closer the number is to one (1), the higher the level of socio-technical construct integration and therefore the more robust the stability of the socio-technical readiness is present in the design framework. When this coefficient value is inputted into the relationship model, as is seen in the example provided in Figure 3, as the outcome approaches zero (0), the more likely the work organization is operating with jointly optimized social and technical factors and is thus a socio-technically designed framework.

$$S = 5 - (rc_1 + rc_2 + rc_3 + rc_4 + rc_5)$$

Figure 2. Example of the Socio-technical Relationship Model used with the First Survey Data

S = 5 (# of socio-construct observations) – (.98 + .98 + .98 + .98 + .98)

S = 5 – 4.9

S = .10

Figure 3. Example of Socio-technical Relationship Model Used to Test the Level of Socio-technical Joint Optimization within an Organization

In reference to the Polychoric and Pearson correlation coefficient outcomes represented in the tables in the next chapter from small, medium, and large-sized manufacturers and their corresponding relationships among the socio-technical indicators, assumptions are made that values within a 98% threshold or higher for socio-technical constructs C1 through C5 may indicate that one is more likely to observe a positive relationship between Industry 4.0 integration (Q12) and Increased Productivity (Q21) based on the increased level of socio-technical organizational design implemented. Thus, the greater the socio-technical readiness the greater the organization's aptitude for integrating Industry 4.0. Again, the example illustrated in Figure 4 provides a visual of the assumption that an 'S' value or Socio-technical Readiness value of zero (0) to .10 equates to a near perfect score of 98% to 100% socio-technical design implementation. Figure 4 displays the assumed acceptable range of the 'S' value to observe increased productivity per employee based on socio-technical design.

P(IP) = .10 (Collective Socio-technical Readiness Maximum Value) to 0 (Collective Socio-technical Readiness Optimal Value)

Figure 4. The Relationship Model of the Acceptable Range of 'S' Value to Observe Increased Productivity Per Employee Based on Socio-technical Design

Socio-technical Readiness = Industry 4.0 Integration Aptitude

Figure 5. The Relationship Model of the Socio-technical Readiness and Industry 4.0 Adoption

The theoretical principles of socio-technical design in the Industry 5.0 context encourage the full integration of technological, social, and environmental priorities in the modern digital transformation. The inclusivity of human-centric approaches develops and encourages effective human-machine co-working. This is core to the concept of Industry 5.0, which leads to creating a more sustainable and resilient work organization and realizes the deficits incumbent of a purely techno-centric approach to organizational design (Peruzzini et al., 2023).

Figure 6 describes the recommended approach to deciphering, designing, constructing, and reorganizing socio-technical factors within complex social and technical systems under the conditions of both pre and post Industry 4.0 adoption contexts. The Reduced Daily Work Hour Goal equates to the numerical value of six (6) possible outcomes at a value of one (1) or 100% for each subtracted from the summation of Polychoric and/or Pearson correlation coefficients of the second survey results for responsible autonomy, productivity & innovation, organizational learning, resource allocation, technology implementation, bottom-up communication, and socio-technical readiness value from the first survey tool.

$$RD = 6 - (r_{\mathrm{RA}} + r_{\mathrm{PI}} + r_{\mathrm{OL}} + r_{\mathrm{RE}} + r_{\mathrm{T}} + r_{\mathrm{C}}) - S$$

Figure 6. The Relationship Model for Achieving a Reduced Daily Work Hour Goal Using the First and Second Survey Results

The desired reduced daily work hour goal range is between .12 and -0.1, where the closer the value is to zero (0), the greater the effectiveness of the socio-technical design framework. The opportunity for a reduced daily work hour goal is greater. We assume from the first survey relationships that a Polychoric and/or Pearson Correlation Coefficient value of .98 or higher for each construct is needed to observe greater operational efficiencies in the socio-economic landscape of Minnesota and North Dakota to result in increased productivity performance. This is expressed in an example illustrated in Figure 7. Each of the variables have been described by academic researchers as integral to the success of the six socio-technical constructs of people, culture, goals, technology, process/procedures, and infrastructure. The six variables employed in the mathematical model also integrate Industry 5.0 concepts, such as innovation, use of data (resource allocation), collaboration between machines and humans and the role of humans in the cyber-physical production setting (Bhattacharya et al., 2023). We assume that the characteristics observed provide a greater opportunity for realizing a reduced daily work hour goal. Figure 7 also highlights the blending of Industry 4.0 technology implementation with Industry 5.0 principles of the integration of human cognition, ethics, and social responsibility (Peireira, A. et al, 2023).

Where S = .10 to 0 [from first survey result]

$$\text{Example: } RD = 6 - (.98 + .98 + .98 + .98 + .98 + .98) - .10$$

$$RD = .02$$

Figure 7. Example of the Reduced Daily Work Hour Goal Relationship Model in Use

Understanding how humans interact with smart devices is becoming increasingly necessary. The use of the two survey tools in combination with the relationship models allow for the deliberate and helpful curation of training data to inform future decision-making with regards to human operator work design in Industry 4.0 and Industry 5.0 contexts. One possible opportunity of the model's utility is its deployment when assessing the human-centric success of job rotation scheduling outcomes. These methodological steps diligently gather useful metrics that add value. The focus is on creating a more unified evaluation framework to assess performance indicators that make transparent the benefits and challenges to integrating human factors into AI environments (Bhattacharya et al., 2023). The transition to Industry 5.0 will require that humans provide creativity to the workflow process when using artificial intelligence systems. Beyond the necessity of digital work skills in AI, data analysis, cyber security, and knowledge management, the independent thinking, flexible, and entrepreneurial worker will be essential in driving this new work paradigm (Lin & Wang, 2022). The modeling also contributes to Industry 5.0's call of action to "recognize, reconsider, realize, reduce, reuse, and recycle", which is a method of optimizing material utilization and logistics, therefore increasing sustainability efforts. The appraisal of work-life balance, innovation processes, and high-level product and service customization will be its outputs (Mourtzis et al., 2022).

The limitation of this study is that the mathematical model was designed from a small sample of manufacturers within a specific socio-economic context of Minnesota and North Dakota. The representation of the breadth of the industrial sector may not be fully illustrated. Another limitation is the lack of validation of the models in the use of an applied workforce context, such as a longitudinal study. The performance indicators that have been significantly recommended by academic researchers may need to bare the weight of added review.

Future studies will test the proposed relationship models for estimating and predicting the state of development of socio-technical factors. The movement to implement Industry 4.0 and move to Industry 5.0 with the closer connectivity of human factors to the newer communication and information technologies is upon us as challenges, such as large-scale job automation through technology, must be directly addressed (Maggioli & Cunha, 2023). According to a 2022 survey conducted by Employbridge, over 19,000 manufacturing and warehouse employees in the United States consider flexibility in work schedules as integral to job retention. Another recent study supported this assertion that flexible job rotation plans build knowledge, skills, and abilities among employees by energizing them with a variety of tasks within short timeframes (Battini et al., 2022). The Operator 5.0 will be a knowledge worker using innovative technologies to create increased operational efficiencies within the manufacturing system. Engaged employees are happy and fully integrated into the socio-technical design, which leads to increased productivity, innovation, competitive advantage, and reduced recidivism (Salvadorinho & Teixeira, 2023).

3. RESEARCH METHODOLOGY

This chapter focuses on the purpose of the study, research questions and hypotheses, research design, target population and sample, procedures, instrumentation, and ethical considerations. The methods to conduct research that develops a socio-technical systems design instrument to support the implementation of Industry 4.0 are supported in this research. The design elements of research, such as the unit of analysis, respondent industry, sample size, and survey administration are described. As well, the measurement items and the method used for analysis are included in this section.

3.1. Purpose of Study

The purpose of the qualitative survey-based research study is to further advance the socio-technical systems theory as method of increasing the adoption of new communication and information technologies of Industry 4.0 among manufacturers in Minnesota and North Dakota. The socio-technical systems theory was assessed through comparing the parameters of 11 socio-technical constructs comprised of forty-five (45) questions that were provided on two survey instruments to receive multilevel employee perceptions among Minnesota and North Dakota manufacturers of socio-technical system design and digital maturity factors. These survey questionnaires are included in the following Ch. 4 Results section. The research insights provided through the completion of these survey instruments may guide or increase the Industry 4.0 implementation through prognostic and diagnostic analyses.

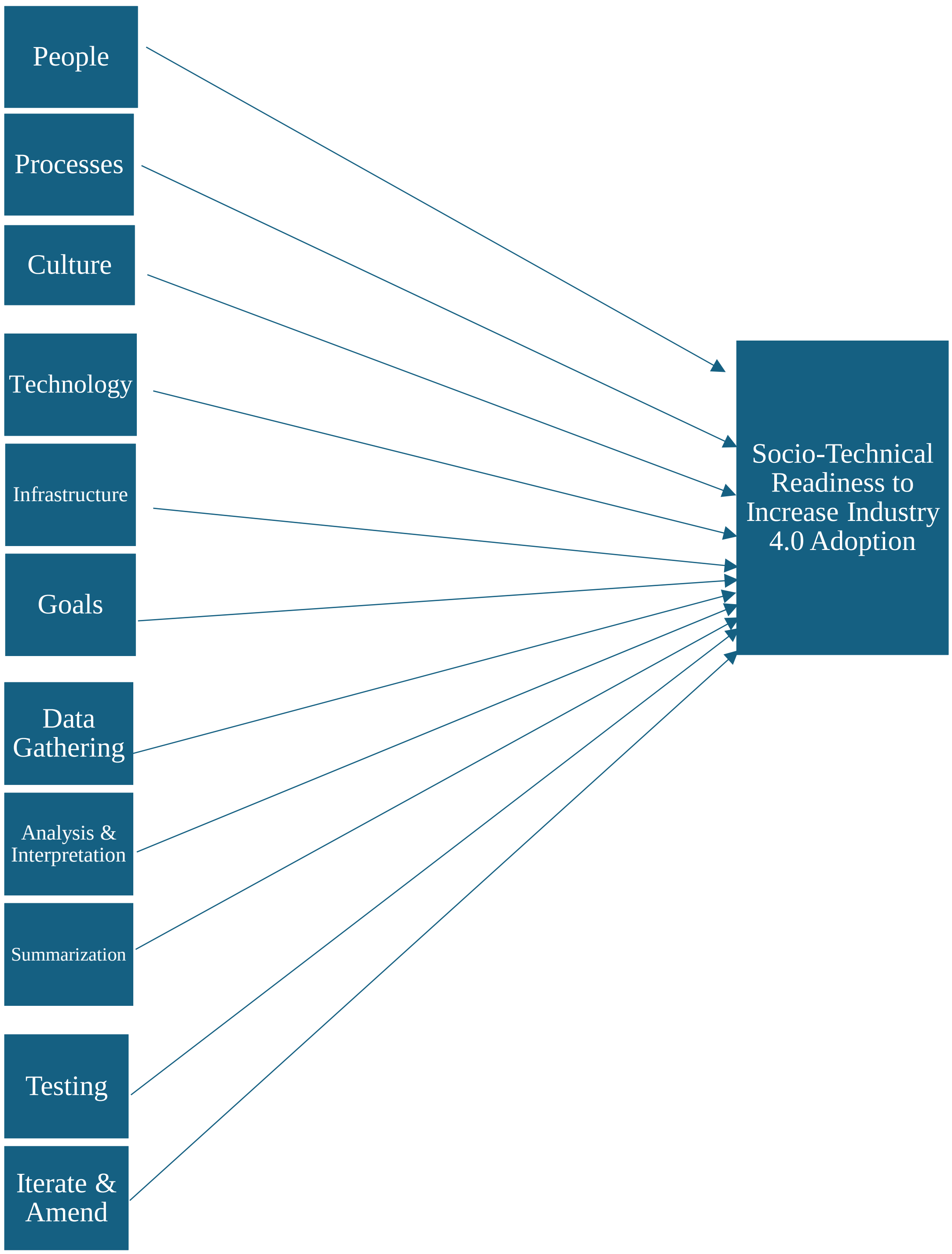

Figure 8. Socio-technical Constructs Researched

3.2. Research Questions and Hypotheses

This qualitative research questionnaire was founded on the unit of analysis of the employee's perspective of socio-technical systems design within the organization and the organization's digital maturity level. The two survey instruments posed forty-five questions collectively that reviewed the parameters of 11 socio-technical constructs within socio-technical systems design, demographic information, assessed digital maturity and Industry 4.0 integration levels. Figure 9 illustrates the socio-technical research framework. The following are the hypotheses and research questions.

1) Hypothesis 1: The socio-technical design principles will be applicable in the Industry 4.0 context among North Dakota and Minnesota manufacturers.

Research Question 1: How applicable are socio-technical design principles in the Industry 4.0 context among North Dakota and Minnesota manufacturers?

2) Hypothesis 2: There is a positive correlation between Industry 4.0 and increased productivity among manufacturers in Minnesota and North Dakota.

Research Question 2: Is there a positive correlation between Industry 4.0 and increased productivity among manufacturers in Minnesota and North Dakota?

3) Hypothesis 3: There is a positive correlation between socio-technical design principles and increased productivity.

Research Question 3: Is there a positive correlation between socio-technical design principles and increased productivity?

4) Hypothesis 4: Organizational learning will have a significantly positive correlation to achieving a reduced daily work hour goal.

Research Question 4: Will organizational learning have a significantly positive correlation to achieving a reduced daily work hour goal?

5) Hypothesis 5: Responsible autonomy has a significantly positive correlation to the promotion of productivity and innovation.

Research Question 5: Will responsible autonomy have a significantly positive correlation to the promotion of productivity and innovation?

6) Hypothesis 6: Responsible autonomy has a significantly positive correlation to organizational learning among regional manufacturers.

Research Question 6: Will responsible autonomy have a significantly positive correlation to organizational learning among regional manufacturers?

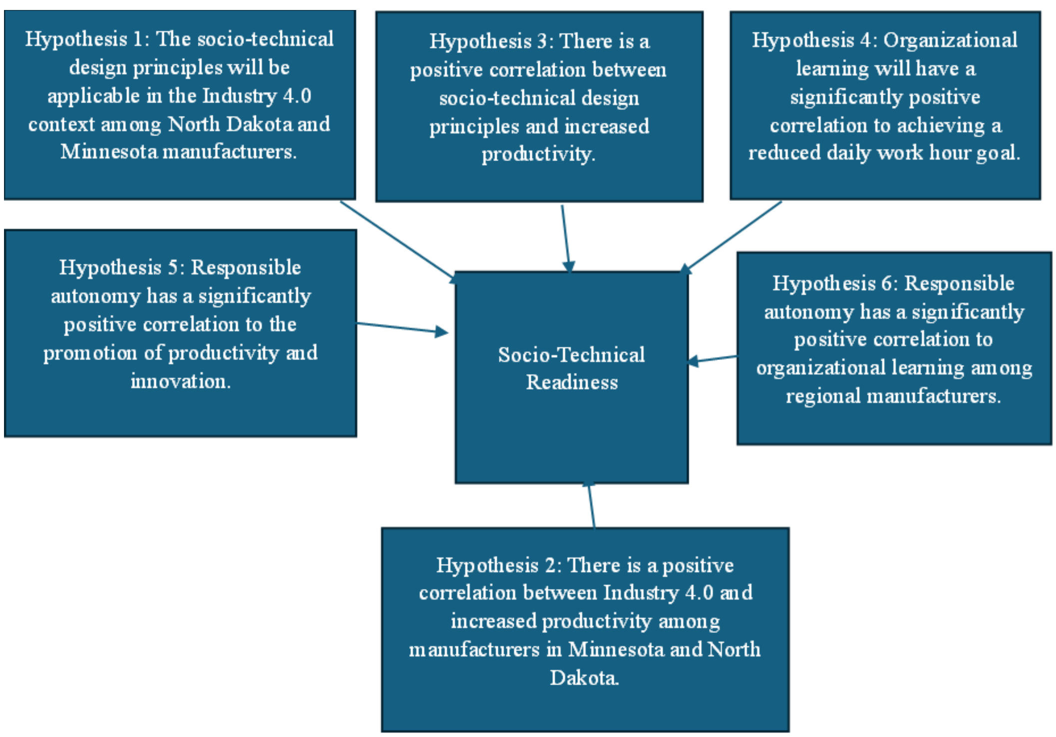

Figure 9. Socio-technical Research Framework

3.3. Research Design

The research study design is non-experimental and qualitative investigation that conducted survey sampling to describe multi-level employee perceptions of socio-technical systems design and digital maturity within an organization. Evidence demonstrated that socio-technical readiness can be assessed through a survey-based research methodology (Wahbeh et al., 2019). In behavioral and social sciences Likert scales are often used to measure participant perceptions (Choi, 2010). A five-level Likert Scales was used with the following response options: (1) *Extremely unlikely*, (2) *Somewhat Likely*, (3) *Neither likely nor unlikely*, (4) *Somewhat likely,* and (5) *Extremely likely*.

3.4. Target Population and Sample

The target population and sample provided a framework to allow for generalizability to be applied. This is defined as "the extension of research findings and conclusions from a study conducted on a sample population to the population at large" (Colorado State University, 2024). The target population of regional manufacturers from Minnesota and North Dakota held subsets of the sample. A descriptive summary of the target population and sample are provided in the following sections.

3.5. Population

The target participants in this socio-technical research study were employees from various employment levels within manufacturing firms located in Minnesota and North Dakota. The manufacturing industry is a leading sector in the implementation of Industry 4.0 (Setyaningsih et al., 2020). Gottlich, 2024 further reported that the manufacturing sector performed sluggishly over the last two years and is seeing a rise in the PMI recently (Gottlich, 2024). External environment considerations may also influence the employee's perceptions of the firm's socio-technical system design.

3.6. Sample Study

Participants met the following criteria: (a) geographically located in North Dakota or Minnesota, (b) employed by a manufacturer, and (c) volunteer their time to provide survey feedback. Participant enterprise details were found from the author's LinkedIn networks, UsBizData.com, a ND Department of Commerce list of manufacturers, Impact Dakota, and the Minn-Dak Manufacturers Association.

3.7. IRB Approval/Exemption

The two survey studies involved human participation and therefore required Institutional Review Board (IRB) evaluations. A request for IRB exemption was submitted to the IRB at North Dakota State University (NDSU) along with a copy of questionnaire prior to disseminating both surveys. As well, an IRB exemption was submitted to the IRB at NDSU for the web scraping project. Upon review IRB at NDSU determined the following exemption statuses

1. Protocol No. IRB0004902, "A Survey of Current Organizational Design Practices",
2. Protocol No. IRB0004709, "A Survey of Current Organizational Design Practices",
3. Protocol No. IRB 0004961, "Web Scraping Research Study".

Relevant documents are furnished in the appendices in this research.

3.8. Data Collection

The survey was developed using Qualtrics at NDSU with the intent of collecting survey responses electronically. Qualtrics allowed for the distribution of surveys through social media, emails, and URL links. The online survey was anonymous. Data was captured for the individual responses from small, medium, and large enterprises in North Dakota and Minnesota. The data was saved onto Excel spreadsheets. The software SAS 9.4 was used to read the data from the Excel spreadsheets directly using Proc IMPORT.

3.9. Data Validity

The internal consistency of the surveys was used to indicate the level of measuring the same construct. Cronbach's alpha statistical factor was calculated to measure the internal consistency of a group of items that are combined to create a single five-level Likert scale. Reliability coefficients of 0.70 or more are considered acceptable. The Cronbach alpha coefficients of the socio-technical system design elements among all industries met this threshold, which indicates the reliability of the survey scales in providing valid results (Aichouni et al., 2023).

3.10. Data Analysis

Once the data was imported into SAS, the Pearson and Polychoric correlation coefficients analyses were conducted using base SAS and SAS/STAT, which are components of the SAS version 9.4. The Pearson correlation was accessed utilizing the Proc CORR function and the Polychoric correlation coefficient were accessed with the Proc FREQ function (SAS Institute Inc., 2023). The p-value < 0.05 was considered significant. Both Polychoric and Pearson correlation coefficients have been used to analyze five-level Likert Scales. The is Polychoric correlation statistic is used for two discrete *ordinal* variables. "The polychoric correlation applies to any ordinal variable, including character variables with measurements levels such as "low", "medium", and "high" (SAS Institute Inc., 2023).

The five-level Likert Scale was used to collect insights on a variety of topics relevant to Industry 4.0 and socio-technical systems design. A five-level Likert Scale was used with the following five response options: (1) *Extremely unlikely*, (2) *Somewhat unlikely*, (3) *Neither likely* *nor unlikely,* (4) *Somewhat likely,* and (5) *Extremely likely*. The responses also include a continuous variable, which notes the degree in which the participant agrees or disagrees with the question. "Although rating and metrical scale data posess the same property of orders as the numbers in the real number system, ordinal data, unlike metrical data, lack the property of equal distances between units or categories. Given that Pearson's r requires metrical data, one must assume that equal distance exists among consecutive response categories in order to to warrant any meaningfulness of the correlation coefficients" (Choi, J., 2010). The assumption of linearity addresses the distance between each level of the Likert scale and assumes that the distance between "*Extremely unlikely*" and "*Somewhat Likely*" are the same distance as between "*Somewhat likely*" and "*Extremely likely*". As well, the distances of both sets of Likert levels should be equal to "*Neither likely nor unlikely*" (Lalla, M., 2017).

Pearson correlation coefficient is defined by SAS as "The Pearson product-moment correlation is a parametric measure of association for two variables. It measures both the strength and the direction of a linear relationship. If one variable *X* is an exact linear function of another variable *Y*, a positive relationship exists if the correlation is 1 and a negative relationship exists if the correlation is –1. If there is no linear predictability between the two variables, the correlation is 0. If the two variables are normal with a correlation 0, the two variables are independent. However, correlation does not imply causality because, in some cases, an underlying causal relationship might not exist" (SAS Institute Inc., 2023).

The Pearson correlation coefficient formula per SAS is noted in the equation below, "where $\bar{x}$ is the sample mean of *x* and is the sample mean of *y*". Also, where r is equal to the correlation coefficient, x_i is the values of the x-variables in a sample, $\bar{x}$ is the mean of the values of the x-variable, y_i are the values of the y-variable in a sample, and $\bar{y}$ is the mean of the values of the y-variables (SAS Institute Inc., 2023).

$$r_{xy} = \frac{\sum_i\left((x_i-\bar{x})(y_i-\bar{y})\right)}{\sqrt{\sum_i(x_i-\bar{x})^2\sum_i(y_i-\bar{y})^2}} \tag{1}$$

Equation 1. Pearson Correlation Coefficient as Provided by SAS Institute Inc.

The Pearson r coefficient was used in the study to indicate whether a significant correlation existed among the socio-technical constructs, as well as, factors of increased productivity, reduced daily work hour goals, and Industry 4.0 integration. The findings in this study may benefit manufacturers in the region in which the study occurred as well as other manufacturers in surrounding communities through leading to organizational improvements in socio-technical readiness to advance strategic planning to invest in Industry 4.0 and realize predictive results, such as reduced daily work hour goals and increased productivity. Studies have used the Pearson correlation coefficient to test the statistical significance of surveys issued using a five-level Likert Scale (Holden, R., 2019).

Pearson’s correlation coefficient measures continuous data on an interval scale, such as the Likert Scale responses. The assumption is that surveys were received from multi-levels of employee perspectives, such as being management and employee-rated responses. This supported the research questions of this study. Pearson’s correlation coefficient measures the linear relationship between two random variables to determine the strength of the correlation (Ly, Marsman, & Wagenmakers, 2019).

The Polychoric correlation coefficient is defined in the SAS manual as “Polychoric correlation estimates the Pearson correlation between two continuous variables that underlie the ordinal variables. As mentioned in the previous section, an ordinal variable, Y, can be thought of as a discretization (or *binning*) of an underlying unobserved continuous variable, X. The unobserved variable is called a *latent variable*. Even if the ordinal variables are character variables, the underlying variables are numeric, which means that they can be standardized. Polychoric correlation assumes that the latent variables are bivariate normal with correlation ρ. The polychoric correlation is defined as the estimate of ρ. That is, when we say that the polychoric correlation between two ordinal variables, Y1 and Y2, is *r*, it means that *r* is an estimate for the Pearson correlation between two latent variables, X1 and X2, that are bivariate normal and that are inferred from Y1 and Y2." (SAS Institute Inc., 2023)

The methods used to conduct the polychoric correlation coefficient analyses using base SAS and SAS/STAT, which are components of SAS version 9.4, utilized the methods cited in Drasgow, 1986 and Olsson, 1979. These citations are provided in the SAS manual (SAS Institute, Inc., 2023).

The Polychoric correlation function first computes the thresholds of the variables from the results of the Likert Scale responses to create a frequency table. Next the thresholds are computed, and the values are used to evaluate the log likelihood of possible values of the Polychoric correlation. The Polychoric correlation is used to compute the conditional probability of the observed responses. "Polychoric correlations are not computed using a closed-form equation, one can iterate across different possible correlations to find the values that maximize the log of likelihood" (Kite, 2024).

"Polychoric correlation measures the correlation between two unobserved, continuous variables that have a bivariate normal distribution. Information about each unobserved variable is obtained through an observed ordinal variable that is derived from the unobserved variable by classifying its values into a finite set of discrete, ordered values" (Drasgow, 1986) (Olsson, 1979).

“The polychoric correlation coefficient is the maximum likelihood estimate of the product-moment correlation between the underlying normal variables. The range of the polychoric correlation is from –1 to 1. Olsson gives the likelihood equations and the asymptotic standard errors for estimating the polychoric correlation. The underlying continuous variables relate to the observed ordinal variables through thresholds, which define a range of numeric values that correspond to each categorical level. PROC CORR uses Olsson’s maximum likelihood method for simultaneous estimation of the polychoric correlation and the thresholds” (SAS Institute Inc., 2023). The Polychoric correlation method for the analyses with base SAS and SAS/STAT, which are components of the SAS version 9.4, used Olsson’s maximum likelihood method of simultaneous estimates of the Polychoric correlations and the threshold. The maximum likelihood method is illustrated in the equations below. As well, a case study of Olsson’s maximum likelihood method of simultaneous estimate is provided below (Olsson, 1979).

The dataset consists of an array of observed frequencies $n_{ij}: i = 1,2, \dots, s\ ;\ j = 1,2, \dots, r$, as given in Table 1. If we denote by π_{ij} the probability that an observation falls into cell (i, j), the likelihood of the sample is

$$L = C. \prod_i^s \prod_j^r \pi_{ij}^{n_{ij}} \qquad (2)$$

Equation 2. Polychoric Maximum Likelihood Method of Simultaneous Estimate by Olsson, 1979

Where C is a constant. Taking logarithms,

$$l = ln\, L = ln\, C + \sum_{i=1}^{s} \sum_{j=1}^{r} n_{ij} ln\, \pi_{ij} \qquad (3)$$

Equation 3. Polychoric Maximum Likelihood Method of Simultaneous Estimate by Olsson, 1979

The thresholds for x are denoted by $a_i, i = 0, \ldots, s$ and the thresholds for y by $b_j, j = 0, \ldots, r$,

where $a_0 = b_0 = -\infty$ and $a_s = b_r = +\infty$. It follows that

$$\pi_{ij} = \Phi_2(a_i, b_j) - \Phi_2(a_{i-1}, b_j) - \Phi_2(a_i, b_{j-1}) + \Phi_2(a_{i-1}, b_{j-1})$$

Where Φ_2 is the bivariate normal distribution function with correlation ρ.

The parameters to be estimated are $\rho, a_1 \ldots a_{s-1}, b_1 \ldots b_{r-1}$. Partial differentiation of l with respect to these parameters yields

$$\frac{\partial l}{\partial \rho} = \sum_{i=1}^{s} \sum_{j=1}^{r} \frac{n_{ij}}{\pi_{ij}} \frac{\partial \pi_{ij}}{\partial \rho}$$

$$\frac{\partial l}{\partial a_k} = \sum_{i=1}^{s} \sum_{j=1}^{r} \frac{n_{ij}}{\pi_{ij}} \frac{\partial \pi_{ij}}{\partial a_k}$$

$$\frac{\partial l}{\partial b_m} = \sum_{i=1}^{s} \sum_{j=1}^{r} \frac{n_{ij}}{\pi_{ij}} \frac{\partial \pi_{ij}}{\partial b_m}$$

Since $\partial \Phi_2(u, v)/\partial \rho = \phi_2(u, v)$ where ϕ_2 is the bivariate normal density function, (see Tallis, 1962, p 344; see also Johnson & Kotz, 1972, p44), it follows that

$$\frac{\partial \pi_{ij}}{\partial \rho} = \phi_2(a_i, bj) - \phi_2(a_{i-1}, b_j) - \phi_2(a_i, b_{j-1}) + \phi_2(a_{i-1}, b_{j-1})$$

Therefore, (5) may be written

$$\frac{\partial l}{\partial \rho} = \sum_{i=1}^{s} \sum_{j=1}^{r} \frac{n_{ij}}{\pi_{ij}} \{\phi_2(a_i, bj) - \phi_2(a_{i-1}, b_j) - \phi_2(a_i, b_{j-1}) + \phi_2(a_{i-1}, b_{j-1})\}$$

In (6), it is evident that

$$\frac{\partial \pi_{ij}}{\partial a_k} = \begin{cases} 0 \text{ if } i \neq k \textit{ and } i \neq k+1, \text{i.e. if the formula for } \pi_{ij} \text{ does not contain } a_k \\ \dfrac{\partial \boldsymbol{\Phi_2}(a_k, b_j)}{\partial a_k} - \dfrac{\partial \boldsymbol{\Phi_2}(a_k, b_{j-1})}{\partial a_k} \quad if\ k = i \\ -\dfrac{\partial \boldsymbol{\Phi_2}(a_k, b_j)}{\partial a_k} + \dfrac{\partial \boldsymbol{\Phi_2}(a_k, b_{j-1})}{\partial a_k} \quad if\ k = i - 1 \end{cases} \tag{4}$$

Equation 4. Case 1: All Parameters are Estimated Simultaneously - Polychoric Maximum Likelihood Method of Simultaneous Estimate by Olsson, 1979

Thus, in (6) it suffices to let i go from k to $k+1$. Therefore, (6) maybe written

$$\frac{\partial l}{\partial a_k} = \sum_{j=1}^{r} \frac{n_{kj}}{\pi_{kj}} \left\{ \frac{\partial \boldsymbol{\Phi}_{\mathbf{2}}(a_k, b_j)}{\partial a_k} - \frac{\partial \boldsymbol{\Phi}_{\mathbf{2}}(a_k, b_{j-1})}{\partial a_k} \right\} + \frac{n_{k+1j}}{\pi_{k+1j}} \left\{ - \frac{\partial \boldsymbol{\Phi}_{\mathbf{2}}(a_k, b_j)}{\partial a_k} + \frac{\partial \boldsymbol{\Phi}_{\mathbf{2}}(a_k, b_{j-1})}{\partial a_k} \right\}$$
$$= \sum_{j=1}^{r} \left(\frac{n_{kj}}{\pi_{kj}} - \frac{n_{k+1,j}}{\pi_{k+1,j}} \right) \left\{ \frac{\partial \boldsymbol{\Phi}_{\mathbf{2}}(a_k, b_j)}{\partial a_k} - \frac{\partial \boldsymbol{\Phi}_{\mathbf{2}}(a_k, b_{j-1})}{\partial a_k} \right\} \tag{5}$$

Equation 5. Polychoric Maximum Likelihood Method of Simultaneous Estimate by Olsson, 1979

Also, if we let ϕ_1 and $\boldsymbol{\Phi}_{\mathbf{1}}$ denote univariate normal density and distribution function, respectively,

$$\frac{\partial \boldsymbol{\Phi}_{\mathbf{2}}(u, v)}{\partial u} = \phi_1(u).\, \boldsymbol{\Phi}_{\mathbf{1}} \left\{ \frac{(v - \rho u)}{(1-\rho^2)^{1/2}} \right\}$$

[Tallis,1962, p 346]. Equation (6) may now be written as

$$\frac{\partial l}{\partial a_k} = \sum_{j=1}^{r} \left(\frac{n_{kj}}{\pi_{kj}} - \frac{n_{k+1,j}}{\pi_{k+1,j}} \right) . \phi_1(a_k). \left[\boldsymbol{\Phi}_{\mathbf{1}} \left\{ \frac{(b_j - \rho a_k)}{(1-\rho^2)^{1/2}} \right\} - \boldsymbol{\Phi}_{\mathbf{1}} \left\{ \frac{(b_{j-1} - \rho a_k)}{(1-\rho^2)^{1/2}} \right\} \right]$$

From the symmetry it also follows that

$$\frac{\partial l}{\partial b_m} = \sum_{i=1}^{s} \left(\frac{n_{im}}{\pi_{im}} - \frac{n_{i,m+1}}{\pi_{i,m+1}} \right) . \phi_1(b_m). \left[\boldsymbol{\Phi}_{\mathbf{1}} \left\{ \frac{(a_i - \rho b_m)}{(1-\rho^2)^{1/2}} \right\} - \boldsymbol{\Phi}_{\mathbf{1}} \left\{ \frac{(a_{i-1} - \rho b_m)}{(1-\rho^2)^{1/2}} \right\} \right]$$

Equations (9), (13) and (14) constitute the set of first order derivatives of the log-likelihood.

We denote the sample size by N, and introduce the notation $\boldsymbol{\theta}' =$ $(\rho, a_1, a_2, \ldots, a_{s-1}, b_1, b_2, \ldots, b_{r-1})$. The matrix $\mathbf{I}_{(\boldsymbol{\theta})}$ of expected second order derivatives of l with respect to $\boldsymbol{\theta}$ is obtained from

$$\left[\mathbf{I}_{(\boldsymbol{\theta})}\right]_{m,n} = N \sum_{i=1}^{s} \sum_{j=1}^{r} \frac{1}{\pi_{ij}} \left(\frac{\partial \pi_{ij}}{\partial \theta_m} \right) \left(\frac{\partial \pi_{ij}}{\partial \theta_n} \right)$$

[Tallis, 1962, p 348]. The derivatives within parenthesis in (19) are obtained from (8) and (10).

A large-sample estimate of the covariance matrix of θ is therefore

$$V = \mathbf{I}_{(\boldsymbol{\theta})}^{\mathbf{-1}} \tag{6}$$

Equation 6. Case 1: Variance/Covariance - Polychoric Maximum Likelihood Method of Simultaneous Estimate by Olsson, 1979

A tetrachoric correlation coefficient analysis was conducted to assess the variables from ordinal and numerical values of the web scraping project to estimate the expected proportion of this ordinal and continuous data (Verhulst, 2021). “If both ordinal variables have two levels, then the polychoric correlation is called the tetrachoric correlation. That is, tetrachoric correlation is used to analyze a 2 x 2 table of frequency count” (SAS Institute Inc., 2023).

$$\boldsymbol{\Phi}(h,k{:}\,\rho) = \left[2\pi(1-\rho^2)^{1/2}\right]^{-1} \int_{-\infty}^{h}\int_{-\infty}^{k} exp\left[-\frac{x^2-2\rho xy+y^2}{2(1-\rho^2)}\right] dxdy \qquad (7)$$

Equation 7. Tetrachoric Correlation Coefficient Provided by Olsson, 1979

The websites of 149 manufacturing firms located in the Minnesota and North Dakota regions was reviewed. Additionally, a patent review was conducted. The correlations of patent holders to the keywords used among Industry 4.0 were assessed with the tetrachoric correlation coefficient. The data was imported into SAS and analyses were conducted using base SAS and SAS/STAT, which are components of the SAS version 9.4. The tetrachoric correlation coefficient were accessed with the Proc FREQ function (SAS Institute Inc., 2023). The results of this study are found in Chapter 5.

3.11. First Survey

The purpose of the first qualitative survey was to capture the individual responses employees of small, medium, and large enterprises in North Dakota and Minnesota. The qualitative survey ascertained the level of socio-technical organizational design utilized and the implementation of Industry 4.0 among business sizes. Additionally, an outcome of productivity increases due to Industry 4.0, socio-technical design, and/or business size implementation was assessed. The questionnaire focused on the collection, analysis, summarization, testing, and iterating and amending of data among 24 small, medium, and large manufacturers in North

Dakota and Minnesota. As well, internal, and external organizational design with consideration of the socio-technical system framework was reviewed. Human-factor analysis of employee communication styles, multidisciplinary teams, and employee development were also assessed. The unit of analysis used in this research was the employees' opinions about the organizational changes observed using socio-technical theory. Random sampling from each business category was conducted in this anonymous study. Respondents represented small, medium, and large manufacturers. Thus, a variety of socio-economic contexts was sampled.

The research was designed by formulating the socio-technical research questions to discover human factors and requirements in the technology-centric Industry 4.0 context, determining the research design, designing a questionnaire in Qualtrics, collecting the data anonymously, analyzing and interpreting the data based on a combination of a five-level Likert Scale, open-ended questions, and defined multiple choice questions to prepare the assessment (Iacobucci, D. & Churchill, Jr., G, 2018). A five-level Likert Scales was used with the following response options: (1) *Extremely unlikely*, (2) *Somewhat Likely*, (3) *Neither likely nor unlikely*, (4) *Somewhat likely*, and (5) *Extremely likely.*

Participant enterprise details were found from the authors' LinkedIn networks, UsBizData.com, a ND Department of Commerce list of manufacturers, Impact Dakota, and the Minn-Dak Manufacturers Association. The online survey consisted of 25 questions, and one format of the survey was provided to all respondents to ensure consistency and comparability of the study.

Participant enterprise details were found from the authors' LinkedIn networks, UsBizData.com, Impact Dakota, and the Minn-Dak Manufacturers Association. The online survey consisted of 20 questions, and one format of the survey was provided to all respondents to ensure the consistency and comparability of the qualitative study. The survey participants were anonymous. The geolocation of respondents was identified through using Qualtrics Survey software analytics. A five-level Likert Scale was used with the following five response options: (1) *Extremely unlikely*, (2) *Somewhat unlikely*, (3) *Neither likely nor unlikely*, (4) *Somewhat likely*, and (5) *Extremely likely*.

The online survey process was selected to streamline and expedite the information-gathering stage. The online survey link was sent through Qualtrics to approximately 750 small, medium, and large manufacturers. A total of 24 responses were received providing viable information over a period of approximately one month, yielding a response rate of 3%. Of the 24 respondent enterprises from North Dakota and Minnesota, there were 10 small, six medium-sized, and eight large manufacturers that responded from North Dakota and Minnesota. Small businesses were considered to have fewer than 50 employees; medium-sized businesses were considered to have between 50 and 250 employees; and large businesses were considered to have more than 250 employees.

3.12. Second Survey

The purpose of the second survey was to collect data anonymously from employees of regional manufacturers on the types of socio-technical organizational design practices implemented within the work organization that contribute to the achievement of a reduced daily work hour goal. The themes of the questions were organizational learning, responsible autonomy, communication strategy, reduced work hour goals, leadership characteristics, digital maturity, resource allocation, bottom-up problem solving, and socio-technical design. The survey included the use of an online qualitative survey to gather the individual responses of 35 small, medium, and large manufacturers in Minnesota and North Dakota.

Random sampling from each business size was conducted in this anonymous study. A variety of socio-economic contexts was sampled. The unit of analysis used in this research was the participants' anonymous opinions about the socio-technical design employed within small-, medium-, and large-sized manufacturers. The survey was designed by formulating the research questions based on nine academic research articles, which are referenced in the 'Results' section, on topics relevant to technology, processes, culture, people, infrastructure, and goals, which are integral to a socio-technical design framework.

The anonymous questionnaire was designed using Qualtrics. The analysis and interpretation of the data was based on a combination of a five-level Likert scale, open-ended questions, and defined multiple choice questions to prepare the assessment [47]. A five-tiered Likert scale was utilized that allowed for the responses of: (1) *Extremely Unlikely*, (2) *Somewhat Unlikely*, (3) *Neither Likely nor Unlikely*, (4) *Somewhat Likely*, and (5) *Extremely Likely*.

Participants were reached through the authors' LinkedIn networks, UsBizData.com (accessed on), an ND Department of Commerce list of manufacturers, Impact Dakota, and the Minn-Dak Manufacturers Association. The questionnaire provided 25 questions, and one format of the survey was provided to the public.

The online survey process was selected to streamline and expedite the information-gathering stage. The online survey link was sent through Qualtrics to approximately 2500 small, medium, and large manufacturers. A total of 35 responses were received providing viable information over a period of approximately one month, yielding a response rate of 1.4%. Small businesses were considered to have fewer than 50 employees; medium-sized businesses were considered to have between 50 and 250 employees; and large businesses were considered to have more than 250 employees.

3.13. Ethical Considerations

The employee perspectives shared were considered the opinions regarding organizations. A voluntary consent statement was provided to information the participant that they are willingly able to complete the surveys. The research procedures provide accessibility to complete the surveys confidentially and anonymously through an embedded link generated through Qualtrics. The data was collected and stored by Qualtrics' online database system. The research surveys were reviewed and approved by North Dakota State University's IRB.

3.14. Summary

The third chapter provided information on the purpose of the study, research design, target population sample, population information, sample study, IRB approval and exemption, data collection, data validity, data analysis, and ethical considerations. The quantitative research study explored the socio-technical readiness and digital maturity through multi-levels of employee perspectives from manufacturers in Minnesota and North Dakota. Chapter 4 provides the results of this research study.

4. RESULTS

4.1. Results for Manufacturers – First Survey

In the first survey it was stated upfront in the message sent to respondents that anonymity and confidentiality would be ensured. Pearson correlation coefficients were used to check the pairwise linear relationships. The relationships tested were among the socio-technical constructs, Industry 4.0 integration, productivity increases, and business sizes of manufacturers surveyed in North Dakota and Minnesota.

The manufacturing businesses were assessed for the current state of socio-technical design in manufacturing setting and Industry 4.0 integration. The manufacturing industry was assessed for the Minnesota and North Dakota markets only. In Minnesota there were four (4) medium-sized businesses and two (2) large businesses that responded. In North Dakota, there were 18 manufacturing businesses with ten (10) representing small businesses, two (2) representing medium-sized businesses, and six (6) representing large businesses.

The following questions were posed and pertain to the first socio-technical construct of Data Gathering.

- How likely is your organization to gather relevant data from appropriate sources to assist in predicting solutions for integrating digital technology? (This was question 3: Q3.)
- How likely is your organization to systematically consider the relationships between internal and external factors to identify the contingencies and direction of relationships? (Q7)
- How likely is your organization to consider that a given end state or result may be reached by many potential means with each of an organization's six dimensions of goals, people, buildings/infrastructure, technology, culture, and process/procedures? (Q14)

The combined Likert scale responses of *Somewhat Likely* and *Extremely Likely* from Minnesota and North Dakota businesses in the manufacturing industry for the first question were 83.3% and 77.77%, respectively. Similar Likert responses for the second question on the first socio-technical construct of Data Gathering for Minnesota and North Dakota were 66.66% and 72.22%, respectively. Similar Likert responses for the third question on the first socio-technical construct of Data Gathering for Minnesota and North Dakota were 83.33% and 8.33%, respectively.

The following questions were posed and pertain to the second socio-technical construct of Analysis and Interpretation.

- How likely is your organization to analyze and classify data collected in your organization to support organizational design? (Q4)
- How likely is your organization to consider the implication of the external environment as it relates to the organizational design? (Q6)
- How likely is your organization to engage in self-inspection to identify the origin of variance? (Q14)

The combined Likert scale responses of *Somewhat Likely* and *Extremely Likely* from Minnesota and North Dakota businesses in the manufacturing industry for the first question were 66.67% and 72.22%, respectively. Similar Likert responses for the second question on the second socio-technical construct of Analysis and Interpretation for Minnesota and North Dakota were 50% and 72.22%, respectively. Similar Likert responses for the third question on the second socio-technical construct of Analysis and Interpretation for Minnesota and North Dakota were 66.67% and 77.78%, respectively.

The following questions were posed and pertain to the third socio-technical construct of Summarizing the Findings.

- How likely is your organization to identify and group key system factors using visual aids, such as infographics? (Q5)
- How likely is your organization to generate key inferences regarding the system and how it works to support predictive work? (Q11)

The combined Likert scale responses of *Somewhat Likely* and *Extremely Likely* from Minnesota and North Dakota businesses in the manufacturing industry for the first question on the third socio-technical construct of Summarizing the Findings were 83.33% and 55.56%, respectively. Similar Likert responses to the second question on the third socio-technical construct for MN and ND, were 83.33% and 66.66%, respectively.

The following questions were posed and pertain to the fourth socio-technical construct of Testing the Results with Stakeholders.

- How likely is your organization to visually consider internal and external dimensions of the work organization to assess underexplored or related areas? (Q7)
- How likely is your organization to include feedback or test analysis from key stakeholders for accuracy, omissions, and interpretations in the organizational design process? (Q9)
- How likely is your organization to diversify the resources utilized among various dimensions by supervisors, technicians, and managers? (Q16)
- How likely is your organization to allow for the employee growth through organizational design without peer pressure to support high-quality work? (Q18)

The combined Likert scale responses of *Somewhat Likely* and *Extremely Likely* from Minnesota and North Dakota businesses in the manufacturing industry for the first question on the fourth socio-technical construct of Testing the Results with Stakeholders were 83.33% and 61.11%, respectively. Similarly, Likert responses to the second question on the fourth socio-technical construct for Minnesota and North Dakota were 50% and 55.55%, respectively. Similar Likert responses to the third question on the fourth socio-technical construct for Minnesota and North Dakota were 83.33% and 66.66%, respectively. Similar Likert responses to the fourth question on the fourth socio-technical construct for Minnesota and North Dakota were 66.66% and 61.11%, respectively.

The following questions pertain to the fifth socio-technical construct of Iterating and Amending as Necessary.

- How likely is your organization to modify the organizational design process after discussion? (Q10)
- How likely is your organization to design information systems to provide information in the first place when action is needed? (Q17)
- How likely is your organization to task multidisciplinary teams to continuously evaluate and review the work system design process? (Q19)
- How likely is your organization to add any relevant factors to the organizational design that emerge from the data during analysis or following previous steps? (Q20)

The combined Likert scale responses of *Somewhat Likely* and *Extremely Likely* from Minnesota and North Dakota businesses in the manufacturing industry for the first question on the fifth socio-technical construct of Iterating and Amending as Necessary were 66.67% and 83.33%, respectively. The similar Likert responses to the second question on the fifth socio-technical construct for Minnesota and North Dakota were 100% and 72.22%, respectively. Similar Likert responses to the third question on the fifth socio-technical construct for Minnesota and North

Dakota were 83.33% and 66.66%, respectively. Similar Likert responses to the fourth question on the fifth socio-technical construct for Minnesota and North Dakota were 66.67% and 72.22%, respectively.

Question 12 addressed Industry 4.0 specifically. It read, “How likely is your organization to align the organizational design with Industry 4.0 integration?”. The combined Likert scale responses of *Somewhat Likely* and *Extremely Likely* from Minnesota and North Dakota were 16.67% and 38.89%, respectively.

Question 21 addressed the variable of productivity. It read, “How likely is your organization to observe increased productivity per employee due to the implementation of organizational design?” The combined Likert scale responses of *Somewhat Likely* and *Extremely Likely* from Minnesota and North Dakota were 50% and 33.33%, respectively.

The tables are organized with the top numbers being the Pearson’s correlation coefficient and the lower numbers the p-values. The null hypothesis between the variables was zero.

Table 4 displays the outcomes of all 24 manufacturers surveyed in Minnesota and North Dakota. The table measures socio-technical constructs, which are noted as C1 through C5, Industry 4.0 integration (Q12), productivity increases (Q21), and small, medium, and large business sizes (Q1). A strong and positive Pearson’s correlation coefficient is observed among the five socio-technical constructs (C1-C5) and Industry 4.0 integration (Q12). A negative relationship was observed among Data Gathering (C1), Analysis and Interpretation (C2), Testing (C4), Iterating and Amending as Necessary (C5), and Increased Productivity (Q21). A weak, positive relationship was observed between Summarization (C3) and Increased Productivity (Q21). A positive relationship was observed between (C4) Testing and (C5) Iterate and Amend. A weak, positive relationship was observed among (C1) Data Gathering, (C2) Analysis and

Interpretation, and (Q1) business size. A strong positive, correlation exists among the five socio-technical constructs C1 through C5, solely. Aggregately, the business size (Q1) had either a weak, positive or negative correlation to socio-technical constructs (C1–C5). One small manufacturer from North Dakota responded affirmatively on the Likert scale to Industry 4.0 integration (Q12) and Increased Productivity (Q21). Additionally, Testing the Results with Stakeholders (C4) appeared to have a less robust positive correlation with Data Gathering (C1), Analysis and Interpretation (C2), and Summarization (C3). Moreover, Iterating as Necessary had a less robust positive correlation with Data Gathering (C1) and Analysis and Interpretation (C2). Further, a negative correlation between Industry 4.0 integration (Q12) and increased productivity (Q21) existed. Aggregately, the business size had either a weak, positive, or negative correlation to socio-technical constructs. One small manufacturer from North Dakota responded affirmatively on the Likert scale to both questions.

Table 4. All Minnesota and North Dakota Manufacturers Surveyed

Pearson Correlation Coefficients, N = 24
Prob > |r| under H0: Rho=0

	C1	C2	C3	C4	C5	Q12	Q21	Q1
C1 **Data Gathering**	1.00000	0.78702 <.0001	0.66922 0.0003	0.59699 0.0021	0.60184 0.0019	0.68726 0.0002	-0.17301 0.4188	0.03850 0.8582
C2 **Analysis + Interpretation**	0.78702 <.0001	1.00000	0.66179 0.0004	0.63047 0.0010	0.60041 0.0019	0.62221 0.0012	-0.35932 0.0846	0.00501 0.9815
C3 **Summarization**	0.66922 0.0003	0.66179 0.0004	1.00000	0.63335 0.0009	0.70082 0.0001	0.66714 0.0004	0.01948 0.9280	-0.19964 0.3496
C4 **Testing**	0.59699 0.0021	0.63047 0.0010	0.63335 0.0009	1.00000	0.80213 <.0001	0.65348 0.0005	-0.25893 0.2218	-0.31335 0.1360
C5 **Iterate+Amend**	0.60184 0.0019	0.60041 0.0019	0.70082 0.0001	0.80213 <.0001	1.00000	0.67129 0.0003	-0.21569 0.3114	-0.36567 0.0789
Q12 **How likely is your organization to align the organizational design with Industry 4.0 integration?**	0.68726 0.0002	0.62221 0.0012	0.66714 0.0004	0.65348 0.0005	0.67129 0.0003	1.00000	-0.18761 0.3800	-0.06654 0.7574
Q21 **How likely is your organization to observe increased productivity per employee due to the implementation organizational design?**	-0.17301 0.4188	-0.35932 0.0846	0.01948 0.9280	-0.25893 0.2218	-0.21569 0.3114	-0.18761 0.3800	1.00000	0.23030 0.2790
Q1 **How many employees are in your work organization?**	0.03850 0.8582	0.00501 0.9815	-0.19964 0.3496	-0.31335 0.1360	-0.36567 0.0789	-0.06654 0.7574	0.23030 0.2790	1.00000

Table 5 displays the 10 responses to integrating Industry 4.0 by small manufacturing businesses in North Dakota and Minnesota. A weak, positive relationship between Industry 4.0 integration (Q12) and Increased Productivity (Q21) was observed. A strong, positive correlation between the socio-technical constructs of C1 through C5 and Industry 4.0 integration (Q12) was observed. Of the five socio-technical constructs, Analysis and Interpretation (C2) and Testing (C4) correlated the least positively with Industry 4.0 integration (Q12). A strong, positive correlation among the socio-technical constructs of C1 through C5 was observed. A weak, positive correlation between Summarization (C3) and Increased Productivity (Q21) was observed. One small manufacturer from North Dakota responded affirmatively to both Industry 4.0 integration (Q12) and Increased Productivity (Q21) survey questions.

Table 5. Small Manufacturers in Minnesota and North Dakota Integrating Industry 4.0 (Q12)

Pearson Correlation Coefficients, N = 10 Prob > |r| under H0: Rho=0							
	C1	**C2**	**C3**	**C4**	**C5**	**Q12**	**Q21**
C1 **Data Gathering**	1.00000	0.73155 0.0162	0.73828 0.0148	0.65554 0.0396	0.90057 0.0004	0.77874 0.0080	-0.17848 0.6218
C2 **Analysis + Interpretation**	0.73155 0.0162	1.00000	0.68153 0.0300	0.84028 0.0023	0.82563 0.0033	0.52700 0.1175	-0.39377 0.2602
C3 **Summarization**	0.73828 0.0148	0.68153 0.0300	1.00000	0.71746 0.0195	0.72604 0.0174	0.85856 0.0015	0.11806 0.7453
C4 **Testing**	0.65554 0.0396	0.84028 0.0023	0.71746 0.0195	1.00000	0.79590 0.0059	0.58580 0.0752	-0.33696 0.3410
C5 **Iterate + Amend**	0.90057 0.0004	0.82563 0.0033	0.72604 0.0174	0.79590 0.0059	1.00000	0.61916 0.0563	-0.23724 0.5093
Q12 **How likely is your organization to align the organizational design with Industry 4.0 integration?**	0.77874 0.0080	0.52700 0.1175	0.85856 0.0015	0.58580 0.0752	0.61916 0.0563	1.00000	0.21921 0.5429
Q21 **How likely is your organization to observe increased productivity per employee due to the implementation organizational design?**	-0.17848 0.6218	-0.39377 0.2602	0.11806 0.7453	-0.33696 0.3410	-0.23724 0.5093	0.21921 0.5429	1.00000

Table 6 displays the six responses to integrating Industry 4.0 by medium-sized manufacturing businesses in North Dakota and Minnesota. A negative relationship was observed between Industry 4.0 integration (Q12) and increased productivity (Q21). A strong, positive correlation among Data Gathering (C1), Analysis and Interpretation (C2), Testing (C4), Iterating and Amending as necessary (C5), and Industry 4.0 integration (Q12) existed. A strong positive correlation among all socio-technical constructs with the exception of a moderate positive correlation between Data Gathering (C1) and Summarization (C3) was observed. A negative relationship among C1, C2, C4, and C5 constructs and Increased Productivity (Q21) existed. A weak, positive relationship with Summarization (C3) and Increased Productivity (Q21) existed.

Table 6. Medium-sized Manufacturers in Minnesota and North Dakota Integrating Industry 4.0 (Q12)

Pearson Correlation Coefficients, N = 6 Prob > |r| under H0: Rho=0							
	C1	**C2**	**C3**	**C4**	**C5**	**Q12**	**Q21**
C1 Data Gathering	1.00000	0.84830 0.0328	0.41690 0.4109	0.89285 0.0166	0.93517 0.0062	0.84830 0.0328	-0.44661 0.3746
C2 Analysis + Interpretation	0.84830 0.0328	1.00000	0.58199 0.2256	0.62855 0.1813	0.89767 0.0152	0.89286 0.0166	-0.52378 0.2862
C3 Summarization	0.41690 0.4109	0.58199 0.2256	1.00000	0.06455 0.9033	0.54993 0.2583	0.24942 0.6336	0.09380 0.8597
C4 Testing	0.89285 0.0166	0.62855 0.1813	0.06455 0.9033	1.00000	0.68476 0.1334	0.68401 0.1340	-0.27113 0.6033
C5 Iterate+Amend	0.93517 0.0062	0.89767 0.0152	0.54993 0.2583	0.68476 0.1334	1.00000	0.89767 0.0152	-0.61295 0.1957
Q12 How likely is your organization to align the organizational design with Industry 4.0 integration?	0.84830 0.0328	0.89286 0.0166	0.24942 0.6336	0.68401 0.1340	0.89767 0.0152	1.00000	-0.76553 0.0760
Q21 How likely is your organization to observe increased productivity per employee due to the implementation organizational design?	-0.44661 0.3746	-0.52378 0.2862	0.09380 0.8597	-0.27113 0.6033	-0.61295 0.1957	-0.76553 0.0760	1.00000

Table 7 displays the eight responses to integrating Industry 4.0 by large manufacturing businesses in North Dakota and Minnesota. A strong negative correlation between Industry 4.0 integration (Q12) and Increased Productivity (Q21) existed. A neutral relationship between Iterating and Amending as necessary (C5) and Increased Productivity (Q21) existed. A negative relationship among C2, C3, C4, and Increased Productivity (Q21) existed. A weak, positive relationship between Data Gathering (C1) and Increased Productivity (Q21) existed. A moderate, positive relationship between Data Gathering (C1) and Industry 4.0 integration (Q12) existed. A strong, positive correlation among all socio-technical constructs with the exception of a moderate, positive relationship between Data Gathering (C1) and Iterating and Amending as necessary (C5) existed. A strong, positive correlation between C2 through C5 and Industry 4.0 integration (Q12) existed.

Table 7. Large Manufacturers in Minnesota and North Dakota Integrating Industry 4.0 (Q12)

Pearson Correlation Coefficients, N = 8 Prob > |r| under H0: Rho=0							
	C1	**C2**	**C3**	**C4**	**C5**	**Q12**	**Q21**
C1 **Data Gathering**	1.00000	0.87370 0.0046	0.86614 0.0054	0.55183 0.1562	0.38960 0.3401	0.46351 0.2474	0.05143 0.9037
C2 **Analysis + Interpretation**	0.87370 0.0046	1.00000	0.93611 0.0006	0.66031 0.0747	0.61498 0.1047	0.64409 0.0848	-0.12309 0.7715
C3 **Summarization**	0.86614 0.0054	0.93611 0.0006	1.00000	0.79146 0.0193	0.75388 0.0307	0.78079 0.0222	-0.03018 0.9434
C4 **Testing**	0.55183 0.1562	0.66031 0.0747	0.79146 0.0193	1.00000	0.80050 0.0170	0.77009 0.0254	-0.09934 0.8150
C5 **Iterate+Amend**	0.38960 0.3401	0.61498 0.1047	0.75388 0.0307	0.80050 0.0170	1.00000	0.78865 0.0200	0.00000 1.0000
Q12 **How likely is your organization to align the organizational design with Industry 4.0 integration?**	0.46351 0.2474	0.64409 0.0848	0.78079 0.0222	0.77009 0.0254	0.78865 0.0200	1.00000	-0.14535 0.7313
Q21 **How likely is your organization to observe increased productivity per employee due to the implementation organizational design?**	0.05143 0.9037	-0.12309 0.7715	-0.03018 0.9434	-0.09934 0.8150	0.00000 1.0000	-0.14535 0.7313	1.00000

Table 8 displays the responses of the six manufacturers in Minnesota with regards to Industry 4.0 integration, increased productivity, and socio-technical constructs. A strong, negative correlation between Industry 4.0 integration (Q12) and Increased Productivity (Q21) existed. A strong, positive correlation was observed among all socio-technical constructs with the exception of the linear relationship between Summarization (C3) and Testing (C4), in which a moderate positive correlation was observed. A strong, positive correlation between C1, C2, C4, and C5 and Industry 4.0 integration (Q12) existed. A moderate, positive correlation between Summarization (C3) and Industry 4.0 integration (Q12) existed. A negative correlation between C1 through C5 and Q21 increased productivity existed.

Table 8. Minnesota Manufacturers Surveyed

Pearson Correlation Coefficients, N = 6
Prob > |r| under H0: Rho=0

	C1	**C2**	**C3**	**C4**	**C5**	**Q12**	**Q21**
C1 **Data Gathering**	1.00000	0.92376 0.0085	0.51640 0.2943	0.90439 0.0133	0.73581 0.0955	0.77460 0.0705	-0.24194 0.6442
C2 **Analysis + Interpretation**	0.92376 0.0085	1.00000	0.59628 0.2116	0.73715 0.0946	0.73245 0.0978	0.74536 0.0890	-0.34922 0.4975
C3 **Summarization**	0.51640 0.2943	0.59628 0.2116	1.00000	0.34340 0.5051	0.91717 0.0100	0.33333 0.5185	-0.15617 0.7676
C4 **Testing**	0.90439 0.0133	0.73715 0.0946	0.34340 0.5051	1.00000	0.60292 0.2052	0.68680 0.1318	-0.10726 0.8397
C5 **Iterate+Amend**	0.73581 0.0955	0.73245 0.0978	0.91717 0.0100	0.60292 0.2052	1.00000	0.65512 0.1579	-0.37856 0.4593
Q12 **How likely is your organization to align the organizational design with Industry 4.0 integration?**	0.77460 0.0705	0.74536 0.0890	0.33333 0.5185	0.68680 0.1318	0.65512 0.1579	1.00000	-0.78087 0.0668
Q21 **How likely is your organization to observe increased productivity per employee due to the implementation organizational design?**	-0.24194 0.6442	-0.34922 0.4975	-0.15617 0.7676	-0.10726 0.8397	-0.37856 0.4593	-0.78087 0.0668	1.00000

Table 9 displays the relationship among socio-technical constructs, Industry 4.0 integration, and increased productivity among 18 manufacturers in North Dakota. A strong, positive correlation among all socio-technical constructs, C1 through C5, and Industry 4.0 integration (Q12) existed. The least positive socio-technical construct correlation was Industry 4.0 integration (Q12) was Analysis and Interpretation (C2). A strong, positive correlation among all socio-technical constructs solely existed. A negative correlation between C1 through C5 socio-technical constructs and increased productivity (Q21) existed. A weak, positive correlation between Industry 4.0 integration (Q12) and increased productivity (Q21) existed.

Table 9. North Dakota Manufacturers Surveyed

Pearson Correlation Coefficients, N = 18
Prob > |r| under H0: Rho=0

	C1	**C2**	**C3**	**C4**	**C5**	**Q12**	**Q21**
C1 **Data Gathering**	1.00000	0.75822 0.0003	0.74342 0.0004	0.51797 0.0277	0.58387 0.0110	0.67158 0.0023	-0.17984 0.4752
C2 **Analysis + Interpretation**	0.75822 0.0003	1.00000	0.74224 0.0004	0.62763 0.0053	0.60058 0.0084	0.57846 0.0119	-0.32501 0.1882
C3 **Summarization**	0.74342 0.0004	0.74224 0.0004	1.00000	0.67800 0.0020	0.68353 0.0018	0.77803 0.0001	-0.04848 0.8485
C4 **Testing**	0.51797 0.0277	0.62763 0.0053	0.67800 0.0020	1.00000	0.83735 <.0001	0.66499 0.0026	-0.37122 0.1293
C5 **Iterate+Amend**	0.58387 0.0110	0.60058 0.0084	0.68353 0.0018	0.83735 <.0001	1.00000	0.69970 0.0012	-0.25241 0.3123
Q12 **How likely is your organization to align the organizational design with Industry 4.0 integration?**	0.67158 0.0023	0.57846 0.0119	0.77803 0.0001	0.66499 0.0026	0.69970 0.0012	1.00000	0.04767 0.8510
Q21 **How likely is your organization to observe increased productivity per employee due to the implementation organizational design?**	-0.17984 0.4752	-0.32501 0.1882	-0.04848 0.8485	-0.37122 0.1293	-0.25241 0.3123	0.04767 0.8510	1.00000

Table 10 displays the relationship between Q3 on gathering relevant data from appropriate sources to assist in predicting solutions for integrating digital technology and Q12 on Industry 4.0 integration for manufacturers of all sizes. Eight (8) companies of all sizes out of 24 showed a positive correlation between gathering relevant data from appropriate sources to assist in predicting solutions for integrating digital technology and aligning the organizational design with Industry 4.0 integration. Table 11 highlights the Pearson and Polychoric Correlation Coefficients for Q3 by Q12 for all MN and ND manufacturers. The Pearson Correlation Coefficient value is .5314 and the Polychoric Correlation Coefficient value is .6378, which indicates a positive correlation. There is room for growth and improvement. Table 12 highlights the relationship between Q3 and Q21 on increased productivity for all MN and ND manufacturers. Four (4) companies of all sizes out of 24 manufacturers showed a positive correlation between gathering relevant data from appropriate sources to assist in predicting solutions for integrating digital technology and observing increased productivity per employee due to the implementation of organization design. Table 13 assesses the Pearson and Polychoric Correlation Coefficients for Q3 and Q21. Both Pearson and Polychoric values indicate a negative correlation for Q3 and Q21. Table 14 indicates the relationship between Q12 and Q21 for all MN and ND manufacturers. One (1) company illustrated a positive correlation between Industry 4.0 integration and increased productivity. Table 15 highlights the Pearson and Polychoric Correlation Coefficients for Q12 on Industry 4.0 integration and Q21 on increased productivity. The Pearson and Polychoric Correlation Coefficients indicate a negative correlation between Industry 4.0 integration and increased productivity.

Table 10. The relationship between Q3 and Q12 for MN and ND Manufacturers

Table of Q3 by Q12						
Q3(How likely is your organization to gather relevant data from appropriate sources to assist in predicting solutions for integrating digital technology?)	**Q12(How likely is your organization to align the organizational design with Industry 4.0 integration?)**					
Frequency Row Pct	**1**	**2**	**3**	**4**	**5**	**Total**
1	1 50.00	1 50.00	0 0.00	0 0.00	0 0.00	2
2	0 0.00	0 0.00	2 100.00	0 0.00	0 0.00	2
3	0 0.00	0 0.00	1 100.00	0 0.00	0 0.00	1
4	1 11.11	1 11.11	4 44.44	2 22.22	1 11.11	9
5	0 0.00	0 0.00	5 50.00	2 20.00	3 30.00	10
Total	2	2	12	4	4	24

Table 11. The Pearson and Polychoric Correlation Coefficients for Q3 by Q12 for MN and ND Manufacturers

Statistic	Value	ASE
Gamma	0.6444	0.1499
Kendall's Tau-b	0.4473	0.1234
Stuart's Tau-c	0.3776	0.1198
Somers' D C|R	0.4508	0.1299
Somers' D R|C	0.4439	0.1246
Pearson Correlation	0.5315	0.1302
Spearman Correlation	0.5094	0.1388
Polychoric Correlation	0.6378	0.1556
Lambda Asymmetric C|R	0.0833	0.0798
Lambda Asymmetric R|C	0.1429	0.0935
Lambda Symmetric	0.1154	0.0783
Uncertainty Coefficient C|R	0.2475	0.0703
Uncertainty Coefficient R|C	0.2627	0.0674
Uncertainty Coefficient Symmetric	0.2549	0.0662

Table 12. The Relationship between Q3 and Q21 for MN and ND Manufacturers

Table of Q3 by Q21					
Q3(How likely is your organization to gather relevant data from appropriate sources to assist in predicting solutions for integrating digital technology?)	**Q21(How likely is your organization to observe increased productivity per employee due to the implementation organizational design?)**				
Frequency Row Pct	**1**	**2**	**3**	**4**	**Total**
1	0 0.00	1 50.00	1 50.00	0 0.00	2
2	1 50.00	1 50.00	0 0.00	0 0.00	2
3	0 0.00	0 0.00	0 0.00	1 100.00	1
4	3 33.33	2 22.22	2 22.22	2 22.22	9
5	5 50.00	0 0.00	3 30.00	2 20.00	10
Total	9	4	6	5	24

Table 13. The Pearson and Polychoric Correlation Coefficients for Q3 by Q21

Statistic	Value	ASE
Gamma	-0.0959	0.2265
Kendall's Tau-b	-0.0697	0.1653
Stuart's Tau-c	-0.0648	0.1532
Somers' D C|R	-0.0725	0.1715
Somers' D R|C	-0.0670	0.1593
Pearson Correlation	-0.0203	0.1610
Spearman Correlation	-0.0771	0.1982
Polychoric Correlation	-0.0943	0.2458
Lambda Asymmetric C|R	0.1333	0.0878
Lambda Asymmetric R|C	0.1429	0.0935
Lambda Symmetric	0.1379	0.0569
Uncertainty Coefficient C|R	0.2104	0.0614
Uncertainty Coefficient R|C	0.2204	0.0485
Uncertainty Coefficient Symmetric	0.2153	0.0546

Table 14. The relationship between Q12 by Q21 for all MN and ND Manufacturers

Table of Q12 by Q21					
Q12(How likely is your organization to align the organizational design with Industry 4.0 integration?)	**Q21(How likely is your organization to observe increased productivity per employee due to the implementation organizational design?)**				
Frequency Row Pct	**1**	**2**	**3**	**4**	**Total**
1	1 50.00	1 50.00	0 0.00	0 0.00	2
2	0 0.00	0 0.00	1 50.00	1 50.00	2
3	4 33.33	2 16.67	3 25.00	3 25.00	12
4	1 25.00	0 0.00	2 50.00	1 25.00	4
5	3 75.00	1 25.00	0 0.00	0 0.00	4
Total	9	4	6	5	24

Table 15. The Pearson and Polychoric Correlation Coefficients for Q12 by Q21

Statistic	Value	ASE
Gamma	-0.2466	0.2222
Kendall's Tau-b	-0.1779	0.1613
Stuart's Tau-c	-0.1667	0.1517
Somers' D C|R	-0.1837	0.1655
Somers' D R|C	-0.1722	0.1578
Pearson Correlation	-0.1876	0.1854
Spearman Correlation	-0.2144	0.1919
Polychoric Correlation	-0.2440	0.2279
Lambda Asymmetric C|R	0.1333	0.1241
Lambda Asymmetric R|C	0.0000	0.0000
Lambda Symmetric	0.0741	0.0691
Uncertainty Coefficient C|R	0.2077	0.0577
Uncertainty Coefficient R|C	0.2049	0.0445
Uncertainty Coefficient Symmetric	0.2063	0.0500

Individual scatter plots of the socio-technical constructs of Data Gathering (C1), Analysis and Interpretation (C2), Summarization (C3), Testing (C4), and Iterate and Amend (C5) on the *x*-axis and Industry 4.0 (Q12) on the *y*-axis were created for the manufacturing firms surveyed. These are illustrated in Figures 10-14 below. The three lines are the simple linear regressions for small, medium, and large companies. The linear regression highlights positive slopes for all three business sizes, indicating that, as Industry 4.0 integration increases, the socio-technical constructs are increasingly utilized within the work organization. In Figure 10, medium-sized companies integrating Industry 4.0 are more aligned with the socio-technical construct of Data Gathering than small and large companies. In Figure 11 the small companies integrating Industry 4.0 are more aligned early on with the socio-technical construct of Analysis and Interpretation than medium and large companies. Medium-sized companies are improving over time, perhaps due to being more equipped to apply these socio-technical techniques. Larger businesses do not seem to be as agile. In Figure 12 the larger companies integrating Industry 4.0 are more aligned with the socio-technical construct of Summarization. Figure 13 displays a positive correlation for all three business sizes integrating Industry 4.0 with the socio-technical construct of Testing. Large companies are doing better; however, the trend of medium companies is that they may surpass large and small companies. The data, however, is not available to support this conclusively. Figure 14 displays a positive correlation for all three business sizes that are integrating Industry 4.0 with the socio-technical construct of Iterate and Amend. Small and large companies are following the same slope. The trajectory for medium companies is more positive. Medium companies are more advanced in socio-technical system design and are responding uniquely in comparison. The medium companies may be more agile than large and have more resources than smaller companies in the region.

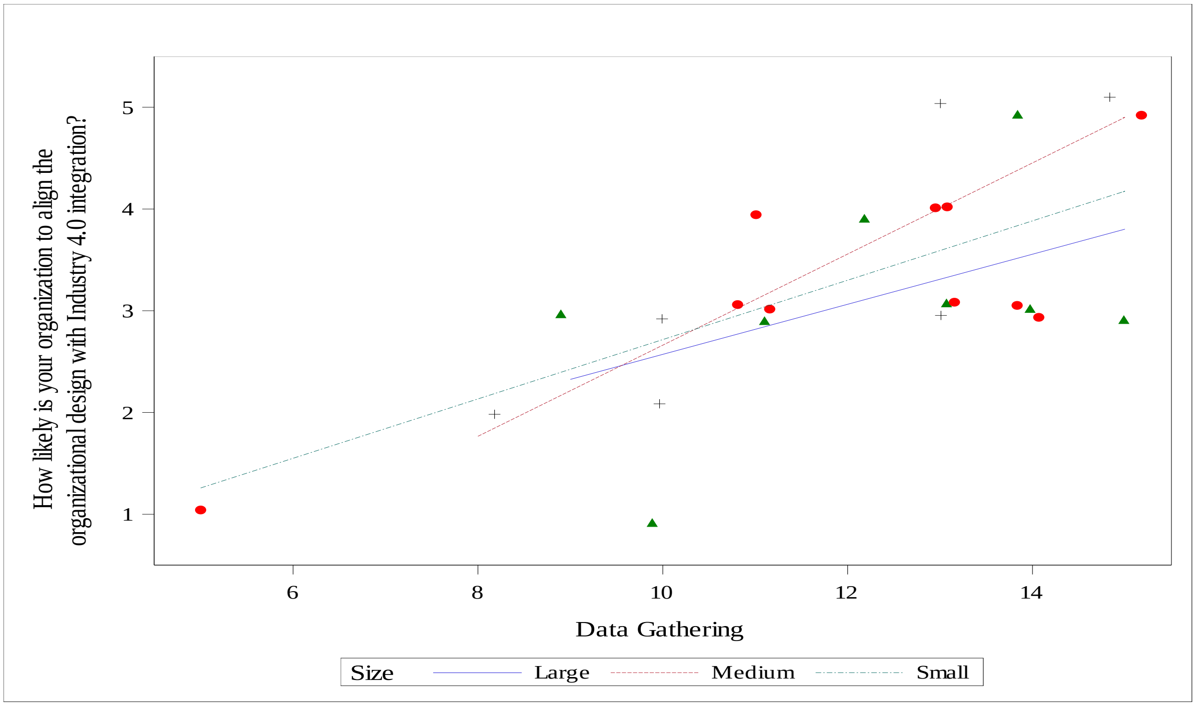

Figure 10. Data Gathering

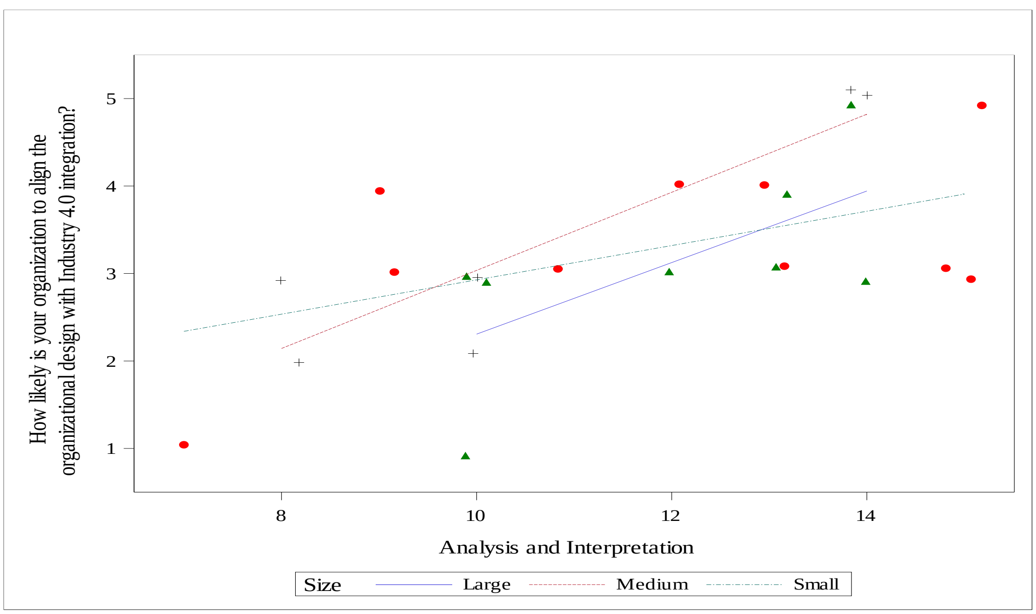

Figure 11. Analysis and interpretation

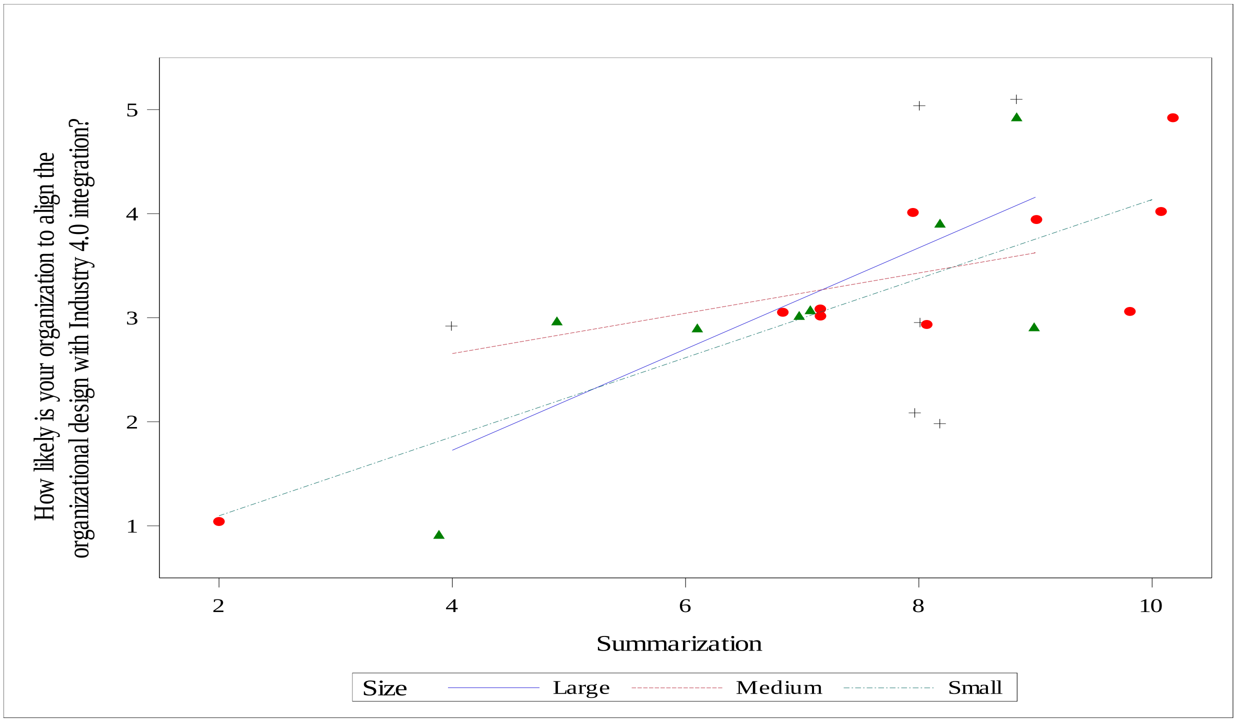

Figure 12. Summarization

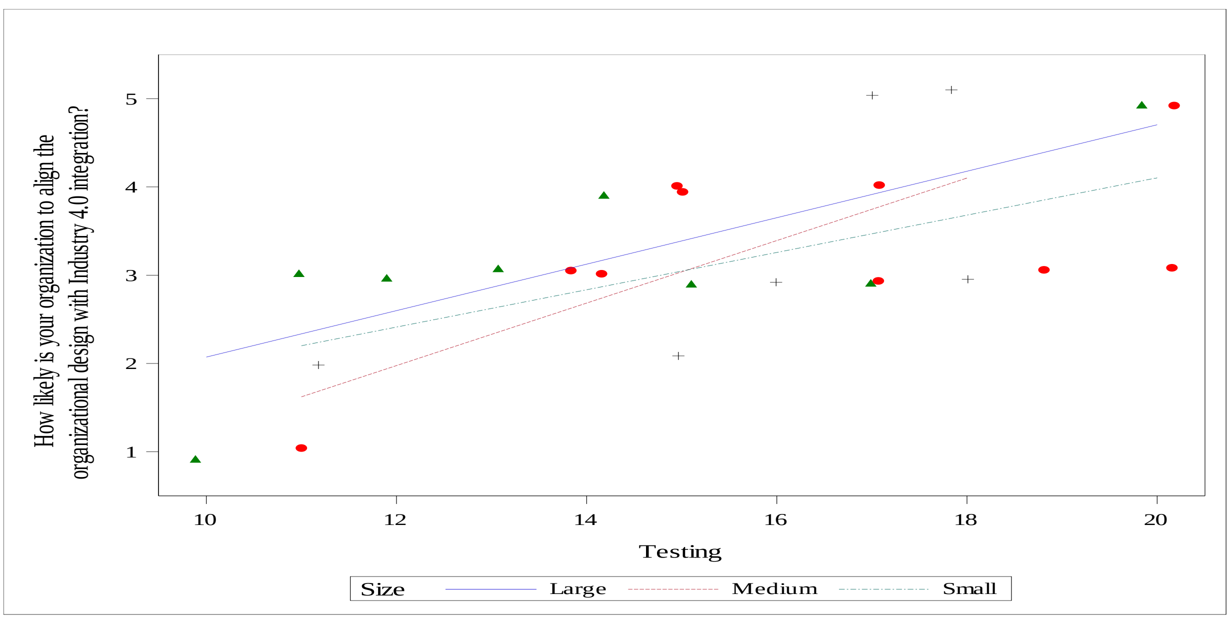

Figure 13. Testing

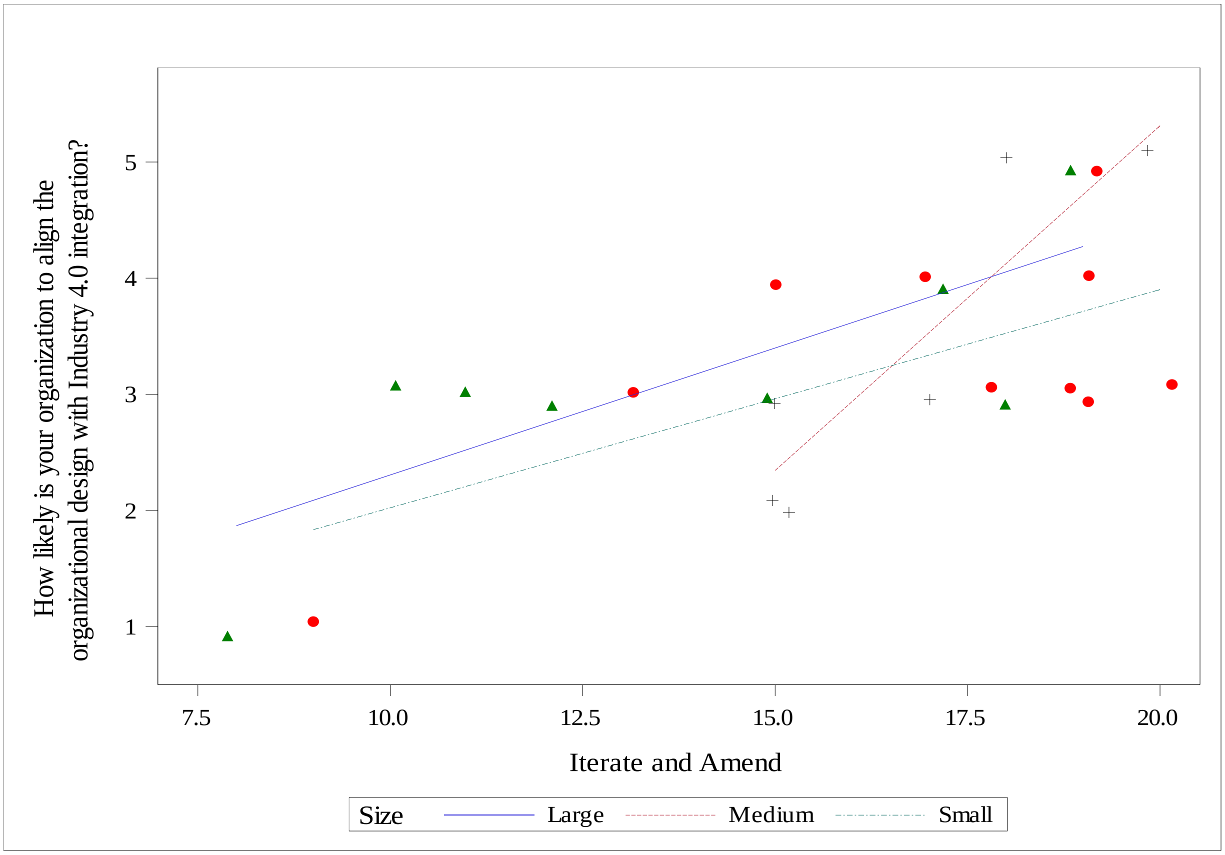

Figure 14. Iterate and Amend

4.2. Results for Manufacturers – Second Survey

In the second survey the adoption level of 22 Socio-technical practices was assessed using a five-point Likert scale or multiple-choice option. The first three questions were demographic and inquired about the business size based on the number of employees, the U.S. state in which the business is located, and the industry category, respectively. The survey assessed the current socio-technical organizational design practices and the motivation to adopt socio-technical work design, organizational learning, responsible autonomy, communication strategies, leadership skills, resource allocation, and flexible work arrangements conducive to implementing Industry

4.0. Out of the 35 manufacturers surveyed, 22 were small, seven (7) were medium, and six (6) were large that responded from Minnesota and North Dakota markets.

It was stated upfront in the message sent to respondents that anonymity and confidentiality would be ensured. Pearson and Polychoric correlation coefficients were used to check the pairwise linear relationships. As well, simple frequency charts and cross tabulation comparison charts were generated. The relationships tested were 22 socio-technical design practices grouped into six socio-technical constructs of people, culture, goals, technology, processes, and infrastructure.

The following questions were posed and pertain to the first socio-technical construct of Technology.

- Which digital maturity level best describes your current organization? The following options were provided and participants were limited to selecting one option – paper-based, spreadsheet, commercial or customized quality IT solutions, product lifecycle management software integrated (i.e. SAP, Oracle, and etc.), Highest level of digital maturity – closed-loop manufacturing, closed-loop quality data & product lifecycle management software integrated (Q4) (Dutta et al., 2021).
- How likely are employees to experience decision support through learning algorithms from various applications? (Q16) The following definition was provided, "Employee autonomy and decision-making are both impacted by learning algorithms in various IT applications. Algorithmic management can vary from decision support to judgment substitution for the employee. Learning algorithms shape the choices available to employees by automating decision-making, specifically by imposing predefined rules and by rapidly processing massive amounts of data" (Perez et al., 2022).

- In reference to the prior question, how likely are employees to experience judgment substitution for the employee through learning algorithms from various applications, such as software platforms, as an example? (Q17) (Perez et al., 2022)

The combined Likert scale responses of *Somewhat Likely* and *Extremely Likely* from Minnesota and North Dakota businesses for Q16 were 11.43% and 0%, respectively. Similar Likert responses for Q17 were 14.29% and 0%, respectively. In response to Q4, workflow processes indicated that eight (8) firms were paper-based, six (6) used spreadsheets, seven (7) leveraged commercial or customized quality IT solutions, eleven (11) used product lifecycle management software integrated only, and three (3) implemented close-loop manufacturing, closed-quality data, and product lifecycle management software that was integrated.

Q4 indicated that 20% of manufacturers that responded to the question were likely to establish a reduced daily work schedule or 14.29% of those surveyed. This response represents one (1) paper-based firm, two (2) firms utilizing spreadsheets, one (1) firm utilizing commercial or customized quality IT solutions, and one (1) firm leveraging product lifecycle management software integrated, and no firms using closed-loop manufacturing, closed-loop quality data, and product lifecycle management software integrated.

The following questions were posed and pertain to the second socio-technical construct of Processes.

- How likely is your organization to follow an operational process that includes these steps: data gathering, analysis and interpretation, summarizing the findings, testing the results with stakeholders, and iterating and amending as necessary to communicate recommendations to employees and stakeholders? (Q5) (Davis et al., 2014).

- How likely is your organization to create cross-functional diagrams, which are used to map the workflow of interrelated activities and resources (i.e. product, workers, machine, material, workstation setup, production line, factory operations, external factors, etc.) that transform inputs into outputs, as well as, to portray relationships among the various resources performing actions? (Q6) (Alsakka et al., 2023).
- Which timeline(s) does your organization generate, that include(s) key factors leading up to the event or scenario analyzed, grouped by the six factors of goals, people, buildings/infrastructure, technology, culture, and processes/procedures? The following options were provided and participants were allowed to select all that applied – long-standing (3+ months), issues immediately preceding the event (0-3 months), factors involved on the day, and the option to provide a customized response. (Q7) (Davis et al., 2014).
- How likely is your organization to continuously improve communication across departments and teams to instill employee engagement? (Q20) (Whiteoak, 2022).
- How likely is your organization to operate with standard operating procedures on work processes, systems architecture, and data formats? (Q23) (Enehaug, 2017).
- How likely is your organization to recognize both technology and people dimension to ensure that systems are highly efficient and contain better human characteristics that lead to better employee satisfaction? (Q25) (Sergei et al., 2023).

The combined Likert scale responses of *Somewhat Likely* and *Extremely Likely* from Minnesota and North Dakota businesses in the manufacturing industry for the Q5 were 25.71% and 20%, respectively. Similar Likert responses for Q6 were of the second socio-technical construct of Processes were 25.71% and 14.29%, respectively. Similar Likert responses for Q20 were 59.38% and 34.38%, respectively. Similar Likert responses for Q23 were 28.13% and 56.25%, respectively. Similar Likert responses for Q25 were 40.63% and 25%, respectively.

Responses for Q7 were as follows: 27.27% selected long-standing (3+ months) only, 9.09% selected long-standing (3+ months) and issues immediately preceding the event (0-3 months), 6.06% selected long-standing (3+ months), issues immediately preceding the event (0-3 months), and factors involved on the day, 27.27% selected issues immediately preceding the event (0-3 months) only, 3.03% selected issues immediately preceding the event (0-3 months) and factors involved on the day, 15.15% selected factors involved on the day. Seven participants provided a customized response. Responses included statements such as, “We use 3-month, 1 year, project specific, and long-term campaign strategy timelines” and “Some have a 1-3 month roll out, others 6-12 months”.

The following questions were posed and pertain to the third socio-technical construct of Culture.

- How likely is your organization characterized by continuity and adaptation of work processes and human factors? (Q8) (Enehaug, 2017).
- How likely is your organization to promote the productivity and innovation of teams while minimizing conflicts? (Q9) (Enehaug, 2017).
- Productive organizational learning has three classifications. Which classification best describes the level of productive organizational learning in your work organization? The following options were provided and participants were able to make one selection: organizational inquiry that improves the way tasks are solved, inquiry in which the organization explores and restructures values and criteria for better performance, and

- inquiry that betters the organizational learning of both types 1 and 2. (Q11) (Enehaug, 2017).
- How likely is your organization engaged in a culture of organizational learning? The following definition was provided to participants, "Organizational learning is defined as organizational inquiry that improves the ways tasks are solved, in for better performance. Employees are creative, innovative, and willing to continuously learn and develop". (Q22) (Fischer et al., 2023).
- How likely would your organization be defined as organizationally flexible? The following definition was provided to participants, "Organizational flexibility is defined as relying on flexible structures, applying leadership skills, and organizing processes and projects based on agile teamwork". (Q24) (Sergei et al., 2023).

The combined Likert scale responses of Somewhat Likely and Extremely Likely from Minnesota and North Dakota businesses in the manufacturing industry for Q8 of the socio-technical construct of Culture were 34.29% and 25.71%, respectively. Similar Likert responses for Q9 were 45.71% and 22.86%, respectively. As well, similar Likert responses for Q22 were 34.38% and 25%, respectively. Similar Likert responses for Q24 were 40.64% and 25%, respectively.

Responses for Q11 were as follows: 41.18% responded affirmatively to "organizational inquiry that improves the way tasks are solved", 11.76% responded affirmatively to "inquiry in which the organization explores and restructures values", and 47.06% responded affirmatively to "inquiry that betters the organizational learning of both types 1 and 2".

The following questions pertain to the fourth socio-technical construct of People.

- How likely is your organization to specify roles, responsibilities, and/or tasks that are specific to that job when you are trying to optimize or streamline a process? (Q10) (Enehaug, 2017).
- How likely is your organization to leverage a bottom-up problem-solving approach? The following example was provided to participants, "i.e. Job crafting that focuses on co-workers deciding and designing together to improve their work and workplaces during change". (Q18) (Whiteoak, 2022).
- How likely is your organization to develop cross-functional teams? (Q19) (Leso et al., 2022).
- How likely is your organization defined as engaging in responsible autonomy with employees and teams to achieve specific goals? The definition provided to participants was, "Responsible autonomy is defined as teams or groups having the discretion to judge and decide the organization, timing and pace of work tasks, which entails a relaxation of direct management supervision and helps to avoid 'silo thinking' by engaging the entire system". (Q21) (Fischer et al., 2023).

The combined Likert scale responses of *Somewhat Likely* and *Extremely Likely* from Minnesota and North Dakota businesses in the manufacturing industry for Q10 were 25.71% and 37.14%, respectively. Similar Likert responses for Q18 were 48.57% and 11.43%, respectively. Similar Likert responses for Q19 were 37.14% and 37.14%, respectively. Question 21 responses were 40.63% and 21.88%, respectively.

The following question pertains to the fifth socio-technical construct of Infrastructure.

- How likely is your organization to support allocation of resources and work to change and improve the production practices, organize work tasks, and strengthen internal cooperation? (Q12) (Enehaug, 2017)

The combined Likert scale responses of *Somewhat Likely* and *Extremely Likely* from Minnesota and North Dakota businesses in the manufacturing industry for Q12 were 37.14% and 31.43%, respectively.

The following questions pertain to the sixth socio-technical construct of Goals.

- How likely will establishing a reduced daily work hour goal serve as a way to jointly optimize the technical and human factors of your organization to achieve higher productivity and employee wellbeing? (Q13) (Enehaug, 2017)
- Are flexible working hours applied in activities upstream or downstream of the production system? The following examples were provided "i.e. design, protocoling, manufacturing, fabrication, testing, quality control, packaging, and shipping". The participants were provided with the option of responding 'yes' or 'no'. If a 'yes' reply was provided the participant was encouraged to provide a customized additional response to include further information. (Q14) (Cimini & Cavalieri, 2022)
- Are the hourly labor requirements and productivity goals achievable with a reduced hourly work week schedule when considering organizational factors? The following examples were provided "i.e. product-related or design-related factors, worker-related factors, material-related factors, factory operations-related factors, and production-line related factors". The participants were provided with the option of responding 'yes' or 'no'. If a 'yes' reply was provided the participant was encouraged to provide a customized

- additional response to include further information. (Q15) (Cimini, C. & Cavalieri, S., 2022)

The combined Likert scale responses of Somewhat Likely and Extremely Likely from Minnesota and North Dakota businesses in the manufacturing industry for Q13 were 14.29% and 5.71%, respectively.

The responses gathered for Q14 indicate that 48.57% responded 'yes' and 51.43% responded 'no'. The following customized responses were provided: 1) we are a brewery with a restaurant, taproom, and catering business. As long as the team communicates with each other and tasks get completed as scheduled, time is flexible. Restaurant has regular hours that we must maintain, but staff schedule time off as needed., 2) activity, 3) manufacturing and fabrication are flexed to accommodate jobs as necessary, 4) all work hours are flexible as long as the get their 40 hours in. 5) we are not a public based business, so hours can be flexible for our employees, 6) we have flexible work hours, up to a point. 7) Yes, for those types of support functions, very flexible working hours. The unwritten rule is that these functions should also put in a lot more time that 40 hrs/wk., and 8) Flexibility is more available in the downstream process. Chi-Square tests were completed for Q14 and a strong positive relationship was found with Q12, Q13, Q21 (responsible autonomy), Q24, and Q25. A T Test was constructed and illustrated a strong positive relationship between Q14 and the socio-technical constructs of Technology, Processes, Culture, People, and Goals.

The responses provided for Q15 indicate that 14.28% responded 'yes' and 85.72% responded no'. The following customized responses were provided: 1) delivery schedules, 2) Yes, we are struggling to keep employees busy with current workloads and 3) We can be flexible with hours, as needed.

The cross tabulations of Q15 and Q12 on allocation of resources indicated that three out of 35 manufacturers positively correlate. The cross tabulations for Q15 and Q13 on the reduced daily work hour goal indicated that four out of 35 manufacturers positively correlate. The comparison of Q15 and Q16 on learning algorithms indicated that one out of 35 manufacturers positively correlated. Comparing Q15 to Q17 on judgment substitution noted no correlation. Question 15 compared to Q18 on bottom-up problem-solving approach indicated five affirmative responses out of 35. Question 15 compared to Q19 on developing cross-functional teams illustrated an outcome of four positive correlations out of 35. Question 15 compared to Q20 on continuously improving communication achieved the outcome of six affirmative responses out of 32. Question 15 compared to Q21 on responsible autonomy indicated six positive responses out of 32. Question 15 compared to Q22 a culture of organizational learning illustrated three out of 32 positive correlations. Question 15 compared to Q23 on utilizing standard operating procedures indicated four positive correlations out of 32. Question 15 compared to Question 24 on organizational flexibility indicated six out of 32 positive correlations. Question 15 compared to Question 25 on socio-technical design and four positive observations were noted.

Chi-Square tests were completed for Q15 and a strong positive relationship was found with Q13, and Q21 (responsible autonomy). A T Test was constructed and showed a strong positive relationship between Q15 and the socio-technical constructs of Technology and Goals. The tables are organized with the top numbers being the Pearson’s correlation coefficient and the lower numbers the p-values. The null hypothesis between the variables was zero. Tables 16-18 display the 32 viable outcomes resulting from the correlation between organizational learning and reduced daily work hour goals, responsible autonomy and the promotion of productivity and innovation, and responsible autonomy and organizational learning among regional manufacturers.

Table 19 measures the socio-technical constructs of all manufacturers surveyed, which are noted as the technical subsystems of Technology, Processes, Infrastructure and social subsystems of Culture, People, and Goals. A strong and positive Pearson's correlation coefficient is observed between the following six relationships: Processes and Culture, Processes and People, Processes and Infrastructure, Culture and People, Culture and Infrastructure, and Infrastructure and People constructs. A moderate and positive relationship was observed between the following two relationships: Technology and Processes and Technology and Goals constructs.

The number of observations used for a pair of variables is the number that provided data for both variables in the pair. There is no other selection criterion for the Pearson Correlation Coefficient determination. Therefore, in the case of 31 observations in Table 19, as an example, there were four participants of the total 35 manufacturers that did not provide complete data for the socio-technical constructs in question.

The Pearson and Polychoric Correlation Coefficients indicate a negative correlation between Industry 4.0 integration and increased productivity. Tables 16 through 18 indicated the following items:

- Table 16 illustrates data collected from small manufacturers from MN and ND surveyed. Q13 on Reduced Daily Work Hours notes no significant relationship with Q18 (bottom-up communication), Q20 (communication across departments), Q21 (responsible autonomy), Q22 (organizational learning), and Q9 (promote productivity and innovation).
- Q18 has a positive correlation with Q20 and Q21.

- Q20 has a positive correlation also with Q22.
- Q9 has a positive correlation with Q22.
- Table 17 illustrates all medium-sized manufacturers from Minnesota and North Dakota surveyed. Q13 and Q21 have a positive correlation.
- Table 18 illustrates all large-sized manufacturers from MN and ND surveyed. No positive correlations were observed.

Figures 15 through 17 highlight the following outcomes:

- Fig. 15 illustrates that medium businesses are most engaged in responsible autonomy while engaging in a culture of organizational learning.
- Fig. 16 illustrates a slight positive slope for medium businesses on organizational learning and reduced daily work hour goal.
- Fig. 17 illustrates that small businesses only display a positive slope for responsible autonomy with promoting productivity and innovation.

Table 22 illustrates that for MN and ND production companies five out of 34 responded positively to Q15, which is assessing hourly labor requirements and productivity goals being achievable with a reduced daily work hour goal and the relationship to Q13 of the reduced daily work hour goal. Table 23 illustrates a positive Pearson and Polychoric Correlation Coefficient for Q15 to Q13.

Table 24 illustrates that for MN and ND production companies, 1 out of 34 responded affirmatively to a correlation between Q15 of hourly labor requirements and productivity goals being achievable with a reduced daily work hour weekly schedule when considering organizational factors and Q16 on productivity by learning algorithms. Table 25 did not show a significant Pearson Correlation Coefficient yet illustrated a significant Polychoric Correlation Coefficient.

Table 26 notes that seven (7) out of 34 responded affirmatively to Q15 on productivity to Q21 on responsible autonomy. Table 27 displays that no significant Polychoric and Pearson Correlation Coefficients assessing the relationship between Q15 and Q21 were observed. Table 28 displays all MN and ND manufacturers responses for the relationship between Q14 on flexible work hours and Q13 on reduced work hours. There were six (6) out of 34 responses in the affirmative. Table 29 highlights that the Pearson and Polychoric Correlations Coefficients on this relationship was not significant.

Table 30 illustrates the outcomes for all MN and ND manufacturers for the relationship between Q14 on flexible hours and Q16 on learning algorithms. Two out 34 manufacturers responded in the affirmative. Table 31 notes that the Pearson Correlation Coefficient is not significant, however, the Polychoric Correlation Coefficient is moderately significant.Table 32 reports that all MN and ND companies illustrate a affirmative response of 15 out of 34 for the relationship between Q14 flexible hours and Q16 learning algorithms. Table 33 illustrates no significance between this relationship with both correlation coefficient types.

Table 34 illustrates that 16 out of 34 MN and ND manufacturers responded affirmatively to the relationship between Q14 on flexible hours and Q21 on responsible autonomy. Table 35 shows a moderate significant Pearson Correlation Coefficient and significant Polychoric Correlation Coefficient Table 36 indicates that 16 out of 34 manufacturers responded affirmatively to the relationship between Q14 on flexible hours and Q24 organizational flexibility. Table 37 highlights a moderately significant Pearson Correlation Coefficient and a significant Polychoric Correlation Coefficient.

Table 16. All Small Manufacturers from Minnesota and North Dakota Surveyed

Pearson Correlation Coefficients, N = 21 Prob > |r| under H0: Rho=0						
	Q13	**Q18**	**Q20**	**Q21**	**Q22**	**Q9**
Q13 **How likely will establishing a reduced daily work hour goal serve as a way to jointly optimize the technical and human factors of your organization to achieve higher productivity and employee wellbeing?**	1.00000	0.14144 0.5408	-0.32759 0.1472	0.18253 0.4284	-0.00993 0.9659	0.08149 0.7255
Q18 **How likely is your organization to leverage a bottom-up problem-solving approach?**	0.14144 0.5408	1.00000	0.46792 0.0324	0.74514 0.0001	0.32888 0.1455	0.18483 0.4225
Q20 **How likely is your organization to continuously improve communication across departments and teams to instill employee engagement?**	-0.32759 0.1472	0.46792 0.0324	1.00000	0.36809 0.1006	0.53437 0.0126	0.03522 0.8795
Q21 **How likely is your organization defined as engaging in responsible autonomy with employees and teams to achieve specific goals?**	0.18253 0.4284	0.74514 0.0001	0.36809 0.1006	1.00000	0.22480 0.3272	0.37329 0.0956
Q22 **How likely is your organization engaged in a culture of organizational learning?**	-0.00993 0.9659	0.32888 0.1455	0.53437 0.0126	0.22480 0.3272	1.00000	0.56457 0.0077
Q9 **How likely is your organization to promote productivity and innovation of teams while minimizing conflicts?**	0.08149 0.7255	0.18483 0.4225	0.03522 0.8795	0.37329 0.0956	0.56457 0.0077	1.00000

Table 17. All Medium-sized Manufacturers from Minnesota and North Dakota Surveyed

Pearson Correlation Coefficients, N = 6 Prob > |r| under H0: Rho=0						
	Q13	**Q18**	**Q20**	**Q21**	**Q22**	**Q9**
Q13 **How likely will establishing a reduced daily work hour goal serve as a way to jointly optimize the technical and human factors of your organization to achieve higher productivity and employee wellbeing?**	1.00000	-0.07495 0.8878	0.52145 0.2887	0.82268 0.0444	0.18210 0.7299	-0.42400 0.4021
Q18 **How likely is your organization to leverage a bottom-up problem-solving approach?**	-0.07495 0.8878	1.00000	0.15811 0.7648	0.21437 0.6834	0.38651 0.4491	0.53033 0.2791
Q20 **How likely is your organization to continuously improve communication across departments and teams to instill employee engagement?**	0.52145 0.2887	0.15811 0.7648	1.00000	0.54233 0.2663	0.76827 0.0743	0.44721 0.3739
Q21 **How likely is your organization defined as engaging in responsible autonomy with employees and teams to achieve specific goals?**	0.82268 0.0444	0.21437 0.6834	0.54233 0.2663	1.00000	0.53029 0.2791	-0.24254 0.6433
Q22 **How likely is your organization engaged in a culture of organizational learning?**	0.18210 0.7299	0.38651 0.4491	0.76827 0.0743	0.53029 0.2791	1.00000	0.62470 0.1848
Q9 **How likely is your organization to promote productivity and innovation of teams while minimizing conflicts?**	-0.42400 0.4021	0.53033 0.2791	0.44721 0.3739	- 0.24254 0.6433	0.62470 0.1848	1.00000

Table 18. All Large-sized Manufacturers from Minnesota and North Dakota Surveyed

Pearson Correlation Coefficients, N = 5 Prob > |r| under H0: Rho=0						
	Technology	**Processes**	**Culture**	**People**	**Infrastructure**	**Goals**
Q13 **How likely will establishing a reduced daily work hour goal serve as a way to jointly optimize the technical and human factors of your organization to achieve higher productivity and employee wellbeing?**	0.79057 0.1114	0.00000 1.0000	-0.34503 0.5696	-0.62017 0.2644	-0.64550 0.2394	1.00000 <.0001
Q18 **How likely is your organization to leverage a bottom-up problem-solving approach?**	-0.60820 0.2764	0.34151 0.5738	0.04826 0.9386	0.83856 0.0760	0.36116 0.5504	-0.46625 0.4286
Q20 **How likely is your organization to continuously improve communication across departments and teams to instill employee engagement?**	0.03341 0.9575	0.78571 0.1152	0.69985 0.1883	0.10483 0.8668	0.32733 0.5908	0.42258 0.4784

Table 18. All Large-sized Manufacturers from Minnesota and North Dakota Surveyed (Continued)

Pearson Correlation Coefficients, N = 5 Prob > |r| under H0: Rho=0						
	Technology	**Processes**	**Culture**	**People**	**Infrastructure**	**Goals**
Q21 How likely is your organization defined as engaging in responsible autonomy with employees and teams to achieve specific goals?	0.39528 0.5101	-0.42258 0.4784	-0.86258 0.0599	-0.31009 0.6116	-0.64550 0.2394	0.50000 0.3910
Q22 How likely is your organization engaged in a culture of organizational learning?	-0.35722 0.5550	0.50918 0.3809	0.75724 0.1382	0.08006 0.8982	0.66667 0.2191	0.00000 1.0000
Q9 How likely is your organization to promote productivity and innovation of teams while minimizing conflicts?	-0.91856 0.0276	0.58191 0.3033	0.80178 0.1027	0.72058 0.1697	1.00000 <.0001	-0.64550 0.2394

Table 19. Socio-technical Construct Comparison of all Manufacturers Surveyed

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations						
	Technology	**Processes**	**Culture**	**People**	**Infrastructure**	**Goals**
Technology	1.00000 32	0.38014 0.0319 32	0.20899 0.2592 31	0.15564 0.3950 32	0.06698 0.7157 32	0.47906 0.0055 32
Processes	0.38014 0.0319 32	1.00000 32	0.79181 <.0001 31	0.77428 <.0001 32	0.68667 <.0001 32	0.18294 0.3162 32
Culture	0.20899 0.2592 31	0.79181 <.0001 31	1.00000 31	0.79063 <.0001 31	0.66443 <.0001 31	-0.05447 0.7710 31
People	0.15564 0.3950 32	0.77428 <.0001 32	0.79063 <.0001 31	1.00000 32	0.72450 <.0001 32	-0.10001 0.5860 32
Infrastructure	0.06698 0.7157 32	0.68667 <.0001 32	0.66443 <.0001 31	0.72450 <.0001 32	1.00000 32	-0.03092 0.8666 32
Goals	0.47906 0.0055 32	0.18294 0.3162 32	-0.05447 0.7710 31	-0.10001 0.5860 32	-0.03092 0.8666 32	1.00000 32

Table 20 displays the relationship between digital maturity level and hourly labor requirements and productivity goals being achievable with a reduced hourly work week schedule when considering organizational factors. Three (3) out of 35 or 8.57% of businesses responded in the affirmative that utilized commercial or customized quality IT solutions or product lifecycle management software integrated into their operations. No businesses that utilized closed-loop manufacturing, closed-loop quality data & product lifecycle management software combined responded affirmatively. Significant to the design of cyber-physical systems, such as Digital twin, is closed loop interaction and control between human factors and smart communication and information technologies (Guha et al., 2023). Product lifecycle management leverages big data, visual computing, horizontal and vertical integration, cyber-physical systems, supply chain and management, which brings the product closer to the customer leading to greater customization and supports value creation in the Industry 4.0 context (Sivananda et al., 2021). Product life cycle management is an integration process also known as "end-to-end" that is based on vertical and horizontal integrations and closely connects the customer, product design, and manufacturing (Yao et al., 2021).

Table 20. Comparison of Digital Maturity Level (Q4) with Reduced Hourly Work Week Schedule (Q15)

Table of Q4 by Q15n			
Q4(Which digital maturity level best describes your current organization?)	**Q15n**		
Frequency Row Pct	**Yes**	**No**	**Total**
Paper-based	2 25.00	6 75.00	8
Spreadsheet	1 16.67	5 83.33	6
Commercial or customized quality IT solutions	1 14.29	6 85.71	7
Product Lifecycle Management software integrated	2 18.18	9 81.82	11
Highest level of digital maturity	0 0.00	3 100.00	3
Total	6	29	35

Table 21 displays the relationship between the productive organizational learning type and responsible autonomy. A total of 31 manufacturers out of 35 responded to Questions 11 and 21. A total of 19 of 31 or 61% of responses were in the affirmative to describing the type of organizational learning that is or would be completed, as well as, engaging in responsible autonomy with employees and teams to achieve specific goals. As well, Tables 15-22 and Figures 27-29 provide additional information regarding the results of the second survey set.

Table 21. Comparison of Productive Learning type (Q11) to Responsible Autonomy (Q21)

Table of Q11 by Q21						
Q11(Productive organizational learning has three classifications. Which classification best describes the level of productive organizational learning in your work organization?)	**Q21(How likely is your organization defined as engaging in responsible autonomy with employees and teams to achieve specific goals?)**					
Frequency Row Pct	**1**	**2**	**3**	**4**	**5**	**Total**
organizational inquiry that improves the way tasks are solved	1 7.69	3 23.08	1 7.69	5 38.46	3 23.08	13
inquiry in which the organization explores and restructures values	1 33.33	1 33.33	1 33.33	0 0.00	0 0.00	3
inquiry that betters the organizational learning of both types 1 and 2	2 13.33	1 6.67	1 6.67	8 53.33	3 20.00	15
Total	4	5	3	13	6	31
Frequency Missing = 4						

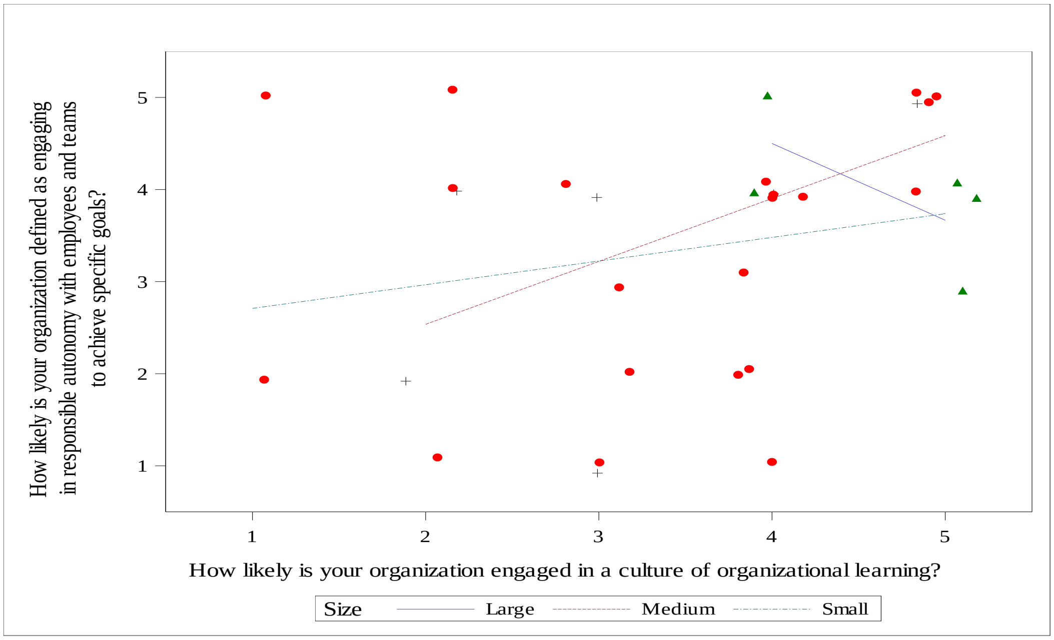

Figure 15. Q21 Responsible Autonomy comparison to Q22 Organizational Learning

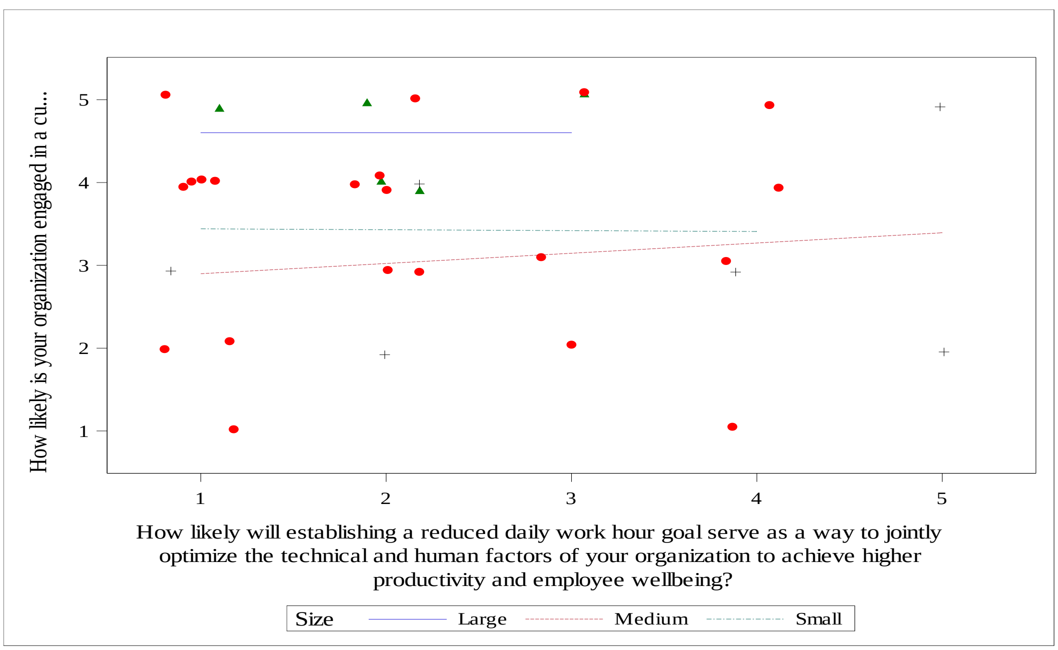

Figure 16. Q22 Organizational Learning Compared to Q13 Reduced Daily Work Hour Goal

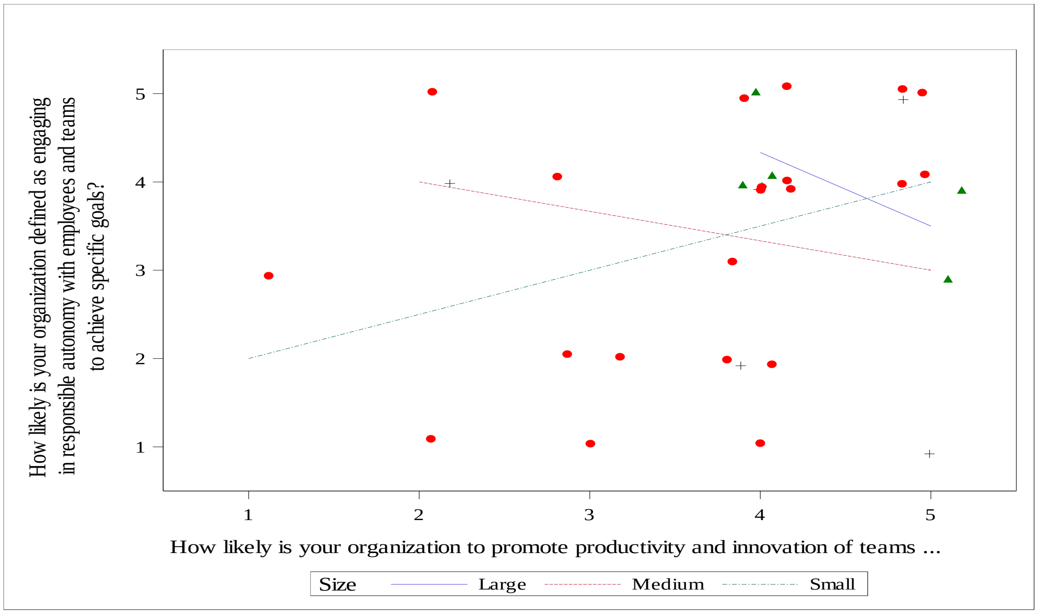

Figure 17. Q21 Responsible Autonomy Compared to Q9 on Productivity and Innovation

Table 22. Minnesota and North Dakota Production Companies – Second Survey

Table of Q15n by Q13						
Q15n(Are the hourly labor requirements and productivity goals achievable with a reduced hourly work week schedule when considering organizational factors?)	**Q13(How likely will establishing a reduced daily work hour goal serve as a way to jointly optimize the technical and human factors of your organization to achieve higher productivity and employee wellbeing?)**					
Frequency Row Pct	**1**	**2**	**3**	**4**	**5**	**Total**
No	10 37.04	11 40.74	3 11.11	2 7.41	1 3.70	27
Yes	0 0.00	0 0.00	2 28.57	4 57.14	1 14.29	7
Total	10	11	5	6	2	34

Table 23. Pearson and Polychoric Correlation Coefficients for Q15 by Q13 – Second Survey

Statistic	Value	ASE
Gamma	0.8851	0.0817
Kendall's Tau-b	0.5371	0.0913
Stuart's Tau-c	0.5329	0.1465
Somers' D C|R	0.8148	0.0940
Somers' D R|C	0.3540	0.0942
Pearson Correlation	0.6070	0.1178
Spearman Correlation	0.5912	0.1002
Polychoric Correlation	0.8128	0.1199
Lambda Asymmetric C|R	0.1739	0.0790
Lambda Asymmetric R|C	0.2857	0.2957
Lambda Symmetric	0.2000	0.1254
Uncertainty Coefficient C|R	0.1733	0.0570
Uncertainty Coefficient R|C	0.5042	0.1103
Uncertainty Coefficient Symmetric	0.2579	0.0764

Table 24. Minnesota and North Dakota Production Companies – Second Survey

Table of Q15n by Q16					
Q15n(Are the hourly labor requirements and productivity goals achievable with a reduced hourly work week schedule when considering organizational factors?)	**Q16(How likely are employees to experience decision support through learning algorithms from various applications?)**				
Frequency Row Pct	**1**	**2**	**3**	**4**	**Total**
No	14 51.85	8 29.63	3 11.11	2 7.41	27
Yes	0 0.00	3 42.86	3 42.86	1 14.29	7
Total	14	11	6	3	34

Table 25. Pearson and Polychoric Correlation Coefficients for Q15 by Q16 – Second Survey

Statistic	Value	ASE
Gamma	0.7273	0.1427
Kendall's Tau-b	0.4089	0.1124
Stuart's Tau-c	0.3875	0.1336
Somers' D C|R	0.5926	0.1409
Somers' D R|C	0.2821	0.0984
Pearson Correlation	0.4065	0.1403
Spearman Correlation	0.4399	0.1198
Polychoric Correlation	0.6174	0.1864
Lambda Asymmetric C|R	0.1500	0.0798
Lambda Asymmetric R|C	0.0000	0.3499
Lambda Symmetric	0.1111	0.1361
Uncertainty Coefficient C|R	0.1122	0.0462
Uncertainty Coefficient R|C	0.2761	0.0859
Uncertainty Coefficient Symmetric	0.1596	0.0602

Table 26. Minnesota and North Dakota Production Companies – Second Survey

Table of Q15n by Q21						
Q15n(Are the hourly labor requirements and productivity goals achievable with a reduced hourly work week schedule when considering organizational factors?)	**Q21(How likely is your organization defined as engaging in responsible autonomy with employees and teams to achieve specific goals?)**					
Frequency Row Pct	**1**	**2**	**3**	**4**	**5**	**Total**
No	4 14.81	5 18.52	3 11.11	10 37.04	5 18.52	27
Yes	0 0.00	0 0.00	0 0.00	5 71.43	2 28.57	7
Total	4	5	3	15	7	34

Table 27. Pearson and Polychoric Correlation Coefficients for Q15 by Q21

Statistic	Value	ASE
Gamma	0.6124	0.1935
Kendall's Tau-b	0.2817	0.1066
Stuart's Tau-c	0.2734	0.1214
Somers' D C|R	0.4180	0.1536
Somers' D R|C	0.1899	0.0828
Pearson Correlation	0.3220	0.0938
Spearman Correlation	0.3086	0.1178
Polychoric Correlation	0.4916	0.2160
Lambda Asymmetric C|R	0.0000	0.0000
Lambda Asymmetric R|C	0.0000	0.0000
Lambda Symmetric	0.0000	0.0000
Uncertainty Coefficient C|R	0.0728	0.0279
Uncertainty Coefficient R|C	0.2055	0.0617
Uncertainty Coefficient Symmetric	0.1075	0.0376

Table 28. Minnesota and North Dakota Production Companies – Second Survey

Table of Q14n by Q13						
Q14n(Are flexible working hours applied in activities upstream or downstream of the production system?)	**Q13(How likely will establishing a reduced daily work hour goal serve as a way to jointly optimize the technical and human factors of your organization to achieve higher productivity and employee wellbeing?)**					
Frequency Row Pct	**1**	**2**	**3**	**4**	**5**	**Total**
No	6 37.50	7 43.75	1 6.25	2 12.50	0 0.00	16
Yes	4 22.22	4 22.22	4 22.22	4 22.22	2 11.11	18
Total	10	11	5	6	2	34

Table 29. Pearson and Polychoric Correlation Coefficients for Q14n by Q13 – Second Survey

Statistic	Value	ASE
Gamma	0.4643	0.2121
Kendall's Tau-b	0.2938	0.1418
Stuart's Tau-c	0.3599	0.1756
Somers' D C|R	0.3611	0.1761
Somers' D R|C	0.2391	0.1146
Pearson Correlation	0.3390	0.1481
Spearman Correlation	0.3234	0.1569
Polychoric Correlation	0.4345	0.1955
Lambda Asymmetric C|R	0.0000	0.1230
Lambda Asymmetric R|C	0.3125	0.2375
Lambda Symmetric	0.1282	0.1474
Uncertainty Coefficient C|R	0.0645	0.0399
Uncertainty Coefficient R|C	0.1381	0.0874
Uncertainty Coefficient Symmetric	0.0880	0.0547

Table 30. Minnesota and North Dakota Production Companies – Second Survey

Table of Q14n by Q16					
Q14n(Are flexible working hours applied in activities upstream or downstream of the production system?)	**Q16(How likely are employees to experience decision support through learning algorithms from various applications?)**				
Frequency Row Pct	**1**	**2**	**3**	**4**	**Total**
No	10 62.50	4 25.00	1 6.25	1 6.25	16
Yes	4 22.22	7 38.89	5 27.78	2 11.11	18
Total	14	11	6	3	34

Table 31. Pearson and Polychoric Correlation Coefficients for Q14 by Q16 – Second Survey

Statistic	Value	ASE
Gamma	0.5962	0.2009
Kendall's Tau-b	0.3756	0.1431
Stuart's Tau-c	0.4394	0.1668
Somers' D C|R	0.4410	0.1671
Somers' D R|C	0.3199	0.1234
Pearson Correlation	0.3687	0.1567
Spearman Correlation	0.4041	0.1536
Polychoric Correlation	0.5075	0.1898
Lambda Asymmetric C|R	0.1500	0.1529
Lambda Asymmetric R|C	0.3750	0.1849
Lambda Symmetric	0.2500	0.1457
Uncertainty Coefficient C|R	0.0778	0.0567
Uncertainty Coefficient R|C	0.1408	0.1022
Uncertainty Coefficient Symmetric	0.1002	0.0728

Table 32. Minnesota and North Dakota Production Companies – Second Survey

Table of Q14n by Q18						
Q14n(Are flexible working hours applied in activities upstream or downstream of the production system?)	**Q18(How likely is your organization to leverage a bottom-up problem-solving approach?)**					
Frequency Row Pct	**1**	**2**	**3**	**4**	**5**	**Total**
No	3 18.75	3 18.75	3 18.75	6 37.50	1 6.25	16
Yes	1 5.56	1 5.56	1 5.56	12 66.67	3 16.67	18
Total	4	4	4	18	4	34

Table 33. Pearson and Polychoric Correlation Coefficients for Q14 by Q18 – Second Survey

Statistic	Value	ASE
Gamma	0.5882	0.2065
Kendall's Tau-b	0.3608	0.1393
Stuart's Tau-c	0.4152	0.1638
Somers' D C|R	0.4167	0.1642
Somers' D R|C	0.3125	0.1203
Pearson Correlation	0.3754	0.1520
Spearman Correlation	0.3918	0.1518
Polychoric Correlation	0.4912	0.1900
Lambda Asymmetric C|R	0.0000	0.0000
Lambda Asymmetric R|C	0.3750	0.1712
Lambda Symmetric	0.1875	0.0895
Uncertainty Coefficient C|R	0.0668	0.0508
Uncertainty Coefficient R|C	0.1299	0.0996
Uncertainty Coefficient Symmetric	0.0883	0.0672

Table 34. Minnesota and North Dakota Production Companies Q14 by Q21 – Second Survey

Table of Q14 by Q21						
Q14(Are flexible working hours applied in activities upstream or downstream of the production system?)	**Q21(How likely is your organization defined as engaging in responsible autonomy with employees and teams to achieve specific goals?)**					
Frequency Row Pct	**1**	**2**	**3**	**4**	**5**	**Total**
No	4 25.00	4 25.00	2 12.50	4 25.00	2 12.50	16
Yes	0 0.00	1 5.56	1 5.56	11 61.11	5 27.78	18
Total	4	5	3	15	7	34

Table 35. Pearson and Polychoric Correlation Coefficients for Q14 by Q21 – Second Survey

Statistic	Value	ASE
Gamma	0.6842	0.1723
Kendall's Tau-b	0.4507	0.1284
Stuart's Tau-c	0.5398	0.1592
Somers' D C|R	0.5417	0.1594
Somers' D R|C	0.3750	0.1045
Pearson Correlation	0.5272	0.1250
Spearman Correlation	0.4936	0.1421
Polychoric Correlation	0.6325	0.1562
Lambda Asymmetric C|R	0.0000	0.1489
Lambda Asymmetric R|C	0.5000	0.1531
Lambda Symmetric	0.2286	0.1310
Uncertainty Coefficient C|R	0.1273	0.0531
Uncertainty Coefficient R|C	0.2642	0.1134
Uncertainty Coefficient Symmetric	0.1718	0.0722

Table 36. Minnesota and North Dakota Production Companies Q14 by Q24– Second Survey

Table of Q14 by Q24						
Q14(Are flexible working hours applied in activities upstream or downstream of the production system?)	**Q24(How likely would your organization be defined as being organizationally flexible?)**					
Frequency Row Pct	**1**	**2**	**3**	**4**	**5**	**Total**
No	3 18.75	3 18.75	3 18.75	6 37.50	1 6.25	16
Yes	0 0.00	0 0.00	2 11.11	9 50.00	7 38.89	18
Total	3	3	5	15	8	34

Table 37. Pearson and Polychoric Correlation Coefficients for Q14 by Q24 – Second Survey

Statistic	**Value**	**ASE**
Gamma	0.7919	0.1324
Kendall's Tau-b	0.5080	0.1055
Stuart's Tau-c	0.6055	0.1355
Somers' D C|R	0.6076	0.1354
Somers' D R|C	0.4248	0.0836
Pearson Correlation	0.5644	0.1000
Spearman Correlation	0.5548	0.1179
Polychoric Correlation	0.7318	0.1298
Lambda Asymmetric C|R	0.0000	0.0000
Lambda Asymmetric R|C	0.4375	0.1555
Lambda Symmetric	0.2000	0.0745
Uncertainty Coefficient C|R	0.1465	0.0467
Uncertainty Coefficient R|C	0.2992	0.1055
Uncertainty Coefficient Symmetric	0.1967	0.0646

5. WEB SCRAPING AND INNOVATION RESEARCH STUDY

The digital transformation of manufacturers is measured through the selection of transformation technology, the designed scope of work, and the subsequent results of the digital implementation. The increased use of digital technology in the manufacturing sector has produced positive results, such as fostering corporate innovation, reducing trade costs, optimizing resource allocation, optimizing organizational efficiencies and improving financial performance. Indirectly, digital transformation can reduce an organization’s carbon emissions (Gao, 2023). At the micro-level of enterprises, a web scraping project was utilized as an accessible and inexpensive method of accessing web data to assess the digital maturity from a sample of Minnesota and North Dakota manufacturers that had been presented with both surveys (Speckmann, 2021). The keywords examined represent the nine fields of Industry 4.0, which are cyber-physical systems, the internet of things, big data, cyber security, cloud computing, additive manufacturing, advanced robotics, modelling and simulation, and augmented virtual reality. Through the methodology of web data extraction, this study reviewed a sample population of 149 websites of regional manufacturers. The data was reviewed through text analysis techniques to ensure the relevancy of the keywords to the project subject matter (Roth et al., 2024).

A recent keyword study found that the most frequently used terms associated with Industry 4.0 were ‘design’, ‘management’, ‘internet’, ‘big data’, ‘system’, ‘model’, and ‘Industry 4.0’. Industry 5.0 is referred to through keywords as ‘big data’, ‘system’, ‘design’, or ‘Industry 5.0’ (Michulek and Gajanova, 2023).

Furthermore, a recent bibliometric analysis of keyword co-occurrence within the Industry 5.0 context was conducted by Ghobakhloo et al. The colors of the nodes represent the co-occurrence of keyword groups and the edges represent the limits or constraints of the bibliometric study constructed by Ghobakhloo et al. The node sizes are scaled larger based on a greater number of connections and therefore are based on the importance in the study. Fig. 18 “implies that the literature associates several technologies with Industry 5.0, most notably AI and IoT. Sustainable development, man-made integration, and human-centric manufacturing are among the most acknowledged expected impacts of Industry 5.0. The Industry 5.0 literature pays particular attention to the issue of sustainability and efficiency in the energy context” (Ghobakhloo et al., 2023).

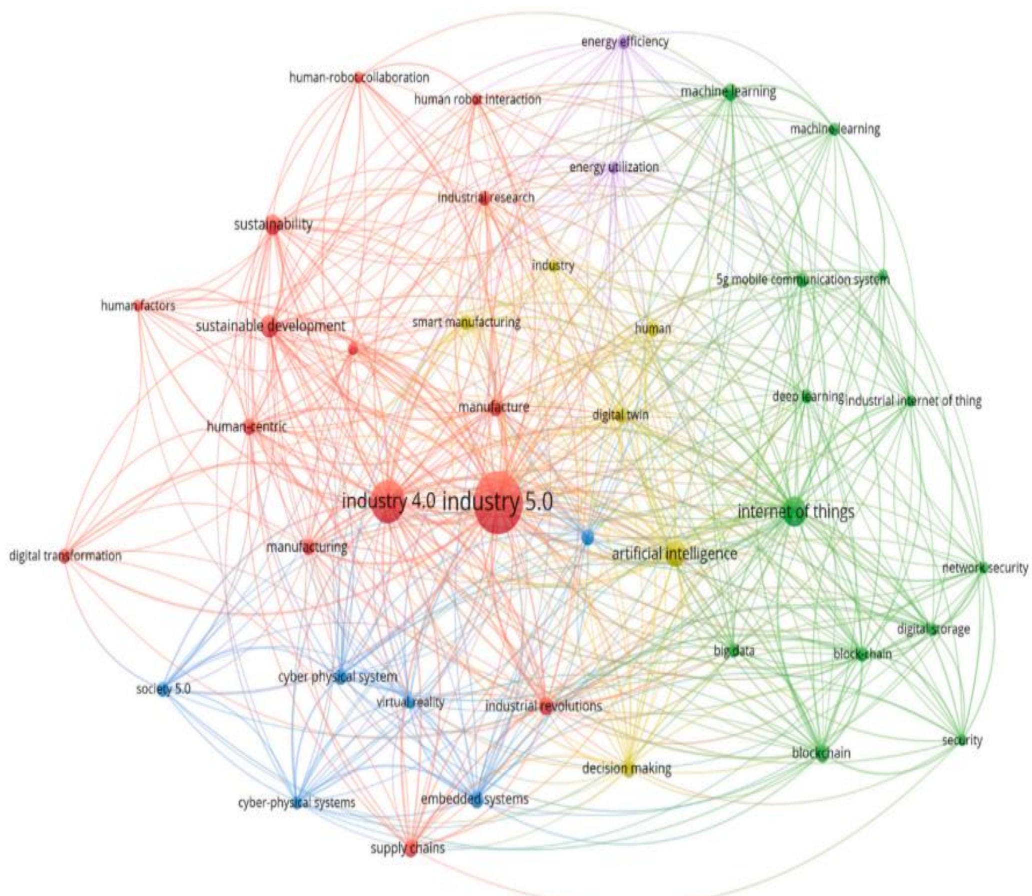

Figure 18. Bibliometric Analysis of Keyword Co-occurrence within Industry 5.0 Context from Ghobakhloo et al.

5.1. Background

The two surveys that were issued to regional manufacturers in Minnesota and North Dakota were very insightful, however, this is one dimension of a subjective depiction of a manufacturer's current operational status. This is where gathering data from manufacturers' websites is instrumental as this provides access to large amounts of structured data. A variety of manufacturing sectors were represented among the regional manufacturers assessed in the web scraping project. Small, medium, and large manufacturers are also represented (Roth et al., 2024).

5.2. Research Methodology

The Internet actively and consciously delivers broad information. The use of web scraping in research studies has steeply increased to greater than 2000 articles annually after 2019 (Mann, 2021). The research was conducted using manufacturer's websites as they are used to provide information on innovation, products, services, achievements, strategies, and relationships (Kinne & Lenz, 2021). The first task was to conduct a manual web scraping, which was conducted in a sample of 40 manufacturers' websites to assess the likelihood of adequate keyword representation within the large sample group of 149 manufacturers. The most prominent words characteristic to Industry 4.0 were listed during this first process. Afterwards, a keyword frequency analysis of the nine dimensions of Industry 4.0 was completed. The second task was to conduct the automated web scraping project, which included the output of web links and textual analysis reviewed.

The gathering of indirect data through the web scraping approach provides a method of assessing large amounts of data in an automated manner. Through web scraping, data collection is organized onto an Excel worksheet, which simplifies the analysis process. The information was collected from a variety of sources located on company websites, which may be from reports and blogs, as examples during a one-month period of November 1st through November 30th of 2023.

The collection of data was conducted in an ethical and legal manner, as it was cleared through North Dakota State University's Institutional Review Board (Speckmann, 2021). The web scraping software, Beautifulsoup from the open-source Python library designed for parsing HTML and XML documents. This tool facilitates the extraction of data from web pages by simplifying the process with its user-friendly methods for navigating the parse tree and locating specific elements. Diverse web scraping tasks are enabled through its adaptability to include data collection, content aggregation, and automated information retrieval. The use of this tool was utilized to ensure that certain security protocols were not bypassed and the collection of copywritten information was not conducted without authorization.

The web scraping initiative commenced by compiling website links of engineering and technological companies predominantly situated in the Fargo and Moorehead area. A total of 149 links to the companies' homepages were gathered for initial exploration. Subsequently, a request connection was employed incorporating appropriate header parameters such as User-Agent, Accept-Language, Accept-Encoding, and Connection, to establish effective interaction with each website. Following this, a Beautiful Soup object was initiated with the HTML data from the homepage and utilized an HTML tree parser for in-depth analysis. The Beautifulsoup Python software starts with the manufacturer's homepage, where the general information is located, and then downloads sub-webpages, where more specific information is hosted, for review. Employing an iterative approach, text data was systematically retrieved from all pages across the websites and archived the extracted information in a CSV file for further processing and analysis.

Data mining is leveraged to identify unique patterns in larger data sets. The data analysis phase commences with the preprocessing of raw data. Utilizing regular expressions punctuation marks, URLs, email addresses, emojis, and other non-essential elements are eliminated.

Subsequently, Natural Language Toolkit (NLTK) comes into play for segmenting the text into sentences and tokens, followed by the removal of stop words to refine the dataset further. Leveraging the resulting tokens, we calculate the frequency of each token present on the website of the corresponding company. These frequencies are then stored in a dictionary, with tokens serving as keys and frequencies as values. To discern which companies are spearheading technological advancements, the frequency of a predetermined list of keywords are tallied. The outcomes of this analysis are elucidated in the results section. The keywords are evaluated based on the semantic intent of the text retrieved was initiated. Thirty-three (33) keywords associated with the nine categories of Industry 4.0 were researched. The Git Hub link for the code is located at https://github.com/alamincse32/WebScraping.git. The number of words used for each keyword within each industry is illustrated in Table 40 below.

Lastly, an unknown innovation status among the regional manufacturers exists, therefore, a subsequent assessment of the number of patent holders among the manufacturers reviewed in the web scraping project was also conducted by cross-referencing the U.S. Patent and Trademark Office's online patent directory. Innovative organizations are flexible with the decision-making structure. Innovation is a significant catalyst to economic growth and therefore patents serve a key role. Innovation is defined as a new commercial application of progress outside of experimentation. The process of attaining an innovation is through the assessment and assembly of data, information, and knowledge that is creatively ordered and reordered to produce new knowledge. Organizations can secure patent protection from the U.S. Patent and Trademark Office, which provides patent protection to ensure monopoly profits and thereby creates substantial incentives to invest in new technologies (Shaffer et al., 2004).

The patent review did not exclude any date ranges and therefore may include product innovation, business process innovation, abandoned innovation activities, on-going innovation activities, and in-house or external research and development activities (Crjns et al., 2023). Approximately 37% or 55 manufacturers from the sample of 149 held patents. Digital transformation is more significant in regions with intellectual property protection and capital-intensive businesses (Gao, 2023).

5.3. Results

Preprocessing and language detection were completed, where web texts lacking relevant content were removed. The Beautifulsoup web scraping engine collected targeted data including the following manufacturer's information: (a) source URL and (b) text. The initial results identifying the keywords of the nine fields of Industry 4.0 are highlighted in Tables 38 and 40, as well as, Figures 20 through 26 below. Table 38 and Figure 20 display the five keywords associated with the first category of Cyber-physical systems. The number of manufacturers' websites utilizing each keyword are ranked as shown in Table 40.

Table 38. Number of Manufacturing Websites Using Keywords Associated with Cyber-physical Systems

Keywords for Cyber Physical Systems	Number of Manufacturers
Automated	31
Devices	29
Automation	21
Detection	15
Cyber Physical	0
Wearable Devices	0

Under the second category of Internet of Things, there were three (3) businesses leveraging the term ‘IoT’ on their respective websites. Figure 21 and Table 40 describe the third category of Big Data here the results indicate that two (2) manufacturers utilize ‘big data’ and seventy-four (74) utilize the keyword ‘data’. Figure 22 and Table 40 also provide a review of the fourth category of ‘Cyber Security’ is displayed where two (2) manufacturers utilize ‘cyber’ and forty-eight (48) leverage the term ‘compliance’. The fifth Cloud Computing category is also noted in Figure 23 and Table 40 and highlights the outcome of two (2) websites using the term ‘cloud computing’ and eighteen (18) utilizing the keyword ‘cloud’ (Roth et al., 2024).

Two keywords were searched under the sixth category of Additive Manufacturing as noted in Figure 24 and Table 40. The results for ‘3D printing’ were five (5) manufacturers’ websites leveraging this information. There were no websites found expressing the term ‘4D printing’. Table 40 displays the information for the seventh Advanced Robotics category, where nineteen (19) websites utilized the term ‘robot’, one (1) website presented the term ‘advanced technology’ and no (0) results were found for ‘robot welders’. Figure 26 illustrates the eighth category of Modelling and Simulation, which resulted in the number of the keywords per manufacturer’s website as shown in Table 40.

In the ninth category of Augmented Virtual Reality, only three (3) manufacturers’ websites used the term ‘virtual reality’, which is also noted in Table 40.

A keyword search was also conducted for keywords related to Industry 4.0 and Industry 5.0. For the keyword ‘sustainable’, which is a core principle of Industry 5.0, twenty-four (24) manufacturers’ websites described their businesses using this term. Figure 27 displays the keywords associated to the topic of Industry 4.0.

Table 39. Industry 4.0 Categories and Keywords Searched in Web Scraping Project

Nine Industry 4.0 Categories & Corresponding Keywords				
1) Cyber-Physical Systems Keywords: automated, automation, detection, cyber physical, wearable devices	2) Internet of Things Keyword: IoT	3) Big Data Keywords: Big Data, Data	4) Cyber Security Keywords: Cyber, Compliance	5) Cloud Computing Keywords: Cloud Computing, Cloud
6) Additive Manufacturing Keywords: 4D Printing, 3D Printing	7) Advanced Robotics Keywords: Robot, Robot Welders, Advance Technology	8) Modelling and Simulation Keywords: Intellectual Property, Digital Twin, Research, Design, Development, Testing	9) Augmented Virtual Reality Keyword: Virtual Reality	

Table 40. Number of Manufacturing Websites Using Keywords Associated with the Nine Industry 4.0 Categories

Keyword	**Number of Manufacturers**
Automated	31
Devices	29
Automation	21
Detection	15
Cyber-Physical	0
Wearable Devices	0
IoT	3
Big Data	2
Data	74
Cyber	2
Compliance	48
Cloud Computing	2
Cloud	18
3D Printing	5
4D Printing	0
Robot	19
Advanced Technology	1
Robot Welders	0
Virtual Reality	3
Technology	84
Digital	38
AI	10

Table 40. Number of Manufacturing Websites Using Keywords Associated with the Nine Industry 4.0 Categories (Continued)

Keyword	**Number of Manufacturers**
5g	8
Programming	13
Artificial Intelligence	5
Computing	3

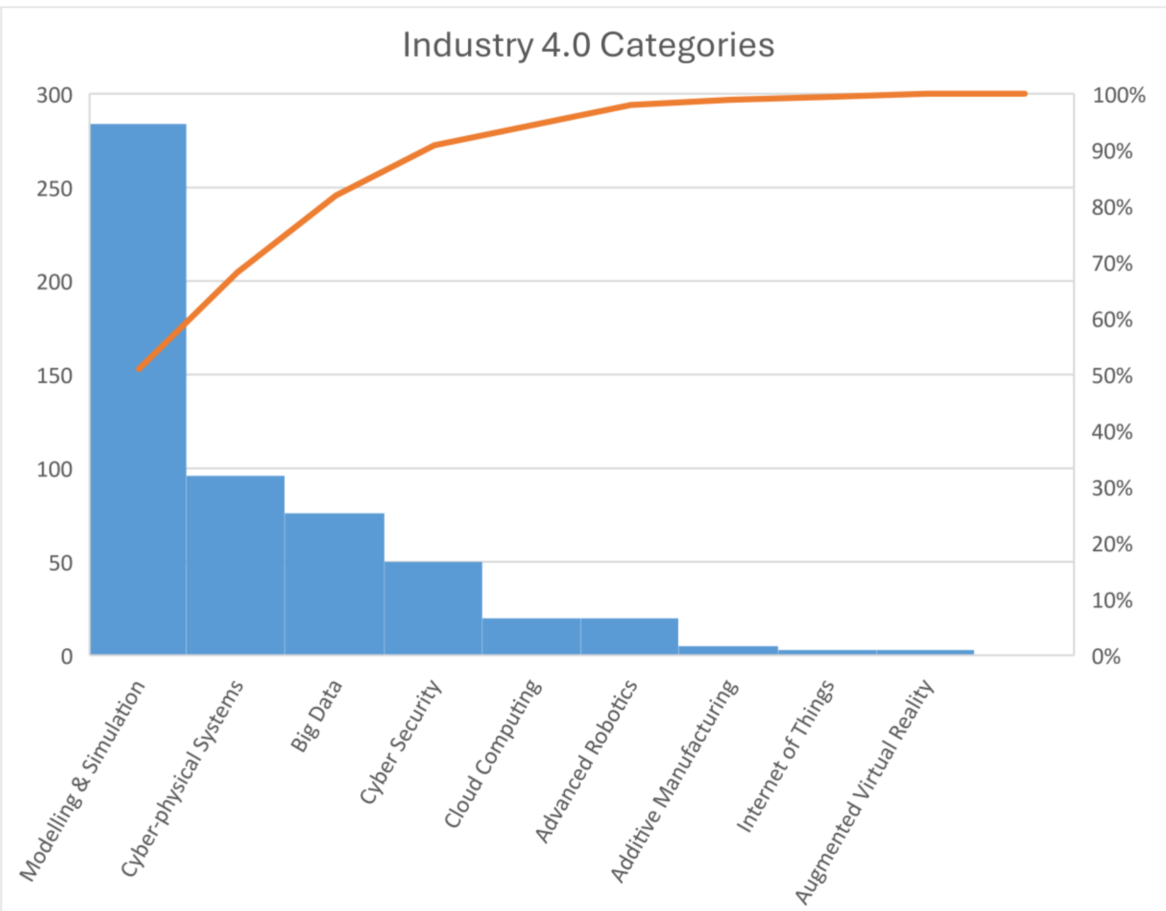

Figure 19. Current Status of Industry 4.0 Utilization Deduced from Sampled Minnesota and North Dakota Manufacturers

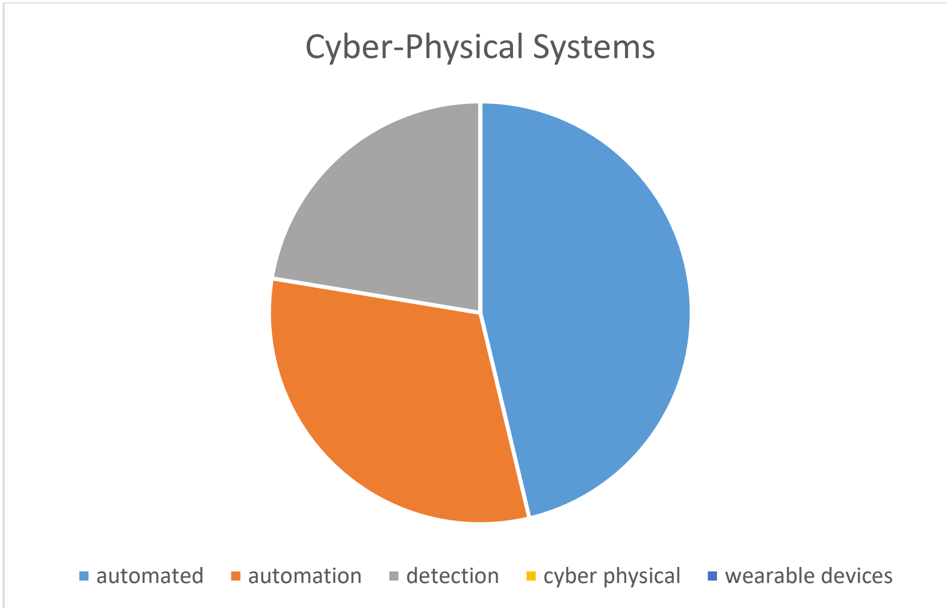

Figure 20. Web Scraping Results for Keywords Associated with Cyber-physical Systems

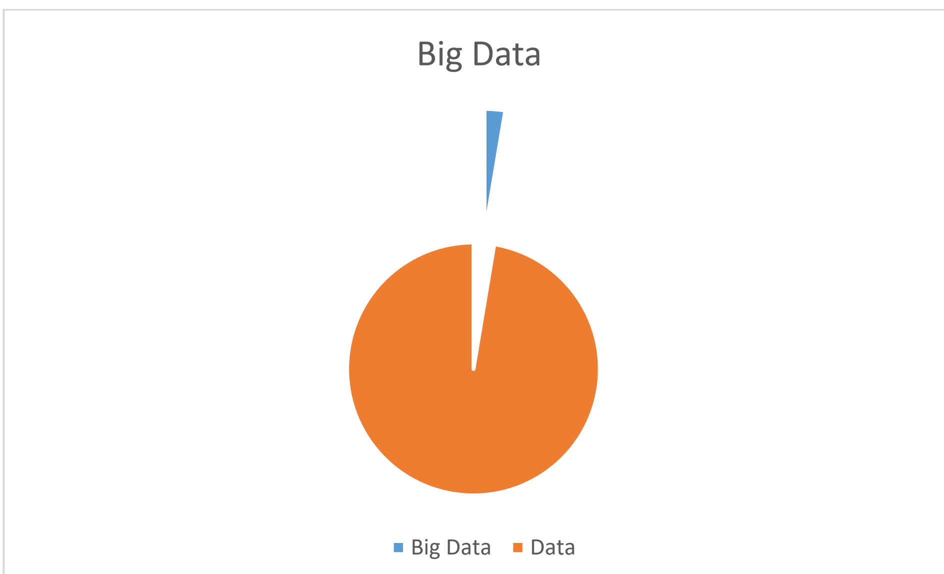

Figure 21. Web Scraping Results for Keywords Associated with Big Data

Figure 22. Web Scraping Results for Keywords Associated with Cyber Security

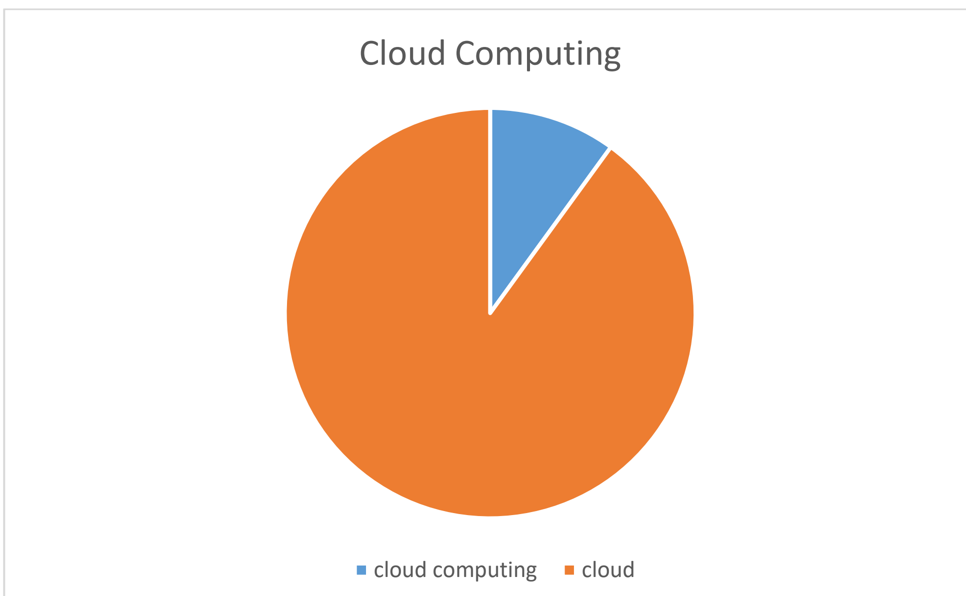

Figure 23. Web Scraping Results for Keywords Associated with Cloud Computing

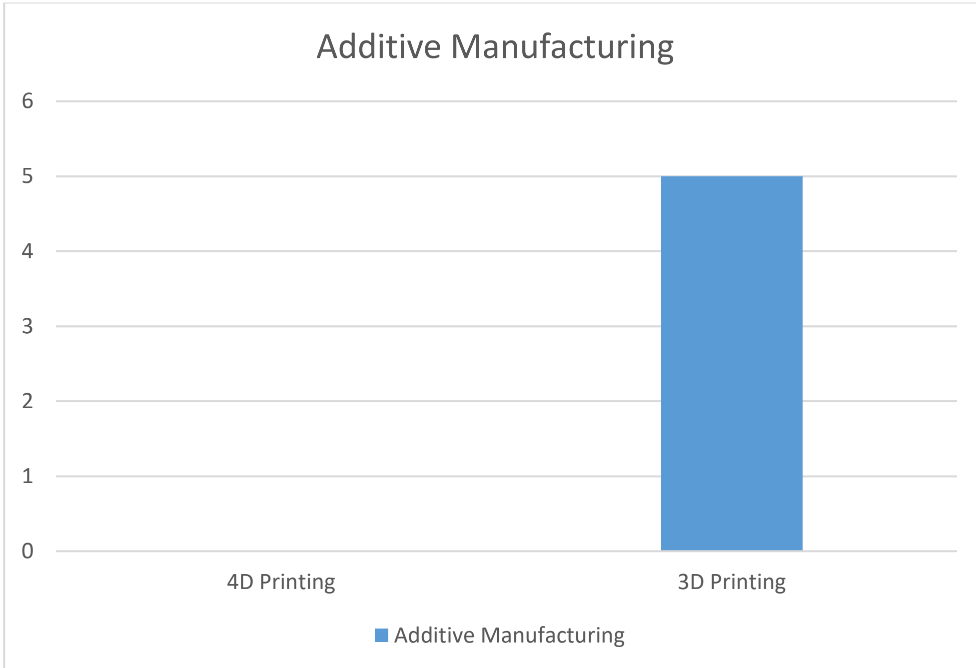

Figure 24. Web Scraping Results for Keywords Associated with Additive Manufacturing

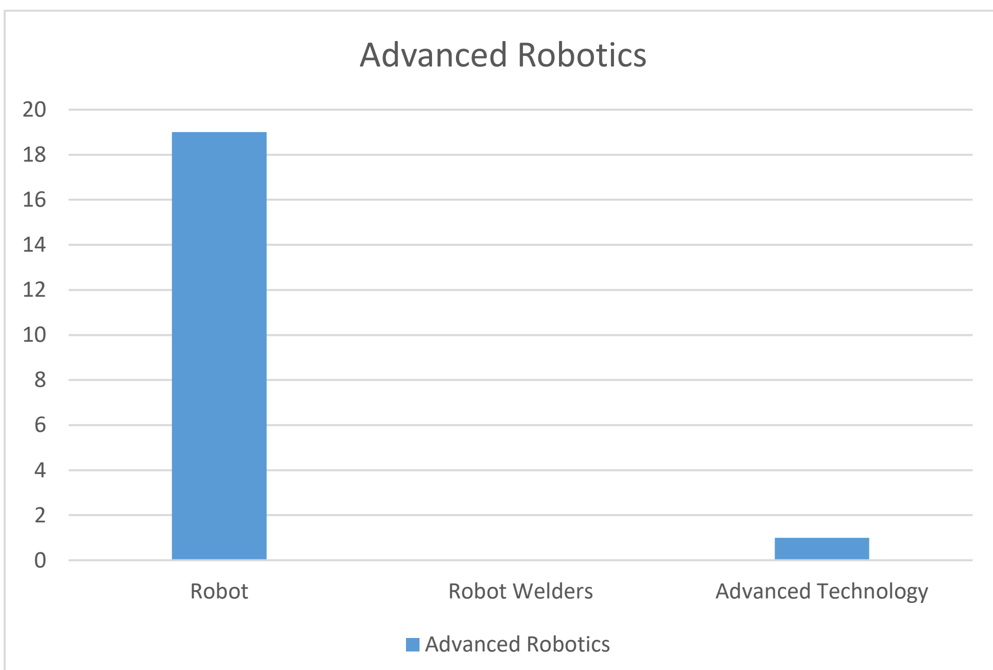

Figure 25. Web Scraping Results for Keywords Associated with Advanced Robotics

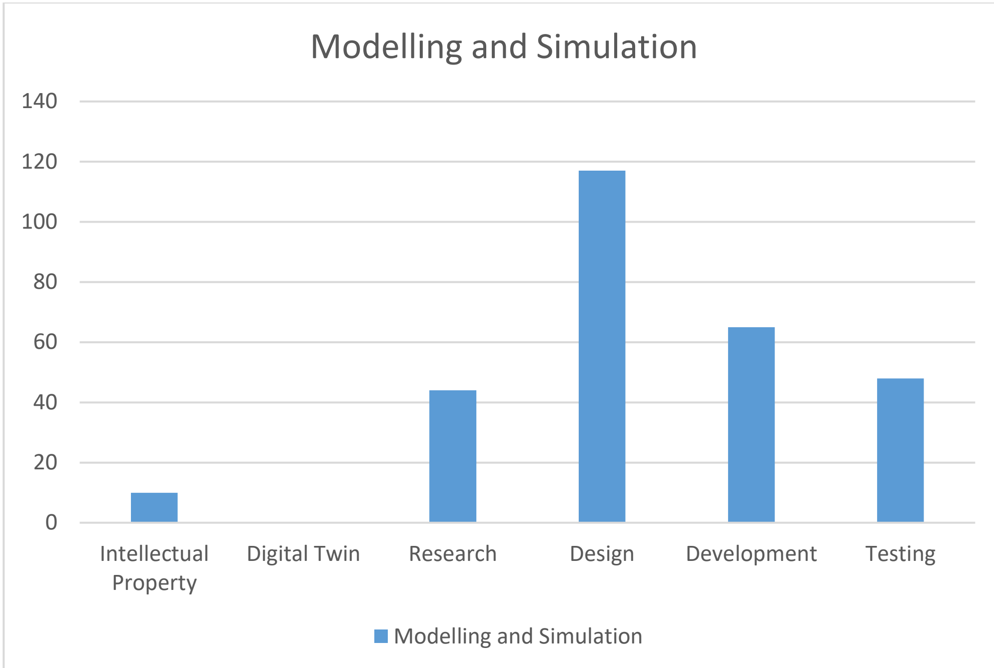

Figure 26. Web Scraping Results for Keywords Associated with Modelling and Simulation

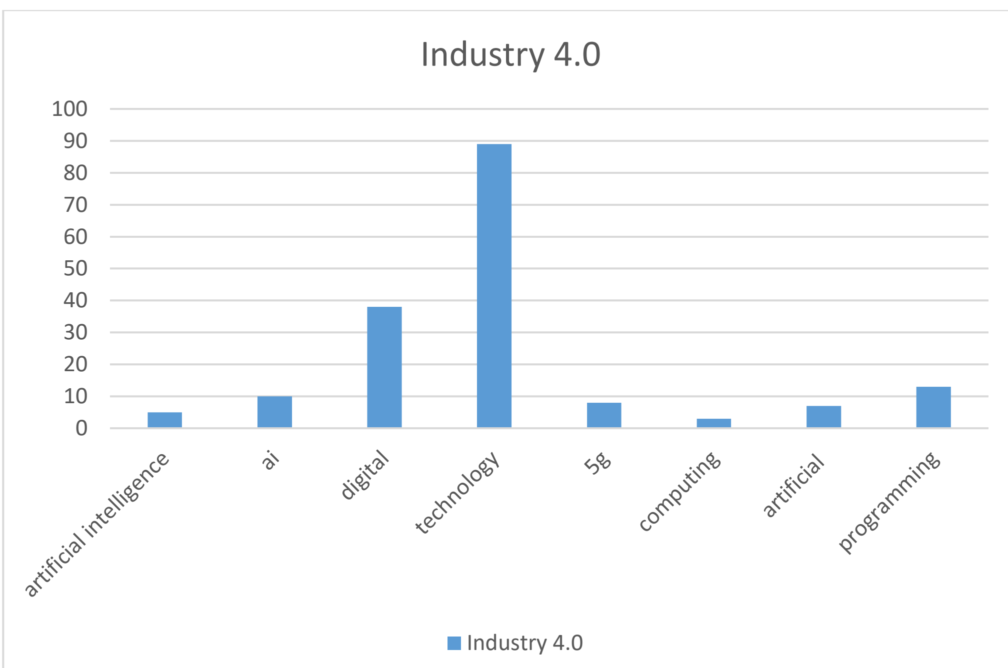

Figure 27. Web Scraping Results for Keywords Associated with Industry 4.0

5.4. Quantitative Analysis

Descriptive statistics, such as tetrachoric correlation, and also a frequency distribution analysis, were used to analyze the manufacturing websites that indicated each of the nine (9) Industry 4.0 categories (Norcross et al., 2020). A Tetrachoric Correlation was assessed to identify significant relationships between those manufacturers holding patents and Industry 4.0 keywords. According to this assessment, the keywords of 'Advanced Technology' and 'Big Data' had the most significant Tetrachoric Correlations with .9539 and .9841, respectively (Roth et al., 2024).

The frequency distribution analysis was also used to evaluate the current organizational design status of regional manufacturers in the Industry 4.0 and Industry 5.0 contexts. The quantitative analyses displayed that the Modelling and Simulation category of Industry 4.0 was the most prevalently communicated on websites and the Augmented Virtual Reality category of Industry 4.0 was the least communicated on websites.

5.5. Support of First and Second Survey Results

The purpose of the web scraping and innovation research study is to map the digital transformation through Industry 4.0 adoption and innovation and to support the results of the two qualitative surveys issued to the regional manufacturers in Minnesota and North Dakota requesting feedback on the current socio-technical design practices in the Industry 4.0 context. Through the results of the Industry 4.0 regional mapping, which considers regional socio-economic conditions, we identify a picture of a "digital transformation divide" and more specifically an "IoT divide" among regional manufacturers, where IoT is fundamental to digital transformation (Russo et al., 2022). As indicated in the Literature Review chapter of this study, IoT and cloud computing are the least expensive and easiest technologies for SMEs to adopt. However, there is a low investment indicated in the web scraping results in both technology categories. As an example, key products within the IoT sector are sensor technologies (Cotrino, A. et al., 2020). The first survey responses to Q12, which asks "How likely is your organization to align the organizational design with Industry 4.0 integration?" found eight (8) manufacturers or 33% responding affirmatively. There is minimal diversity of Industry 4.0 technologies used, which may indicate a support for the first surveys results.

Aggregately, in the first survey the socio-technical construct of 'Data Gathering' had significant correlations to all other socio-technical constructs. The significant level of representation of the keywords 'Data' and 'Big Data' from the web scraping project would appear to support the results of the first survey. The first survey also noted no significant correlation between 'Data Gathering' and 'Summarization' among medium-sized manufacturers in Minnesota and North Dakota, which may indicate that the appropriate Industry 4.0 technology are not fully integrated into the production design to realize productivity gains. As well, among large-sized manufacturers 'Data Gathering' did not correlate significantly to 'Testing' and 'Iterate and Amend' socio-technical constructs. The question "How likely is your organization to design information systems to provide information where it is first needed?" was included in the 'Iterate and Amend' socio-technical construct. The lack of correlation to this inquiry indicates that technical solutions may not be fully integrated to assist with the interpretation of data throughout the entire workflow process.

The outcomes of the web scraping study confirm the results of the second survey, which indicated that among small manufacturers in Minnesota and North Dakota there may be significant gaps in technical knowledge acquisition as the correlation between Q22 on organizational learning and the Technology socio-technical construct was insignificant. As well, a poor correlation exists in the second survey results between the Infrastructure socio-technical construct of resource allocation to improve production practices and the Technology socio-technical construct of technology adoption.

Approximately 68% of manufacturers responded affirmatively to Q9 of the second survey, which asks, "How likely is your organization to promote the productivity and innovation of teams while minimizing conflicts?" There were 55 manufacturers identified holding patents or approximately 37% of the sample population. As well, a significant correlation was found between Q22 on organizational learning and Q9. Additionally, a significant presence of the keyword 'Design' was found among the manufacturers studied. The innovation study appears to support the second survey responses (Roth et al., 2024).

5.6. Limitations of the Study

The research conducted in this web scraping project is focused solely on the socio-economic context of regional manufacturers in western Minnesota and eastern North Dakota. The industry sector in this geographic area is smaller in scope and may not represent the depth of capabilities performed by the manufacturing sector in larger geographic areas. Additionally, web scraping was conducted during the timeframe of a thirty-day window of time in November of 2023, which is a static period. Continuous data collection was not conducted to evaluate trends during a longer period.

5.7. Contribution of Web Scraping Research

The web scraping research project contributed a regionally focused mapping of the current investment decisions of regional manufacturers in selected Industry 4.0 technologies. As well, the level of patent holders may indicate future technological needs, which may be assessed through similar web scraping projects conducted over a longer period.

5.8. Recommendations for Future Study

This study is an innovative method of collecting relevant information on the use of emerging communication and information technologies employed by the regional manufacturing sector. Conducting subsequent web scraping research periodically will reveal the dynamic trends in the integration of Industry 4.0 technologies. Conducting a similar study over time in the manufacturing sector in newer geographic markets will establish a comparative trends analysis study. Future research could include central and western North Dakota, as well as, central and eastern Minnesota geographic regions. Added manufacturing information, such as NAICS codes, could be included in the analysis. Future analyses may combine data from patents, websites, news activities, as examples, to produce a holistic review of the Industry 4.0 landscape and innovation activities in Minnesota and North Dakota (Russo et al., 2022) (Crijns et al., 2023).

5.9. Conclusion

Continuous assessment measures and outreach to promote innovation are signs of science, technology, and innovation policy (Kinne & Lenz, 2021). Digital transformation promotes innovation, market competitiveness, and sustainability for regional manufacturers. Studies have shown that industries depicted by high energy consumption, yet low technological input, may observe through the implementation of artificial intelligence technologies, reduced carbon emissions through energy efficiency, increased financial performance, and developing green innovation (Gao, 2023). Surveys are commonly used as assessment tools among diverse industry sectors. The survey tools provide a wealth of information on the current state of practice in a specific industry. Web scraping is an inexpensive tool to support anonymous survey methods, test hypotheses, or extend existing findings (Speckmann, 2021). The results of this study demonstrate the utility of web scraping to identify current technological aptitudes and competitive advantages within the manufacturing sector. Web scraping combined with the two survey tools used provide significant insights into the industrial sectors current organizational design status in the Industry 4.0 context.

6. DISCUSSION

When combined, the first and second surveys act as a holistic sequential socio-technical management competence tool to advance the work organization. As suggested in *2.1.9 Implementing Industry 4.0 by utilizing a Socio-Technical SWOT analysis,* the Socio-technical surveys may be integrated into a strengths, weaknesses, opportunities, and threats (SWOT) analysis prior to the completion of the business model canvas to jointly optimize the social and technical factors of an organization within the context of the organization's specific tasks and goals during the Industry 4.0 implementation process. As well, the socio-technical surveys are issued throughout the Technology, Resilience, and Innovation phases of the digital transformation process to provide additional statistical analyses. This method is a new business application for the Socio-technical theory that serves to successfully achieve both Industry 4.0 and Industry 5.0 transformations.

The first survey addresses the digital transformation of Industry 4.0, which impacts both social and technical aspects of work organizations and is increasing the interfaces between human labor and computer-controlled processes. The replacement of low-skilled work tasks by highly skilled, non-routine work is creating a more human work design. Digitalization is influencing organizational learning by creating competencies for the use of innovative Industry 4.0 technologies (Kuper, 2020). Digitalization is also providing an expansion of opportunities in streamlining, redesigning, and redeveloping organizational processes and procedures – the technical components of a socio-technical work organization (Kurtz et al., 2023).

The socio-technical constructs used in this survey were based on a socio-technical framework of identifying cross-system relationships between social and technical system components, such as people and processes, to develop system-level advice and to lead organizational change (Davis et al., 2019).

In reference to Table 4, SMEs and large manufacturers surveyed in Minnesota and North Dakota need to invest more time in the socio-technical tasks involved with testing results with stakeholders and utilizing data to make meaningful contributions to increase productivity. The Testing the Results with Stakeholders construct requires resources and a long-term strategy. Resources may include tools, materials, final products, equipment, and human resources. Both the physical assets and the personnel hold tangible information that may be shared and processed (Li et al., 2019). As the socio-technical construct questions suggest, this process requires an investment in organizational learning for employees, resources for employees at all levels, inclusion of external stakeholders in the data-capturing process for decision-making at the organization design level, and surveying of all internal and external stakeholders to inform socio-technical organizational design. Iterating and amending the organizational design process requires a multidisciplinary task to continuously evaluate, extract, and use data meaningfully. The socio-technical principle of incompletion supports this focus of identifying the solutions that must first be implemented. The socio-technical design process is continuous improvement and must constantly be monitored.

The first survey results illustrated that, among all Minnesota and North Dakota manufacturers, a strong, positive correlation between the socio-technical constructs and Industry 4.0 integration exists, yet increased productivity is not pervasive. Additionally, there may be a lack of diffusion of knowledge regarding the utility of innovative technologies, hindering work teams from practicing responsible autonomy. This finding may indicate gaps in organizational learning, leading to a deficit in the technical knowledge of leadership and employees among

SMEs and large manufacturers in the region to extract data from newer autonomous and communication technologies. Moreover, this outcome may indicate that the organizations employing these technological innovations are operating on short-term strategic plans, rather than long-term strategies. This finding answers the first research question of how applicable socio-technical design principles are to the Industry 4.0 context among North Dakota and Minnesota manufacturers.

The second research question focused on whether a positive correlation between Industry 4.0 and increased productivity among manufacturers in North Dakota and Minnesota would be observed. A negative correlation between Industry 4.0 integration and productivity among all manufacturers surveyed was identified. The root cause of this outcome may be related to inequalities in how the socio-technical design constructs are applied with each work organization. Additionally, the output of data from the innovative technologies may also be under-utilized or not leveraged toward furthering organizational design. As well, there may not be a significant level of Industry 4.0 technology adopted to measure this significance.

There is an aggregately negative correlation between socio-technical constructs and increased productivity regardless of small, medium, or large business size in Minnesota and North Dakota. This outcome is also reflected in a poor correlation between Industry 4.0 and increased productivity. Although the organizations surveyed are utilizing socio-technical design methods, the social and technical aspects are not jointly optimized for extracting maximum value from Industry 4.0. There are inequalities among how the socio-technical constructs are being leveraged, which is contrary to the socio-technical design principle of incompletion, which ensures continuous improvement. This design principle is integral to effectively implementing both Industry 4.0 and socio-technical theory frameworks in organizational design. This outcome addresses the third research question to whether a positive correlation between socio-technical design principles and increased productivity would be observed.

However, assessing only the small manufacturers in Minnesota and North Dakota, a weak, positive relationship between Industry 4.0 integration and increased productivity was observed. This feedback supports the second research question. Possible explanations for this outcome are being unaware of how to capture data fully and not having the technically trained staff to assist with the Industry 4.0 implementation process. The small manufacturers indicated a strong, positive correlation between socio-technical constructs and Industry 4.0 integration, which may indicate a trajectory toward, but not complete realization of, joint optimization of both social and technical factors. This finding may indicate a prematurity of implementing Industry 4.0 prior to socio-technical design readiness. This insight supports the first research question. The full socio-technical framework is applied to support organizational design efforts in small manufacturers surveyed from Minnesota and North Dakota. However, the organizational design may not employ socio-technical theory design continuously; therefore, the outcome of minimal productivity.

Medium-sized manufacturers in Minnesota and North Dakota are not gleaning value from Industry 4.0 to increase productivity. The socio-technical design is directly related to Industry 4.0 integration, as it reflects the organization’s preparedness to adopt new operational strategies. The socio-technical design is partially implemented, providing an environment for new technology adoption. A poor correlation between socio-technical constructs and productivity reveals that possible knowledge barriers exist to the operational practices of the manufacturer to extract value from the organizational design and new technologies, thus meaning that the full socio-technical framework is not jointly optimized.

Large manufacturers in Minnesota and North Dakota experienced a negative correlation between Industry 4.0 (Q12) integration and increased productivity (Q21), which may indicate the lack of leadership's technical knowledge about how to extract and use data from new technologies. A positive correlation existed between all socio-technical constructs and Industry 4.0 integration, which may indicate that this framework is conducive to new and increased technology adoption rates.

Considering specifically Minnesota manufacturers, a negative correlation between Industry 4.0 and increased productivity was observed, which may indicate a lack of technical expertise to capture value from new technologies. A negative correlation between socio-technical constructs and increased productivity existed, indicating that the framework is not fully employed to capture operational efficiencies.

The North Dakota manufacturers surveyed displayed a strong, positive correlation between socio-technical constructs and Industry 4.0 integration, indicating that socio-technical design facilitates the adoption of newer technologies. A positive correlation existed among all socio-technical constructs, indicating that manufacturers are actively engaged in socio-technical design frameworks. The weak correlation between Industry 4.0 integration and increased productivity indicated a potential lack of technical knowledge to address the full adoption of new technology to realize all of its benefits. Additionally, it indicates that the continuous nature of socio-technical design is not utilized at its full capacity.

Industry 4.0 allows for product-centric organizations to move toward servitization, creating a closer relationship with the consumer market (Sony, 2020). Servitization is defined as providing added service value to products, whether service-derived value co-creation or enhanced service-derived value co-creation, to foster organizational sustainability. The five types of manufacturing servitization value co-creation models are product extension, product enhancement, leading product, business unit, and core capability. The value co-creation is observed with enterprises and upstream suppliers, between enterprises and consumers, and among the participation of stakeholders (Li et al., 2022).

A greater volume of data and analytics resulting from the implementation of Industry 4.0 will create bargaining power for buyers. The contribution of analytics for implementing smart services will be prescriptive – what to do?, predictive – what will happen?, diagnostic – why will it happen?, and descriptive – what will happen? (Neuhuttler et al., 2023). There are pros to implementing Industry 4.0, which include competitive advantage, operational efficiency, improved ergonomics, and long-term sustainability. The cons include the negative impact of financial investment in all operationally necessary Industry 4.0 technologies, lack of data confidentiality, and the necessary technical skillsets among leadership and employees of the socio-technical organization (Sony, 2020). The last previous disadvantage noted interferes with the sharing of innovation throughout an organization (Tortella et al., 2022). Industry 4.0 implementation must be welcomed by an organization that has jointly optimized its social and technical aspects to receive the full benefits of productivity from these innovations. Successful implementations provide employees with greater control and freedom and align closely with ownership and empowerment (Minshull et al., 2022).

The second survey was also influenced from the socio-technical framework developed by Davis et al. Their proposed socio-technical framework assesses the six interrelated components of goals, people, building/infrastructure, technology, culture, processes/procedures within the external environment of financial/economic, stakeholders, and regulation. This socio-technical framework supports both predictive and design work. The framework was explained as major steps involved in analyzing and understanding an existing socio-technical system (Davis et al., 2014) This study is a unique approach to analyzing the organizational joint consideration of Industry 4.0, socio-technical factors, and predictive work, as the socio-technical assessment steps were transformed into questions and posed to employees of small, medium, and large manufacturing firms. These survey questions provide a useful tool for socio-technical competence management within an organization when jointly considering human factors while implementing new technologies. Alternately, these socio-technical survey questions may also be utilized in a Socio-technical SWOT analysis of each of the nine components of a business model canvas. Additionally, the survey may serve the purpose of checking the sustainability status of small, medium, and large manufacturing firms by operators from upper management to ensure that new investments in Industry 4.0 technologies and generated data usage therefrom are leveraged adequately to support productivity targets. Small and medium-sized manufacturing firms may be unfamiliar with utilizing this type of analysis to improve an organization. This socio-technical survey tool illustrates an emerging management approach with SMEs in supporting continuous improvement efforts.

In the second survey, in reference to the simple frequency chart outcomes described in the results section the following assumptions are made of the total surveyed population. Aggregately very few manufacturers are utilizing decision support or judgment substitution through learning algorithms from various applications. Two out of 35 manufacturers surveyed that utilize information technology solutions in the workplace were likely to establish a reduced daily work schedule. Nearly 94% of manufacturers responded affirmatively to continuously improving communication across departments and teams to instill employee engagement. However, less than half of manufacturers surveyed are leveraging a socio-technical organizational design framework to guide the flow of information and communication, which is described as data gathering, analysis and interpretation, summarizing the findings, testing the results with stakeholders, and iterating and amending as necessary to communicate recommendations to employees and stakeholders. Socio-technical design is critical to predictive work, such as productivity planning and labor scheduling. These communication strategies are essential to successful Industry 4.0 implementation.

Techniques that contribute to understanding the interrelatedness of social and technical factors of the organization, such as with the development of cross-functional diagrams, are being evaluated by 40% of the businesses. The promotion of productivity and innovation is reported to occur in 68.57% of respondents across business sizes. The innovation process is often observed as the four stages of research, design, prototyping, and testing (Peruzzini et al., 2023). Management innovation is defined as ‘the generation and implementation of a management practice, process, structure, or technique that is new to the state of the art and is intended to further organizational goals’, which is affiliated with social changes within the work organization. The traits of this type of practice are that it is diffused, continuous, and incremental and that it relies on the interrelationships of diverse stakeholders to assimilate and apply technical knowledge. The application of the socio-technical survey questions in conjunction with the SWOT analysis of the business model canvas will support achieving innovation goals.

A large-scale study of Dutch firms reported that management innovation is a profitable performance strategy as it supports the use of technological innovations to make better market decisions. Ultimately, successful firms are employing joint optimization of social and technical factors to manage innovation processes (Cerne et al., 2023). Manufacturing firms continuously support innovation initiatives, which are found in inter-departmental and independent forms.

Examples are business innovation labs, hackathons and start-up events in coordination with suppliers, customers and employees to develop innovation aptitudes (Kurtz et al., 2023). From the work task perspective, examples from corporations, such as Google illustrate a 20% policy, where employees engage in personal projects that are innovative in nature during one-fifth of their work hours. Results of this flexible working arrangement have been products, such as Gmail, Google News, and Adsense (Kostadinova & Vladkova, 2022). As well 3M encourages a 15% culture where employees are encouraged to establish time to pursue innovative ideas. The experimentation may include new technology, process improvement, and team forming to support emerging trends. Innovations such as the Multilayer Optical Film, Cubitron, Abrasive Grains, Emphaze, AEX Hybrid Purifier, APC Flash-Free Adhesive, and Post-It Notes have been created in this manner (https://www.3m.co.uk/3M/en_GB/careers/culture/15-percent-culture, Accessed 3 October 23).

Sixty percent of manufacturers are leveraging a bottom-up problem-solving approach, yet slightly over 62 percent of employers rather than employees are leading the effort of specifying roles, responsibilities, and/or tasks that are specific to a job when optimizing or streamlining a process. In response to supporting the allocation of resources and work to change and improve production practices, organize work tasks, and strengthen internal cooperation, only 68.57% responded in the affirmative, which indicates that there will be significant gaps in the needed resources for continuous growth and will be observed in specific correlations addressed in this section. The reduced work hour goal (Q13) did not have a significant relationship with bottom-up problem-solving approach of (Q18). Yet, the reduced work hour goal (Q13) had a significant relationship with responsible autonomy (Q21). Also, responsible autonomy (Q21) had a strong relationship with the bottom-up problem-solving approach (Q18). In summation, Q18 is important to Q21 and Q21 is important to Q13. The lack of a bottom-up problem-solving approach appears to be a required factor needed for attaining a reduced work hour goal. The socio-technical SWOT analysis prior to the completion of the business model canvas is a framework designed to facilitate the engagement of all employees in the strategic planning process or a bottom-up problem-solving approach that has been emphasized by academic researchers as a critical factor to reducing work hour schedules with manufacturers.

In reference to Table 16, small manufacturers surveyed in Minnesota and North Dakota reported that with regards to Q22 on organizational learning, significant gaps in technical knowledge acquisition exist as the correlations between this question and the technology socio-technical construct were insignificant. The Q13 reduced daily work hour goal corresponded significantly only to the technology construct. Therefore, a socio-technical imbalance is present, which may cause the lack of opportunity in attaining reduced work hour goals.Also, with alpha at .05, Q21 on responsible autonomy and Q9 on the promotion of productivity and innovation did not significantly correlate. As well, Q22 on Organizational Learning and Q21 on Responsible Autonomy did not significantly correlate.

In reference to Table 17, medium-sized manufacturers surveyed in Minnesota and North Dakota reported that there is no significant correlation between organizational learning and a reduced daily work hour goal among medium-sized manufacturers in North Dakota and Minnesota. A significant correlation was not identified between Q21 on responsible autonomy and Q9 on the promotion of productivity and innovation. As well, a significant correlation was not identified between Q22 on organizational learning and Q21 on responsible autonomy.

In reference to Table 18, large-sized manufacturers surveyed in Minnesota and North Dakota reported there is no correlation between Q22 on organizational learning and Q13 on establishing a reduced daily work hour goal to serve to jointly optimize the technical and human factors of an organization to achieve higher productivity and employee wellbeing. A significant correlation was not identified between Q22 organizational learning and Q21 responsible autonomy. As well, a significant correlation was not identified between Q21 responsible autonomy and Q9 the promotion of productivity and innovation.

The first research question sought to identify a relationship between the implementation of organizational practices that support organizational learning and training and reduction of time on tasks/productivity. These outcomes answer the first research question that organizational learning will not be significantly correlated with a reduced daily work hour goal among manufacturers in Minnesota and North Dakota. In reference to Figure 15, the correlation between responsible autonomy (Q21) and a culture of organizational learning (Q22) was not observed as significantly positive. However, the cross comparison of productive organizational learning (Q11) and responsible autonomy (Q21) illustrated that 61% of responses were affirmative to focusing on organizational learning as well as engaging in responsible autonomy with employees to achieve specific goals. The difference between Q22 and Q11 is that Q22 suggests full implementation of organizational learning within the culture where the process is observed as continuous.

They also answer the second research question focused on whether a positive correlation between responsible autonomy and the promotion of productivity and innovation would be observed. Responsible autonomy did not show a strong positive correlation with the promotion of productivity and innovation (Q9) with manufacturers surveyed.

The third research question focused on whether a positive correlation between responsible autonomy and organizational learning among regional manufacturers would be observed. There is no significant correlation between responsible autonomy and organizational learning among small, medium, and large regional manufacturers observed. These outcomes answer the third research question that responsible autonomy will not significantly correlate to a culture of organizational learning among regional manufacturers.

The survey was based on the socio-technical framework developed by Davis et al. This socio-technical framework identifies the social factors of an organization as people, goals, and culture and the technical factors of infrastructure, technology and processes as interdependent. These elements operate within an external environment that offers unique economic conditions, diverse stakeholders, and regulation. The theoretical insights of various academic researchers cited previously contributed to the alignment of a new assessment. This study is a unique approach to analyzing the socio-technical design maturity of manufacturers in Minnesota and North Dakota when considering the implementation of reduced daily work hour goals. Critical success factors pertaining to leadership, responsible autonomy, organizational learning, and communication have been recommended by academic researchers and practitioners when leading organizations towards a modern work environment. The results of the second survey validate the results of the first survey by the authors.

The first survey and academic research journal article provide a useful tool for assessing socio-technical competence management within an organization when jointly optimizing social and technical factors of an organization (Roth & Farahmand, 2023). The second survey tool in combination with the first survey tool are significant instruments for conducting this research and may serve the purpose of checking the socio-technical sustainability status of small, medium, and large manufacturers in the context of a SWOT analysis prior to developing a business model canvas. Organizations continue to digitally transform to offer flexible work arrangements for employees. This survey illustrates an emerging management approach with SMEs in supporting continuous improvement efforts (Roth & Farahmand, 2023).

The IoT and Cloud Computing are the least expensive and easiest technologies for SMEs to adopt. However, there is a low investment indicated in the web scraping results in both technology categories. Socio-technical systems theory has been noted as increasing the adoption rates of technology (Macron et al, 2021). This outcome corresponds to the first research question. A significant correlation was found between socio-technical systems design and Industry 4.0, however, a gap exists in the upward increase potential for investments that could be made in newer information and communication technologies. The web scraping results also appear to support the results for the second research question on the lack of correlation between Industry 4.0 and Increased Productivity among manufacturers in the region. There is minimal diversity of Industry 4.0 technologies used, which may indicate a lesser investment throughout a production process of Industry 4.0. Therefore, increased productivity would not be as readily observed. The significance level of representation of the keywords 'Data' and 'Big Data' from the web scraping project appears to illustrate a presence of a socio-technical systems design work of the Data Gathering socio-technical construct studied in the first survey. The results did not support the third research question, where a significant relationship was not found between socio-technical systems design and increased productivity.

The fourth through sixth research questions supported activity of the second survey. The fourth research question focused on identifying a significant correlation between organizational learning and reduced daily work hour goals, which was not supported by the survey results. The web scraping results illustrated a minimal diversity of Industry 4.0 investments, which may indicate that a culture of organizational learning is not pervasive and significantly correlated to attain a reduced daily work hour goal through the aid of newer technologies. Also, no significant relationship was found in the fifth research question focusing on responsible autonomy to the promotion of productivity and innovation. Only 37% of manufacturers in the regional sample were identified as patent holders. The low percentage would indicate an insignificant promotion of productivity and innovation, which does not allow for the opportunity for this activity to be influenced. Lastly, the sixth research question focuses on the correlation between responsible autonomy and organizational learning. There was no significant relationship found. The goals of Industry 4.0 is to gain autonomy, decentralization, responsibility, and teamwork (Tortorella et al., 2022). This supports responsible autonomy as employees have greater opportunities to customize technology. The presence of learning algorithms is one example of providing opportunities for responsible autonomy to thrive as employees focus on the social subsystems of people, culture, and goals (Fischer et al., 2023). The lack of a presence of diversified information and communication technologies may indicate a lack of an environment to foster responsible autonomy, therefore a lack of correlation may exist supporting the survey outcomes for the sixth research question.

7. CONCLUSION

Researchers are focusing on identifying further insights as to how Industry 4.0 relates to value chains and supply networks, clusters and industrial districts, readiness and adaptation of regional industries, innovation development and ecosystems, and labor markets (Fraske, 2022). The North Dakota and Minnesota manufacturers surveyed illustrate the changing manufacturing environment that is shifting toward the adoption of the new technologies of Industry 4.0 and the sustainability characteristic of Industry 5.0. Increasing the investments in both social and technical factors will provide operational benefits (Minshull et al., 2022).

Practices that facilitate the implementation of Industry 4.0 have been noted as understanding the benefits of practices, adoption research and development, management support, training and development programs, and resources (Trehan & Machhan, 2022). Organizations undertaking the socio-technical joint optimization process of their organizations with both survey tools will incrementally work towards freeing up resources to increase productivity. Starting with smaller projects that can be measured with knowledge performance indicators, such as the socio-technical constructs, lead-time reduction, number of projects delivered per period and cost savings, will prepare for the implementation of large-scale projects (Roy et al., 2023).

The limitations of the first survey study include the small sample size of regional manufacturers that was assessed. Additionally, companies may not be utilizing Industry 4.0 and therefore are not benefiting from its advantages. More education and training for managers and employees on the benefits of socio-technical awareness as both an antecedent to Industry 4.0 adoption and an established practice in the context of Industry 4.0 are needed to develop a future cohort of enhanced manufacturers in the region. Additional studies should be conducted to determine the socio-technical readiness of manufacturers in the region, as doing so would lead to an Industry 4.0 integration readiness. Moreover, future studies should be conducted to assess how manufacturers in North Dakota and Minnesota are utilizing Industry 4.0 technologies to determine opportunities for and challenges to realizing increased productivity levels from these socio-technical organizations and to inform various industrial sustainability policies for regional economic development authorities. As well, an exploration into the development of a regional Industry 4.0 competence center that aims to create synergies and serve as a catalyst for inclusivity in innovation and development among diverse stakeholders of the economic ecosystem, providing access to insights, and mitigating the pressures of rapidly adopting newer technologies on small and medium-sized businesses should be considered (Prodi et al., 2022).

Academic researchers agree that studies be guided by the mission to eliminate the obstacles for small and medium-sized businesses to access Industry 4.0 technologies, which provide significant strategic competitive advantages for firms both regionally and internationally (Fernandes et al., 2022). Strategic planning is critical to the success of digital transformation. Led by employees, barriers, challenges, and opportunities to providing employees with reduced daily work hours will be identified and solved in a bottom-up leadership methodology. Employee autonomy is intrinsic to the successful implementation of job crafting in the Industry 4.0 context, as it contributes to a productive organizational culture of learning and productive behavior (Whiteoak, 2022). Organizational culture is illustrated through a willingness to change, social collaboration and is supported through information and knowledge sharing (Li et al., 2019) Job demands require that the needed resources are allocated for workers to reduce the incidence of burnout (van Kleeff et al., 2023). A method of avoiding conflicts and failed projects is through engagement with those employees completing the tasks involved with high levels of productivity and innovation. Trust is a key factor in the relationship between employees and managers to support these endeavors (Enehaug, 2017).

Leadership vision must be informed by the possible growth opportunities with the adoption of the new communication and information technologies of Industry 4.0 (McDermott et al., 2023). Digital leadership encourages new methods of organizing and communicating. This leadership trait supports employee autonomy, innovation, and creativity through supporting employee job crafting, which is an employee-led job design strategy. Key digital leadership skills are a bottom-up organizational change strategy, a future-oriented vision, digital literacy, and adaptability (Zhu et al., 2022). A key example of organizational change driven by digital leadership is through the development of cross-functional teams, which aids with the dispersion of communication throughout an organization (Leso et al., 2022).

The six socio-technical constructs of this study described how the current organizational design practices contribute to supporting organizational learning, responsible autonomy, and promoting productivity and innovation to achieve reduced daily work hour goals among small, medium, and large manufacturers. This dissertation provides theoretical contributions and is a timely review of the socio-technical design implementation in the region within the manufacturing sector. The study advances the socio-technical practice by highlighting critical socio-technical factors contributing to successful digital transformation strategy. Jointly optimizing both technical and social organizational factors will improve overall performance.

The limitations of the second survey study include the small sample size of regional manufacturers that was assessed. Additionally, companies may not be utilizing Industry 4.0 and therefore are not benefiting from its advantages. As well, few companies are embracing reduced work week schedules or flexible work arrangements in the manufacturing industry in Minnesota and North Dakota. A reason for the regional inattention to this long-term sustainability goal may be a perceived lack of benefit for its intended workforce and to the organization. More education and training for managers and employees on the benefits of socio-technical design in the context of Industry 4.0 are needed to develop a future cohort of enhanced manufacturers in the region.

Future studies should be conducted to assess Industry 4.0 technologies and its implementation and to understand the current level of implementation and commitment among manufacturers in Minnesota and North Dakota to determine the opportunities for and challenges to realizing reduced daily work hour schedules. Future research can build on this study by enriching the survey tools or utilizing the socio-technical SWOT analysis prior to developing a business model canvas as part of longitudinal studies of strategic planning among small, medium, and large manufacturers in the region at various levels of Industry 4.0 investment. As well, future research of how socio-technical design in the Industry 4.0 context supports value co-creation processes should be examined.

REFERENCES

Abgeller, N., Bachmann, R., Dobbins, T., & Anderson, D. (2022). Responsible autonomy: The interplay of autonomy, control and trust for knowledge professionals working remotely during COVID-19. *Economic and Industrial Democracy*, 0143831X221140156. https://doi.org/10.1177/0143831Z221140156

Abildgaard, P. (2019). The Secret of the Four Day Work Week. Frydenlund.

Achieng, M. S., & Malatji, M. (2022). Digital transformation of small and medium enterprises in sub-Saharan Africa: A scoping review. *Journal for Transdisciplinary Research in Southern Africa*, *18*(1), 1-13. https://doi.org/10.4102/td.v18i1.1257

Achouni, M., touahmia, M., Alshammari, S., Ahmed, Said, M., Aichouni, A., Almudayries, M., Aljohani, H., Wu, X., Yang, H., Ji, H. (2023). An Empirical Study of the Contriution of Total Quality Management to Occupational Safety and Health Performance in Saudi Organizations. Int. J. Environ Res Public Health. 20 (2): 1495. www.doi.org/10.3390/ijerph20021495

Agote-Garrido, A., Martín-Gómez, A. M., & Lama-Ruiz, J. R. (2023). Manufacturing System Design in Industry 5.0: Incorporating Sociotechnical Systems and Social Metabolism for Human-Centered, Sustainable, and Resilient Production. *Systems*, *11*(11), 537. https://doi.org/10.3390/systems11110537

Ahmad, A., Whitworth, B., & Bertino, E. (2022). A framework for the application of socio-technical design methodology. *Ethics and Information Technology*, *24*(4), 46. https://doi.org/10.1007/s10676-022-09651-0

Ali, K., Johl, S. K., Muneer, A., Alwadain, A., & Ali, R. F. (2022). Soft and hard total quality management practices promote industry 4.0 readiness: a SEM-neural network approach. *Sustainability*, *14*(19), 11917. https://doi.org/10.3390/su141911917

Alsaadi, N. (2022). Modeling and analysis of Industry 4.0 adoption challenges in the manufacturing industry. *Processes*, *10*(10), 2150. https://doi.org/10.3390/pr10102150

Alsakka, F., Yu, H., Hamzeh, F., & Al-Hussein, M. (2023, June). Factors Influencing Cycle Times in Offsite Construction. In *Proceedings of the 31st Annual Conference of the International Group for Lean Construction (IGLC31), Lille, France* (pp. 723-734). https://doi.org/10.24928/2023/0123

Amble, N. (2013). Autonomy and control when working with humans—A reflection on sociotechnical concepts. Nordic Journal of Working Life Studies. (3)4, 45-62.

Asiimwe, M. M., & De Kock, I. H. (2022, June). Socio-technical Transitions and the Fourth Industrial Revolution: The need for an integrated analysis. In *2022 IEEE 28th International Conference on Engineering, Technology and Innovation (ICE/ITMC) & 3*

International Association For Management of Technology (IAMOT) Joint Conference (pp. 1-9). IEEE. https://doi.org/10.1109/ICE/ITMC-IAMOT55089.2022.10033262

Atik, H., & Ünlü, F. (2019). The measurement of industry 4.0 performance through industry 4.0 index: an empirical investigation for Turkey and European countries. *Procedia Computer Science*, *158*, 852-860. https://doi.org/10.1016/j.proces.2019.09.123

Ávila-Gutiérrez, M. J., Aguayo-González, F., & Lama-Ruiz, J. R. (2021). Framework for the development of affective and smart manufacturing systems using sensorised surrogate models. *Sensors*, *21*(7), 2274. https://doi.org/10.3390/s21072274

Bag, S., Gupta, S., & Kumar, S. (2021). Industry 4.0 adoption and 10R advance manufacturing capabilities for sustainable development. *International journal of production economics*, *231*, 107844. https://doi.org/10.106.j.ijpe.2020.107844

Bajic, B., Suzic, N., Moraca, S., Stefanović, M., Jovicic, M., & Rikalovic, A. (2023). Edge Computing Data Optimization for Smart Quality Management: Industry 5.0 Perspective. *Sustainability*, *15*(7), 6032. https://doi.org/10.3390/su15076032

Bastidas, V., Oti-Sarpong, K., Nochta, T., Wan, L., Tang, J., & Schooling, J. (2023). Leadership for responsible digital innovation in the built environment: A socio-technical review for re-establishing competencies. *Journal of Urban Management*, *12*(1), 57-73. https://doi.org/10.1016/j.jum.2023.01.004

Bastos, T., Salvadorinho, J., & Teixeira, L. (2022). UpSkill@ Mgmt 4.0–A digital tool for competence management: Conceptual model and a prototype. *International Journal of Industrial Engineering and Management*, *13*(4), 225-238. http://doi.org/10.24867/IJIEM-2022-4-315

Battini, D., Berti, N., Finco, S., Zennaro, I., & Das, A. (2022). Towards industry 5.0: A multi-objective job rotation model for an inclusive workforce. *International Journal of Production Economics*, *250*, 108619. https://doi.org/10.1016/j.ijpe.2022.108619

Bednar, P. M., & Welch, C. (2020). Socio-technical perspectives on smart working: Creating meaningful and sustainable systems. *Information Systems Frontiers*, *22*(2), 281-298. https://doi.org/10/1007/s10796-019-09921-1

Bhattacharya, M., Penica, M., O'Connell, E., Southern, M., & Hayes, M. (2023). Human-in-Loop: A Review of Smart Manufacturing Deployments. *Systems*, *11*(1), 35. https://doi.org/10.3390/systems11010035

Bigliardi, B., Bottani, E., Casella, G., Filippelli, S., Petroni, A., Pini, B., & Gianatti, E. (2023). Industry 4.0 and Covid-19: evidence from a case study. *Procedia Computer Science*, *217*, 1803-1809. https://doi.org/10.1016/j.procs.2022.12.380

Blake, R. and Mouton, K. (2001). Grid Organization Development. Classics of Organizational Behavior (No. Ed. 3). Waveland Press, Inc.

Bouchard, S., Gamache, S., & Abdulnour, G. (2023). Operationalizing Mass Customization in Manufacturing SMEs—A Systematic Literature Review. *Sustainability*, *15*(4), 3028. https://doi.org/10.3390/su15043028

Brodeur, J., Pellerin, R., & Deschamps, I. (2022). Operationalization of critical success factors to manage the industry 4.0 transformation of manufacturing SMEs. *Sustainability*, *14*(14), 8954. https://doi.org/10.3390/su14148954

Bradford, M. (2015). Modern ERP - Select, Implement, & Use Today's Advanced Business Systems. (2015). (No. Ed. 3). North Carolina State University.

Budde, L., Benninghaus, C., Hänggi, R., & Friedli, T. (2022). Managerial Practices for the Digital Transformation of Manufacturers. *Digital*, *2*(4), 463-483. https://doi.org/10.3390/digital2040025

Calza, E., Dalla Benetta, A., Kostić, U., Mitton, I., Moraschini, M., Vázquez-Prada Baillet, M., Cardona, M., Papazoglou, M., Righi, R., Torrecillas Jódar, J., López Cobo, M., Cira, P.P, De Prato, G., Analytical insights into the global digital ecosystem (DGTES), Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/811932, JRC132991

Campbell, T. T. (2023). The four-day work week: a chronological, systematic review of the academic literature. *Management Review Quarterly*, 1-17. https://doi.org/10.1007/s11301-023-00347-3

Černe, M., Čater, B., Čater, T., Koman, M., & Redek, T. (2023). Management innovation as an enabler of firm performance in the context of Industry 4.0: a longitudinal multi-source, multi-sector analysis. *Innovation*, 1-26. https://doi.org/10.1080/14479338.2023.2177858

Chakraborty, D., Bhatnagar, S. B., Biswas, W., & Dash, G. (2022). The Subtle Art of Effecting a Four-day Workweek to Drive Performance. *Management and Labour Studies*, *47*(3), 275-297. https://doi.org/10.1177/0258042x221082893

Challenger, R. And Clegg, C. (2011). Crowd disasters: A socio-technical systems perspective. Journal of the Academy of Social Sciences. 6(3), 343-360. https://doi.org/10.1080/21582041.2011.619862

Chaudhuri, R., Chatterjee, S., Vrontis, D., & Chaudhuri, S. (2022). Innovation in SMEs, AI dynamism, and sustainability: The current situation and way forward. *Sustainability*, *14*(19), 12760. https://doi.org/10.3390/su141912760

Cherns, A. (1976). The principles of sociotechnical design. *Human relations*, *29*(8), 783-792. https://doi.org/10.1177/001872677602900806

Chinoperekwegi, J., O'jung'a, A., Tonodzai, T. (2022). Fostering Strategic Change Through Organization Learning and Continuous Improvement. *Organization Development Journal*, *40*(4), 26-38.

Choi, J., Peters, M., and Mueller, R. (2010). Correlational Analysis of Ordinal Data: from Pearson's r to Bayesian polychoric correlation. Asia Pacific Educ. Rev. 11459-466. www.doi.org/10.1007/s/12564-010-9096-y

Choi, T. M., Kumar, S., Yue, X., & Chan, H. L. (2022). Disruptive technologies and operations management in the Industry 4.0 era and beyond. *Production and Operations Management*, *31*(1), 9-31. https://doi.org/10.1111/poms.13622

Chonsawat, N., & Sopadang, A. (2020). Defining SMEs' 4.0 readiness indicators. *Applied sciences*, *10*(24), 8998. http://doi.org/10.3390/app10248998

Cimini, C., & Cavalieri, S. (2022). Industrial Smart Working: a socio-technical model for enabling successful implementation. *IFAC-papers Online*, *55*(2), 505-510. https://doi.org/10.1016/j.ifacol.2022.04.244

Clausen, P. (2023). Towards the industry 4.0 agenda: Practitioners' reasons why a digital transition of shop floor management visualization boards is warranted. *Digital Business*, 100063.

Clegg, C. W. (2000). Sociotechnical principles for system design. *Applied ergonomics*, *31*(5), 463-477. https://doi.org/10.106/S0003-6870(00)00009-0

Colombari, R., & Neirotti, P. (2023). Leveraging Frontline Employees' Knowledge for Operational Data-Driven Decision-Making: A Multilevel Perspective. *IEEE Transactions on Engineering Management*. https://doi.org/10.1109/TEM.2023.3291272

Colorado State University. (2024, March 3). Understanding Generalizability and Transferability. https://writing.colostate.edu/guides.cfm?guideid=65

Cotrino, A., Sebastián, M. A., & González-Gaya, C. (2020). Industry 4.0 roadmap: Implementation for small and medium-sized enterprises. *Applied sciences*, *10*(23), 8566. https://doi.org/10.3390/app10238566

Crijns, A., Vanhullebusch, V., Reusens, M., Reusens, M., & Baesens, B. (2023). Topic modelling applied on innovation studies of Flemish companies. *Journal of Business Analytics*, 1-12. https://doi.org/10.1080/2573234X.2023.2186274

Daft, R. (2021). Organization Theory & Design. (No. Ed. 13). Cengage.

Das, A., & Jayaram, J. (2007). Socio-technical perspective on manufacturing system synergies. *International Journal of Production Research*, *45*(1), 169-205. https://doi.org/10.1080/00207540500381039

Davies, R., Coole, T., & Smith, A. (2017). Review of socio-technical considerations to ensure successful implementation of Industry 4.0. *Procedia Manufacturing*, *11*, 1288-1295. https://doi.org/10.1016/j.promfg.2017/07.256

Davis, M. C., Challenger, R., Jayewardene, D. N., & Clegg, C. W. (2014). Advancing socio-technical systems thinking: A call for bravery. *Applied ergonomics*, *45*(2), 171-180. https://doi.org/10.1016/j.apergo.2013.02.009

de Assis Dornelles, J., Ayala, N. F., & Frank, A. G. (2022). Smart Working in Industry 4.0: How digital technologies enhance manufacturing workers' activities. *Computers & Industrial Engineering*, *163*, 107804. https://doi.org/10.1016/j.cie.2021.107804

Delaney, H., & Casey, C. (2022). The promise of a four-day week? A critical appraisal of a management-led initiative. *Employee Relations: The International Journal*, *44*(1), 176-190. https://doi.org/10.1108/ER-02-2021-0056

Devi K, S., Paranitharan, K. P., & Agniveesh A, I. (2021). Interpretive framework by analysing the enablers for implementation of Industry 4.0: an ISM approach. *Total Quality Management & Business Excellence*, *32*(13-14), 1494-1514.

Dossou, P. E., Laouénan, G., & Didier, J. Y. (2022). Development of a sustainable industry 4.0 approach for increasing the performance of SMEs. *Processes*, *10*(6), 1092. https://doi.org/10.3390/pr10061092

Drasgow, F. (1986). “Polychoric and Polyserial Correlations.” In *Encyclopedia of Statistical Sciences, vol. 7*, edited by S. Kotz, N. L. Johnson, and C. B. Read. New York: John Wiley & Sons.

Dregger, J., Niehaus, J., Ittermann, P., Hirsch-Kreinsen, H., & Ten Hompel, M. (2016, May). The digitization of manufacturing and its societal challenges: a framework for the future of industrial labor. In *2016 IEEE international symposium on ethics in engineering, science and technology (ETHICS)* (pp. 1-3). IEEE.

Dutta, G., Kumar, R., Sindhwani, R., & Singh, R. K. (2021). Digitalization priorities of quality control processes for SMEs: A conceptual study in perspective of Industry 4.0 adoption. *Journal of Intelligent Manufacturing*, *32*(6), 1679-1698. https://doi.org/10.1007/s10845-021-01783-2

Enang, E., Bashiri, M., & Jarvis, D. (2023). Exploring the transition from techno centric industry 4.0 towards value centric industry 5.0: a systematic literature review. *International Journal of Production Research*, 1-37. https://doi.org/10.1080/00207543.2023.2221344

Enehaug, H. (2017). Ten Successful Years: A Longitudinal Case Study of Autonomy, Control and Learning1. *Nordic journal of working life studies Volume*, *7*(S2). https://tidsskrift.dk/njwls/index

Ernur, O., & Yüksel, H. (2022). Assessing Industry 4.0 Transformation of SMEs: A Swot Analysis. *İzmir Yönetim Dergisi*, *3*(1), 23-35. https://doi.org/10.56203/iyd.1113835

Espina-Romero, L., Guerrero-Alcedo, J., Goñi Avila, N., Noroño Sánchez, J. G., Gutiérrez Hurtado, H., & Quiñones Li, A. (2023). Industry 5.0: Tracking Scientific Activity on the Most Influential Industries, Associated Topics, and Future Research Agenda. *Sustainability*, *15*(6), 5554. https://doi.org/10.3390/su15065554

Fernandes, C., Pires, R., & Alves, G. (2022). Digital Entrepreneurship and Sustainability: The State of the Art and Research Agenda. *Economies*, 11(3), 1-15. https://doi.org/10.3390/economies11010003

Ferrara, B., Pansini, M., De Vincenzi, C., Buonomo, I., & Benevene, P. (2022). Investigating the role of remote working on employees' performance and well-being: an evidence-based systematic review. *International Journal of Environmental Research and Public Health*, *19*(19), 12373. https://doi.org/103390/ijerph191912373

Fischer, G., & Herrmann, T. (2011). Socio-technical systems: a meta-design perspective. *International Journal of Sociotechnology and Knowledge Development (IJSKD)*, *3*(1), 1-33. https://doi.org/10.4018/jskd.2011010101

Fischer, L., Wunderlich, N., & Baskerville, R. (2023). Artificial Intelligence and Digital Work: The Sociotechnical Reversal. https://hicss.hawaii.edu

Flinchbaugh, C., Valenzuela, M. A., & Li, P. (2018). Developing employee socio-technical flexibility in a multigenerational workforce. *Journal of Management & Organization*, *24*(4), 517-532. https://doi.org/10.101017/jmo.2016.38

Fraske, T. (2022). Industry 4.0 and its geographies: A systematic literature review and the identification of new research avenues. *Digital Geography and Society*, *3*, 100031. https://doi.org/10.1016/j.diggeo.2022.100031

Gabriel, S., Grauthoff, T., Joppen, R., Kühn, A., & Dumitrescu, R. (2021). Analyzing socio-technical risks in implementation of Industry 4.0-use cases. *Procedia CIRP*, *100*, 241-246. https://www.doi.org/10.1016/j.procir.2021.05.062

Gaitlin-Keener, C. and Lunsford, R. Four-Day Workweek: The Microsoft Japan Experience. Academic and Business Research Institute (AABRI) – Conference in the Cloud Virtual Conference Presentation & Proceedings. P. 1-14

Gales, L., Terquem, V., & Barcellini, F. (2022). A Social Design Approach: Enhancement of Local Social Dialogue on the Transformation of Work by Digital Technology. *Relations industrielles/Industrial Relations*, *77*(3). http://dx.doi.org/10.7202/1094211ar

Gao, J., Xu, N., & Zhou, J. (2023). Does digital transformation contribute to corporate carbon emissions reduction? Empirical evidence from China. *Sustainability*, *15*(18), 13414. https://doi.org/10.3390/su151813414

Garrel, J. V., & Jahn, C. (2022). Design framework for the implementation of AI-based (service) business models for small and medium-sized manufacturing enterprises. *Journal of the knowledge economy*. https://doi.org/10.1007/s13132-022-01003-z

Gebler, M., Juraschek, M., Thiede, S., Cerdas, F., & Herrmann, C. (2022). Defining the "Positive Impact" of socio-technical systems for absolute sustainability: A literature review based on the identification of system design principles and management functions. *Sustainability Science*, *17*(6), 2597-2613. https://doi.org/10.1007/s11625-022-01168-1

Ghobakhloo, M., Iranmanesh, M., Foroughi, B., Tirkolaee, E. B., Asadi, S., & Amran, A. (2023). Industry 5.0 implications for inclusive sustainable manufacturing: An evidence-knowledge-based strategic roadmap. *Journal of Cleaner Production*, *417*, 138023. https://doi.org/10.1016/j.jclepro.2023.138023

Ghobakhloo, M., Iranmanesh, M., Morales, M. E., Nilashi, M., & Amran, A. (2023). Actions and approaches for enabling Industry 5.0-driven sustainable industrial transformation: A strategy roadmap. *Corporate Social Responsibility and Environmental Management*, *30*(3), 1473-1494. https://doi.org/10.1002/csr.2431

Gottlich, M. (2024, March 1). U.S. Manufacturing PMI rises more than forecast in February. Seeking Alpha. https://seekingalpha.com/news/4074620-us-manufacturing-pmi-rises-more-than-forecast-in-february

Govers, M., & van Amelsvoort, P. (2023). A theoretical essay on socio-technical systems design thinking in the era of digital transformation. *Gruppe. Interaktion. Organisation. Zeitschrift für Angewandte Organisationspsychologie (GIO)*, *54*(1), 27-40. https://doi.org/10.1007/s11612-023-00675-8

Gratton, L. (2022). *Redesigning work: how to transform your organization and make hybrid work for everyone*. MIT Press.

Grefen, P., Vanderfeesten, I., Traganos, K., Domagala-Schmidt, Z., & van der Vleuten, J. (2022). Advancing smart manufacturing in europe: Experiences from two decades of research and innovation projects. *Machines*, *10*(1), 45. https://doi.org/10.3390/machines10010045

Grosse, E. H. (2023). Application of supportive and substitutive technologies in manual warehouse order picking: a content analysis. *International Journal of Production Research*, 1-20. https://doi.org/10.1080/00207543.2023.216983

Guertler, M. R., Schneider, D., Heitfeld, J., & Sick, N. (2023). Analysing Industry 4.0 technology-solution dependencies: a support framework for successful Industry 4.0 adoption in the product generation process. *Research in Engineering Design*, 1-22. https://doi.org/10.1007/s00163-023-00426-2

Guest, D., Knox, A., & Warhurst, C. (2022). Humanizing work in the digital age: Lessons from socio-technical systems and quality of working life initiatives. *human relations*, *75*(8), 1461-1482. https://doi.org/10.1177/00187267221092674

Guha, B., Moore, S., & Huyghe, J. M. (2023). Conceptualizing data-driven closed loop production systems for lean manufacturing of complex biomedical devices—a cyber-physical system approach. *Journal of Engineering and Applied Science*, *70*(1), 50. https:/doi.org/10.1186/s44147-023-00222-8

Gupta, M., & Jauhar, S. K. (2023). Digital innovation: An essence for Industry 4.0. *Thunderbird International Business Review*. https://doi.org/10.1002/tie22337

Hagström, M. H., Bergsjö, D., & Wahrén, H. (2023). Barriers from a Socio-Technical Perspective to Implement Digitalisation in Industrial Engineering Processes – A Literature Review. *Proceedings of the Design Society*, *3*, 737-746. https://doi.org/10.1017/pds.2023.74

Haraldseid-Driftland, C., Lyng, H. B., Guise, V., Waehle, H. V., Schibevaag, L., Ree, E., ... & Wiig, S. (2023). Learning does not just happen: establishing learning principles for tools to translate resilience into practice, based on a participatory approach. *BMC Health Services Research*, *23*(1), 646. https://doi.org/10.1186/s12913-023-09653-8

Häring, K., Pimentel, C., & Teixeira, L. (2023). Industry 4.0 Implementation in Small-and Medium-Sized Enterprises: Recommendations Extracted from a Systematic Literature Review with a Focus on Maturity Models. *Logistics*, *7*(4), 99. https://doi.org/10.3390/logistics7040099

Harland, T., Hocken, C., Schröer, T., & Stich, V. (2022). Towards a Democratization of Data in the Context of Industry 4.0. *Sci*, *4*(3), 29. https://doi.org/10.3390/sci4030029

Heininger, R., Jost, T. E., & Stary, C. (2023). Enriching socio-technical sustainability intelligence through sharing autonomy. *Sustainability*, *15*(3), 2590. https://doi.org/10.3390/su15032590

Holden, R. (2019). The Relationship between Self- and Teacher-ratings of Student Engagement and Standardized Test Performance. Grand Canyon University. ProQuest, LLC.

Hughes, H. P., Davis, M. C., Robinson, M. A., & McKay, A. (2021). The pursuit of organizational impact: hits, misses, and bouncing back. *European Journal of Work and Organizational Psychology*, *30*(3), 339-354. https://doi.org/10.1080/1359432X.2020.1722219

Iacobucci, D. (2010). *Marketing research: Methodological foundations*. South-Western Cengage Learning.

Jałowiec, T., & Wojtaszek, H. (2022). Analysis of Directional Activities for Industry 4.0 in the Example of Poland and Germany. *Sustainability*, *14*(7), 3848. https://doi.org/10.3390/su14073848

Javaid, M., Haleem, A., Singh, R. P., Suman, R., & Gonzalez, E. S. (2022). Understanding the adoption of Industry 4.0 technologies in improving environmental sustainability. *Sustainable Operations and Computers*, *3*, 203-217. https://doi.org/10.1016/j.susoc.2022.01.008

Jones, A., Begley, J., Berkeley, N., Jarvis, D., & Bos, E. (2020). Electric vehicles and rural business: Findings from the Warwickshire rural electric vehicle trial. *Journal of Rural Studies*, *79*, 395-408. https://doi.org/10.1016/j.jrurstud.2020.08.007

Kaminski, J. (2022). Editorial. Theory applied to informatics: Socio-Technical Theory. *Canadian Journal of Nursing Informatics*, *17*(3-4). https://cjni.net/journal/?p=10076

Kanovska, L. & Bumberova, V. (2021). Study of SMEs from electrical engineering industry providing smart services in the Czech Republic. SHS Web of Conferences, 05013, 1-10. https://doi.org/10.1051/shsconf/20219205013

Khourshed, N. F., Elbarky, S. S., & Elgamal, S. (2023). Investigating the Readiness Factors for Industry 4.0 Implementation for Manufacturing Industry in Egypt. *Sustainability*, *15*(12), 9641. https://doi.org/10.3390/su15129641

Kinne, J., & Lenz, D. (2021). Predicting innovative firms using web mining and deep learning. *PloS one*, *16*(4), e0249071. https://doi.org/10.1371/journal.pone.0249071

Kite, B. (2024). Computing Polychoric Correlations via the Two-Step Method. www.benkite.com

Kohnová, L., & Salajová, N. (2023). Re-Thinking Industry 4.0 Effect on Competitive Forces: Empirical Study on Innovation. *Sustainability*, *15*(3), 2637. https://doi.org/10.3390/su15032637

Kostadinova, N., & Vladkova, B. (2022). The role of flexible working time as a factor for work conditions. Annual of the University of Mining and Geology, 65:1-7.

Kumar, A., Agrawal, R., Wankhede, V. A., Sharma, M., & Mulat-Weldemeskel, E. (2022). A framework for assessing social acceptability of industry 4.0 technologies for the development of digital manufacturing. *Technological Forecasting and Social Change*, *174*, 121217. https://doi.org/10.1016/j.techfore.2021.121217

Kuo, S. Y., & Chen, L. B. (2021). Applying sociotechnical systems theory to examine the values of lean practices in the context of container shipping. *IEEE Access*, *9*, 146921-146937. https://10.1109/Access.2021.3123448

Kuper, H. (2020). Industry 4.0: changes in work organization and qualification requirements—challenges for academic and vocational education. *Entrepreneurship Education*, *3*, 119-131. https://doi.org/10.1007/s41959-020-00029-1

Kurtz, J., Meyer, P., & Roth, A. (2023). Decoding the context of servitization: socio-technical pivots on the journey to service-oriented business models in manufacturing firms. *Production Planning & Control*, 1-18. https://doi.org/10.1080/09537287.2023.2261880

Kwiotkowska, A., & Gębczyńska, M. (2022). Job satisfaction and work characteristics combinations in Industry 4.0 environment—Insight from the Polish SMEs in the Post–Pandemic era. *Sustainability*, *14*(20), 12978. https://doi.org/10.3390/su142012978

Lalla, M. (2017). Fundamental characteristics and statistical analysis of ordinal variables: a review. Qual Quant. 51:435-458. www.doi.org/10.1007/s11135-016-0314-5

Laursen, C. S., Nielsen, M. L., & Dyreborg, J. (2021). Young workers on digital labor platforms: Uncovering the double autonomy paradox. *Nordic Journal of Working Life Studies*. https://tidsskrift.dk/njwls/index

Leso, B. H., Cortimiglia, M. N., & Ghezzi, A. (2023). The contribution of organizational culture, structure, and leadership factors in the digital transformation of SMEs: a mixed-methods approach. *Cognition, Technology & Work*, *25*(1), 151-179. https://doi.org/10.1007/s10111-022-00714-2

Li, D., Fast-Berglund, Å., & Paulin, D. (2019). Current and future Industry 4.0 capabilities for information and knowledge sharing: Case of two Swedish SMEs. *The International Journal of Advanced Manufacturing Technology*, *105*, 3951-3963. https://doi.org/10.1007/s00170-019-03942-5

Li, G., Wu, J., & Li, N. (2022). Identifying the Value Co-Creation Model and Upgrading Path of Manufacturing Enterprises from the Value Network Perspective. *Sustainability*, *14*(23), 16008. https://doi.org/10.3390/su142316008

Lima, B. F., Neto, J. V., Santos, R. S., & Caiado, R. G. G. (2023). A Socio-Technical Framework for Lean Project Management Implementation towards Sustainable Value in the Digital Transformation Context. *Sustainability*, *15*(3), 1756.

Lin, L. H., & Wang, K. J. (2022). Talent Retention of New Generations for Sustainable Employment Relationships in Work 4.0 Era—Assessment by Fuzzy Delphi Method. *Sustainability*, *14*(18), 11535. https://doi.org/10.3390/su141811535

Liscio, E., Lera-Leri, R., Bistaffa, F., Dobbe, R. I., Jonker, C. M., Lopez-Sanchez, M., ... & Murukannaiah, P. K. (2023, May). Value Inference in Sociotechnical Systems. In *Proceedings of the 2023 International Conference on Autonomous Agents and Multiagent Systems* (pp. 1774-1780). www.ifaamas.org

Liu, S. F., Fan, Y. J., Luh, D. B., & Teng, P. S. (2022). Organizational Culture: the key to improving service management in Industry 4.0. *Applied Sciences*, *12*(1), 437. https://doi.org/10.3390/app12010437

Liu, Y., Ni, Z., Karlsson, M., & Gong, S. (2021). Methodology for digital transformation with internet of things and cloud computing: A practical guideline for innovation in small-and medium-sized enterprises. *Sensors*, *21*(16), 5355. https://doi.org/10.3390/s21165355

Loh, T. C., & Koh*, S. C. L. (2004). Critical elements for a successful enterprise resource planning implementation in small-and medium-sized enterprises. *International journal of production research*, *42*(17), 3433-3455. https://doi.org/10.1080/00207540410001671679

Ly, A. Marsman, M., & Wagenmakers, E. (2018). Analytic posteriors for Pearson's correlation coefficient. Statistica. Neerlandica, 72(1), 4-13. https://doi.org.lopes.idm.oclc.org/10.1111/stan12111

Madhavan, M., Wangtueai, S., Sharafuddin, M. A., & Chaichana, T. (2022). The precipitative effects of pandemic on open innovation of SMEs: a scientometrics and systematic review of Industry 4.0 and Industry 5.0. *Journal of Open Innovation: Technology, Market, and Complexity*, *8*(3), 152. https://doi.org/10.3390/joitmc8030152

Madsen, D. Ø., & Slåtten, K. (2023). Comparing the Evolutionary Trajectories of Industry 4.0 and 5.0: A Management Fashion Perspective. *Applied System Innovation*, *6*(2), 48. https://doi.org/10.3390/asi6020048

Maggioli, S., & Cunha, L. (2023). A Systematic Review Discussing the Sustainability of Men and Women's Work in Industry 4.0: Are Technologies Gender-Neutral?. *Sustainability*, *15*(7), 5615. https://doi.org/10.3390/su15075615

Maguire, M. (2014). Socio-technical systems and interaction design–21st century relevance. *Applied ergonomics*, *45*(2), 162-170. http://dx.doi.org/10.1016/j.apergo.2013.05.011

Maltseva, S., Kornilov, V., Barakhnin, V., & Gorbunov, A. (2022). Self-Organization in Network Sociotechnical Systems. *Complexity*, *2022*. https://doi.org/10/1155/2022/5714395

Mann, S. (2021). Occupational choices in art and agriculture–a mixed-method web scraping approach. *International Journal of Social Economics*, *48*(5), 748-758. https://doi.org/10.1108/IJSE-12-2019-0721

Marcon, É., Soliman, M., Gerstlberger, W., & Frank, A. G. (2022). Sociotechnical factors and Industry 4.0: an integrative perspective for the adoption of smart manufacturing technologies. *Journal of Manufacturing Technology Management*, *33*(2), 259-286. https://doi.org/10.1108/JMTM-01-2021-0017

Margherita, E. G., & Braccini, A. M. (2021). Examining the development of a digital ecosystem in an Industry 4.0 context: A sociotechnical perspective. *SN Business & Economics*, *1*(7), 89. https://doi.org/10.1007/s43546-021-0096-z

Margherita, E. G., & Braccini, A. M. (2021, October). Socio-technical perspectives in the Fourth Industrial Revolution-Analysing the three main visions: Industry 4.0, the socially sustainable factory of Operator 4.0 and Industry 5.0. In *7th International Workshop on Socio-Technical Perspective in IS Development (STPIS 2021)*. http://hdl.handle.net/2067/47877 (accessed on 24 June 2023)

McDermott, O., Nelson, S., Antony, J., & Sony, M. (2023). Industry 4.0 readiness in west of Ireland small and medium and micro enterprises–an exploratory study. *Quality Management Journal*, *30*(2), 105-120. https://doi.org/10.1080/10686967.2023.2171325

Melo, I. C., Queiroz, G. A., Junior, P. N. A., de Sousa, T. B., Yushimito, W., & Pereira, J. (2023). Sustainable digital transformation in small and medium enterprises (SMEs): A review on performance. *Heliyon*. https://doi.org/10.1016/j.heliyon.2023.e13908

Mian, S. H., Salah, B., Ameen, W., Moiduddin, K., & Alkhalefah, H. (2020). Adapting universities for sustainability education in industry 4.0: Channel of challenges and opportunities. *Sustainability*, *12*(15), 6100. https://doi.org/10.3390/su12156100

Michulek, J., & Gajanova, L. (2023). Is the Concept of Industry 4.0 Still Interesting for Scientists due to the Emergence of Industry 5.0? Bibliometric Analysis. *Economics and Culture*, *20*(1), 1-16. https://doi.org/10.274/jec-2023-0001

Minshull, L. K., Dehe, B., & Kotcharin, S. (2022). Exploring the impact of a sequential lean implementation within a micro-firm–a socio-technical perspective. *Journal of Business Research*, *151*, 156-169. https://doi.org/10.1016/j.jbusres.2022.06.052

Mitki, Y., Shani, A. B., & Greenbaum, B. E. (2019). Developing new capabilities: a longitudinal study of sociotechnical system redesign. *Journal of Change Management*, *19*(3), 167-182. http://dx.doi.org/10.1080/14697017.2018.1490337

Mizukami, Y., & Nakano, J. (2022). International comparison of cross-disciplinary integration in industry 4.0: A co-authorship analysis using academic literature databases. *Plos one*, *17*(10), e0275306. https://doi.org/10.1371/journal.pone.0275306

Moeuf, A., Lamouri, S., Pellerin, R., Tamayo-Giraldo, S., Tobon-Valencia, E., & Eburdy, R. (2020). Identification of critical success factors, risks and opportunities of Industry 4.0 in SMEs. *International Journal of Production Research*, *58*(5), 1384-1400. https://doi.org/10.1080/00207543.2019.1636323

Mourtzis, D., Angelopoulos, J., & Panopoulos, N. (2022). A Literature Review of the Challenges and Opportunities of the Transition from Industry 4.0 to Society 5.0. *Energies*, *15*(17), 6276. https://doi.org/10.3390/en15176276

Namugenyi, C., Nimmagadda, S. L., & Reiners, T. (2019). Design of a SWOT analysis model and its evaluation in diverse digital business ecosystem contexts. *Procedia Computer Science, 159*, 1145-1154. https://doi.org/10.1016/j.procs.2019.09.283

Nayernia, H., Bahemia, H., & Papagiannidis, S. (2022). A systematic review of the implementation of industry 4.0 from the organisational perspective. *International Journal of Production Research*, *60*(14), 4365-4396. https://doi.org/10.1080/00207543.2021.2002964

Neuhüttler, J., Feike, M., Kutz, J., Blümel, C., & Bienzeisler, B. (2023). Digital factory transformation from a servitization perspective: fields of action for developing internal smart services. *Sci*, *5*(2), 22. https://doi.org/10.3390/sci5020022

Neumann, W. P., Winkelhaus, S., Grosse, E. H., & Glock, C. H. (2021). Industry 4.0 and the human factor–A systems framework and analysis methodology for successful development. *International journal of production economics*, *233*, 107992. https://doi.org/10.1016/j.ijpe.2020.107992

Nguyen Ngoc, H., Lasa, G., & Iriarte, I. (2022). Human-centered design in industry 4.0: case study review and opportunities for future research. *Journal of Intelligent Manufacturing*, *33*(1), 35-76.

Norcross, J. S., Schuessler, J. H., & Jones, D. G. (2020). Web Scraping to Inform Curriculum Decisions. *Journal of Higher Education Theory and Practice*, *20*(10), 100-112.

Nuryani, S. (2023). Callie Qudsiyyah's business development strategy uses SWOT analysis and the business model canvas. *Journal of Management Science (JMAS)*, *6*(1), 30-37. https://doi.org/10.35335/jmas.v6i1.184

Olsson, U. (1979). "Maximum Likelihood Estimation of the Polychoric Correlation Coefficient." *Psychometrika* 12:443–460.)

Orzes, G., Rauch, E., Bednar, S., & Poklemba, R. (2018, December). Industry 4.0 implementation barriers in small and medium sized enterprises: A focus group study. In *2018 IEEE international conference on industrial engineering and engineering management (IEEM)* (pp. 1348-1352). IEEE.

Oudhuis, M., & Tengblad, S. (2022). The viability of the Scandinavian work-life model and the impact of lean production: The case of Scania. *Economic and Industrial Democracy*, *43*(2), 748-772. https://doi.org/10.1177/0143831X20939/37

Pacaux-Lemoine, M., Berdal, Q., Guerin, C., Rauffet, P., Chauvin, C. (2022). Desiging human-system cooperation in industry 4.0 with cognitive work analysis: a first evaluation. Cognition, Technology & Work. 24:93-111. https://doi.org/10/1007/s10111-021-00667-y

Pang, A. (2020). Shorter. (No. Ed. 1). Public Affairs.

Pasmore, W., Winby, S., Mohrman, S. A., & Vanasse, R. (2019). Reflections: sociotechnical systems design and organization change. *Journal of Change Management*, *19*(2), 67–85. https://doi.org/10.1080/14697017.2018.1553761

Pech, M., & Vrchota, J. (2020). Classification of small-and medium-sized enterprises based on the level of industry 4.0 implementation. *Applied Sciences*, *10*(15), 5150. https://doi.org/10.3390/app10155150

Pereira, A. C., Alves, A. C., & Arezes, P. (2023). Augmented reality in a lean workplace at smart factories: a case study. *Applied Sciences*, *13*(16), 9120. https://doi.org/10.3390/app13169120

Perez, F., Conway, N., & Roques, O. (2022). The autonomy tussle: AI technology and employee job crafting responses. *Relations Industrielles/Industrial Relations*, *77*(3).

Peruzzini, M., Prati, E., & Pellicciari, M. (2023). A framework to design smart manufacturing systems for Industry 5.0 based on the human-automation symbiosis. *International Journal of Computer Integrated Manufacturing*, 1-18. https://doi.org/10.1080/0951192X.2023.2257634

Pietrangeli, I., Mazzuto, G., Ciarapica, F. E., & Bevilacqua, M. (2023). Smart Retrofit: An Innovative and Sustainable Solution. *Machines*, *11*(5), 523. https://doi.org/10.3390/machines11050523

Prodi, E., Tassinari, M., Ferrannini, A., & Rubini, L. (2022). Industry 4.0 policy from a sociotechnical perspective: The case of German competence centres. *Technological Forecasting and Social Change*, *175*, 121341. https://doi.org/10.1016/j.techfore.2021.121341

Qureshi, K. M., Mewada, B. G., Buniya, M. K., & Qureshi, M. R. N. M. (2023). Analyzing Critical Success Factors of Lean 4.0 Implementation in Small and Medium Enterprises for Sustainable Manufacturing Supply Chain for Industry 4.0 Using PLS-SEM. *Sustainability*, *15*(6), 5528. https://doi.org/10.3390/su15065528

Riquet, N., Devroey, X., & Vanderose, B. (2022, May). GitDelver enterprise dataset (GDED) an industrial closed-source dataset for socio-technical research. In *Proceedings of the 19th International Conference on Mining Software Repositories* (pp. 403-407). https://doi.org/10.1145/3524842.3528003

Roth, K. & Farahmand, K. (2023). A Socio-Technical Study of Industry 4.0 and SMEs: Recent Insights from the Upper Midwest. Sustainability, 15 (16), 12559. https://doi.org/10.3390/su151612559

Roth, K., & Farahmand, K. (2023). A Study of Current Socio-Technical Design Practices in the Industry 4.0 Context among Small, Medium, and Large Manufacturers in Minnesota and North Dakota. *Sustainability*, *15*(23), 16438. https://doi.org/10.3390/su152316438

Roth, K., Farahmand, K., Al Amin, M. & Mahmoud, M. (2024). Contemporary Research Study on Web Scraping and Innovation. 2023 International Conference on Computational Science and Computational Intelligence (CSCI). *IEEE Computer Society*, 1-7.

Roy, M. A., Abdul-Nour, G., & Gamache, S. (2023). Implementation of an Industry 4.0 Strategy Adapted to Manufacturing SMEs: Simulation and Case Study. *Sustainability*, *15*(21), 15423. https://doi.org/10.3390/su152115423

Russo, M., Caloffi, A., Colovic, A., Pavone, P., Romeo, S., & Rossi, F. (2022). Mapping regional strengths in a key enabling technology: The distribution of Internet of Things competences across European regions. *Papers in Regional Science*, *101*(4), 875-900. https://doi.org/10.1111/pirs.12679

Salunkhea, O., & Berglunda, Å. F. (2022). Industry 4.0 enabling technologies for increasing operational flexibility in final assembly. *Int. J. Ind. Eng. Manag*, *13*(1), 38-48. http://doi.org/10.24867/IJIEM-2022-1-299

Salvadorinho, J., & Teixeira, L. (2023). Happy and Engaged Workforce in Industry 4.0: A New Concept of Digital Tool for HR Based on Theoretical and Practical Trends. *Sustainability*, *15*(3), 2781. https://doi.org./10.3390/su15032781

SAS Institute Inc. 2023. *SAS/STAT 15.3* User's Guide. Cary, NC: SAS Institute Inc.

SAS Institute Inc. (2023). SAS Manual. Pearson Product – Moment Correlation. www.documentation.sas.com/doc/en/pgmsascdc/9.4_3.5/procstat/procstat_corr_details01.htm

SAS Institute Inc. (2023) Polychoric Correlations. SAS Blogs. Blogs.sas.com/content/iml/2023/12/11/polychoric-correlation.html

Satyro, W. C., Contador, J. C., Monken, S. F. D. P., Lima, A. F. D., Soares Junior, G. G., Gomes, J. A., ... & Silva, L. S. (2023). Industry 4.0 implementation projects: the cleaner production strategy—a literature review. *Sustainability*, *15*(3), 2161. https://doi.org/10.3390/su132212479

Schwalbe, K. (2006). Introduction to Project Management. (No. Ed. 1). Course Technology.

Sergei, T., Arkady, T., Natalya, L., Pathak, R. D., Samson, D., Husain, Z., & Sushil, S. (2023). Digital transformation enablers in high-tech and low-tech companies: A comparative analysis. *Australian Journal of Management*, 03128962231157102. https://doi.org/10.1177/03128962231157102

Setyaningsih, S., Kelle, P., & Maretan, A. S. (2020). Driver and barrier factors of industry 4.0 implementation for small and medium-sized enterprises: An overview. *Economic and Social Development: Book of Proceedings*, 343-354.

Sgarbossa, F., Grosse, E. H., Neumann, W. P., Battini, D., & Glock, C. H. (2020). Human factors in production and logistics systems of the future. *Annual Reviews in Control*, *49*, 295-305. https://doi.org/10.1016/j.arcontrol.2020.04.007

Shaffer, R., Deller, S., & Marcouiller, D. (2004). *Community economics: linking theory and practice* (No. Ed. 2). Blackwell Publishing.

Shahzad, A., bin Zakaria, M. S. A., Kotzab, H., Makki, M. A. M., Hussain, A., & Fischer, J. (2023). Adoption of fourth industrial revolution 4.0 among Malaysian small and medium enterprises (SMEs). *Humanities and Social Sciences Communications*, *10*(1), 1-14. https://doi.org/10.1057/s41599-023-02076-0

Shpak, N., Odrekhivskyi, M., Doroshkevych, K., & Sroka, W. (2019). Simulation of innovative systems under industry 4.0 conditions. *Social Sciences*, *8*(7), 202.

Shuttleworth, L., Schmitz, S., & Beier, W. (2022). Impacts of Industry 4.0 on industrial employment in Germany: A comparison of industrial workers' expectations and experiences from two surveys in 2014 and 2020. *Production & Manufacturing Research*, 10(1), 583-605. https://doi.org/10.1080/21693277.2022.2104400

Sievers, F., Reil, H., Rimbeck, M., Stumpf-Wollersheim, J., & Leyer, M. (2021). Empowering employees in industrial organizations with IoT in their daily operations. *Computers in industry*, *129*, 103445. https://doi.org/10.1016/j.compind.2021.103445

Sitepu, M. H., Matondang, A. R., & Sembiring, M. T. (2020, May). A socio-technical approach to assess readiness of organizations for Industry 4.0. In *Journal of Physics: Conference Series* (Vol. 1542, No. 1, p. 012031). IOP Publishing. https://doi.org/10.1088/1742-6596/1542/1/012031

Sk, R. I. S. N. I. (2020). Planning Business Model Canvas with SWOT Method At XYZ Institute. *Dinasti International Journal of Digital Business Management, 1*(5), 781-793. https://doi.org/10.31933/dijdbm.v1i5.483

Sofic, A., Rakic, S., Pezzotta, G., Markoski, B., Arioli, V., & Marjanovic, U. (2022). Smart and Resilient Transformation of Manufacturing Firms. *Processes*, *10*(12), 2674. https://doi.org/10.3390/pr10122674

Sony, M., & Mekoth, N. (2022). Employee adaptability skills for Industry 4.0 success: a road map. *Production & Manufacturing Research*, *10*(1), 24-41. https://doi.org/10.1080/21693277.2022.2035281

Sony, M., & Naik, S. (2020). Industry 4.0 integration with socio-technical systems theory: A systematic review and proposed theoretical model. *Technology in society*, *61*, 101248. https://doi.org/10.1016/j.techsoc.2020.101248

Speckmann, F. (2021). Web scraping: A useful tool to broaden and extend psychological research. *Zeitschrift für Psychologie*, *229*(4), 241. https://doi.org/10.1027/2151-2604/a000470

Stern, H., & Becker, T. (2019). Concept and evaluation of a method for the integration of human factors into human-oriented work design in cyber-physical production systems. *Sustainability*, *11*(16), 4508. https://doi.org/10.3390/su11164508

Szabó, P., MĺKva, M., Marková, P., Samáková, J., & Janík, S. (2023). Change of Competences in the Context of Industry 4.0 Implementation. *Applied Sciences*, *13*(14), 8547. https://doi.org/10.3390/app13148547

Thomassen, O. J., Heggen, K., & Strand, R. (2017). Applying principles of sociotechnical systems onto working environment research.

Thun, S., Bakås, O., & Storholmen, T. C. B. (2022). Development and implementation processes of digitalization in engineer-to-order manufacturing: enablers and barriers. *AI & SOCIETY*, *37*(2), 725-743. https://doi.org/10.1007/s00146-021-01174-4

Tortorella, G. L., Saurin, T. A., Hines, P., Antony, J., & Samson, D. (2023). Myths and facts of industry 4.0. *International Journal of Production Economics*, *255*, 108660. https://doi.org/10.2139/ssrn.4079749

Tortorella, G., Fogliatto, F. S., Kumar, M., Gonzalez, V., & Pepper, M. (2023). Effect of Industry 4.0 on the relationship between socio-technical practices and workers' performance. *Journal of Manufacturing Technology Management*, *34*(1), 44-66. https://doi.org/10.1108/JMTM-04-2022-0173

Tortorella, G., Prashar, A., Antony, J., Mac Cawley, A. F., Vassolo, R., & Sony, M. (2023). Role of leadership in the digitalisation of manufacturing organisations. *Journal of Manufacturing Technology Management*, *34*(2), 315-336. https://doi.org/10.1108/JMTM-09-2022-0312

Trehan, R., Machhan, R., Singh, P., & Sangwan, K. S. (2022). Industry 4.0 and Society 5.0: Drivers and Challenges. *IUP Journal of Information Technology*, *18*(1), 40-58.

Tubis, A. A., & Grzybowska, K. (2022). In Search of Industry 4.0 and Logistics 4.0 in Small-Medium Enterprises—A State of the Art Review. *Energies*, *15*(22), 8595. https://doi.org/10.3390/en15228595

van Kleeff, R., van Harten, J., Knies, E., & Boselie, P. (2023). 'Lean Dancing': How Involvement in Continuous Improvement and Lean Techniques Relate to Hospital Performance and Workers' Wellbeing through Autonomy. *Sustainability*, *15*(6), 5546. https://doi.org/10.3390/su15065546

Varbanova, M., Dutra de Barcellos, M., Kirova, M., De Steur, H., & Gellynck, X. (2023). Industry 4.0 implementation factors for agri-food and manufacturing SMEs in Central and Eastern Europe. *Serbian Journal of Management*, *18*(1), 167-179. https://doi.org/10.5937/sjm18-39939

Verhulst, B. and Neale, M. (2021). Best Practices for Binary and Ordinal Data Analyses. Behavior Genetics. 51:204-214. https://doi.org/10.1007/s10519-020-10031-x

Vermeerbergen, L., Pless, S., Van Hootegem, G., & Benders, J. (2021). From silos to cells: Reducing repetitive jobs through sociotechnical redesign. *Economic and Industrial Democracy*, *42*(1), 160-178. https://doi.org/10.1177/0143831X18756758journals.sagepub.com/home/eid

Waschull, S., Bokhorst, J. A., Wortmann, J. C., & Molleman, E. (2022). The redesign of blue-and white-collar work triggered by digitalization: collar matters. *Computers & Industrial Engineering*, *165*, 107910. https://doi.org/10.1016/j.cie.2021.107910

Weiss, A., Wortmeier, A. K., & Kubicek, B. (2021). Cobots in industry 4.0: A roadmap for future practice studies on human–robot collaboration. *IEEE Transactions on Human-Machine Systems*, *51*(4), 335-345. https://doi.org/10.1109/THMS.2021.3092684

Whiteoak, J., & Sullivan, M. (2022). Exploring the challenges of a implementing a four-day work week: an Australian manufacturing case study. In *Conference Proceedings* (pp. 1060-1076). Australian and New Zealand Academy of Management. ISBN: 978-0-6481109-7-2

Yadav, O. P., Nepal, B. P., Rahaman, M. M., & Lal, V. (2017). Lean implementation and organizational transformation: a literature review. *Engineering Management Journal*, *29*(1), 2-16.

Yang, F., & Gu, S. (2021). Industry 4.0, a revolution that requires technology and national strategies. *Complex & Intelligent Systems*, *7*, 1311-1325. https://doi.org/10.1007/s40747-020-00267-9

Yao, X., Wang, K., Ma, N., Mai, H., Huang, Y., & Yang, E. (2021, December). DIKW upward enabling manufacturing from digitalization in industry 3.0 to wisdom in industry 4.0. In *2021 IEEE 23rd Int Conf on High Performance Computing & Communications; 7th Int Conf on Data Science & Systems; 19th Int Conf on Smart City; 7th Int Conf on Dependability in Sensor, Cloud & Big Data Systems & Application (HPCC/DSS/SmartCity/DependSys)* (pp. 2166-2171). IEEE. https://doi.10.1109/HPCC-DSS-SmartCity-DependsSys53884.2021.00323

Yıldızbaşı, A., & Ünlü, V. (2020). Performance evaluation of SMEs towards Industry 4.0 using fuzzy group decision making methods. SN Applied Sciences Vol. 2, 355. https://doi.org/10.1007/s42452-020-2085-9

Yue, L., Wang, Z., Fang, Y., & Han, Z. (2020). Implementation of Smart Manufacturing Maturity Assessment Framework: A Socio-Technical Perspective. In *E3S Web of Conferences* (Vol. 179, p. 02023). E3S Web of Conferences.

Zemlyak, S., Gusarova, O., & Sivakova, S. (2022). Assessing the Influence of Collaborative Technology Adoption—Mediating Role of Sociotechnical, Organizational, and Economic Factors. *Sustainability*, *14*(21), 14271. https://doi.org/10.3390/su142114271

Zhou, L., Jiang, Z., Geng, N., Niu, Y., Cui, F., Liu, K., & Qi, N. (2022). Production and operations management for intelligent manufacturing: A systematic literature review. *International Journal of Production Research*, *60*(2), 808-846. https://doi.org/10.1080/00207543.2021.2017055

Zhu, J., Zhang, B., Xie, M., & Cao, Q. (2022). Digital leadership and employee creativity: The role of employee job crafting and person-organization fit. *Frontiers in Psychology*, *13*, 827057. https://doi.org/10.3389/fpsyg.2022.827057

Zizic, M. C., Mladineo, M., Gjeldum, N., & Celent, L. (2022). From industry 4.0 towards industry 5.0: A review and analysis of paradigm shift for the people, organization and technology. *Energies*, *15*(14), 5221. https://doi.org/10.3390/en15145221

APPENDIX A. DATA FROM FIRST SURVEY

Table A1. Data from First Survey

StartDate	EndDate	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21
3/19/2023 18:02	3/19/2023 18:03																				
3/20/2023 14:03	3/20/2023 14:05	1	Media	3	1	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	5
3/20/2023 14:10	3/20/2023 14:17	1	Consulting and Business Improvement, Manufacturing.	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	1
3/20/2023 14:28	3/20/2023 14:32	1	Scientific Research and Development	5	5	5	5	5	5	5	4	5	4	5	5	5	5	5	5	4	2
3/21/2023 7:35	3/21/2023 7:38	3	Aerospace	5	5	4	5	5	4	4	4	4	4	5	5	4	4	5	5	5	5
3/21/2023 7:57	3/21/2023 8:14	3	Mental health	5	5	5	4	5	5	4	4	5	3	5	4	4	3	3	4	4	3
3/21/2023 8:58	3/21/2023 9:03	1	Software	5	5	4	4	5	5	5	5	4	4	4	4	4	5	4	4	5	2
3/21/2023 12:33	3/21/2023 12:40	2	Truck Accessories	4	4	3	3	4	3	3	4	4	4	4	4						
3/22/2023 6:38	3/22/2023 6:42	1	Professional services	2	2	2	2	2	2	2	4	4	2	2	2	4	4	4	4	4	2
3/22/2023 8:50	3/22/2023 8:58	3	Steel Fabrication	3	4	3	3	2	2	3	3	2	3	3	4	3	4	4	4	4	4
3/22/2023 11:56	3/22/2023 12:01	2	Non-profit	3	4	4	4	4	4	4	4	4	3	4	4	4	4	3	4	4	4
3/22/2023 11:59	3/22/2023 12:03	3	manufacturing	5	4	5	3	4	3	4	4	4	4	4	4	4	4	5	5	4	2
3/22/2023 12:16	3/22/2023 12:29	1	Medical Device	4	3	2	1	2	2	3	4	3	1	5	5	5	4	4	2	3	3
3/22/2023 12:36	3/22/2023 12:44	1	Manufacturing	5	5	4	5	4	4	5	4	4	4	5	5	5	5	4	4	5	1
3/22/2023 12:36	3/22/2023 12:55	1	Engineering-Manufacturing	4	3	5	4	4	5	3	5	4	4	2	3	4	4	3	2	4	3
3/22/2023 14:00	3/22/2023 14:02	1	Advertising	4	4	5	4	5	3	3	4	4	4	5	5	4	3	4	4	4	4
3/22/2023 14:01	3/22/2023 14:08	1	Advertising	4	4	4	4	5	5	4	4	4	3	4	4	3	3	4	4	4	2
3/22/2023 16:24	3/22/2023 16:31	2	Information technology	5	5	4	5	4	4	4	5	4	5	4	4	4	5	5	5	5	1
3/22/2023 18:13	3/22/2023 18:17	3	Insurance Agency	5	4	5	4	5	5	5	4	4	3	4	5	1	5	5	5	4	2
3/22/2023 18:16	3/22/2023 18:26	3	logistics	4	4	4	3	4	2	2	3	3	2	3	4	3	4	2	1	2	3
3/22/2023 19:47	3/22/2023 19:49	3	Finance	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	1
3/22/2023 20:16	3/22/2023 20:22	1	Crop Genetics and food ingredients manufacturer	3	3	3	4	4	3	4	3	3	3	3	3	3	4	4	4	4	2
3/23/2023 2:42	3/23/2023 2:53	3	Oil drilling equipments	5	3	4	5	3	2	4	4	4	3	2	3	2	2	1	2	2	4
3/23/2023 6:33	3/23/2023 6:40	3	Government	5	4	5	4	4	4	4	4	4	3	3	4	4	5	4	4	3	2
3/23/2023 6:54	3/23/2023 7:00	3	Manufacturing/Civil	4	4	3	3	3	4	3	2	3	3	3	4	4	4	4	3	3	3
3/23/2023 6:44	3/23/2023 7:28	3	Manufacturing	5	4	4	5	4	2	2	4	3	3	3	5	4	3	3	1	3	3
3/23/2023 8:16	3/23/2023 8:19	1	Engineering	5	5	1	5	5	5	5	5	5	5	5	5	5	5	5	5	5	1
3/23/2023 8:35	3/23/2023 8:41	2	Construction	4	3	3	4	4	3	3	4	4	3	4	4	3	2	3	1	2	2
3/23/2023 9:52	3/23/2023 10:00	2	Engineering Consulting	2	4	4	2	4	4	4	4	4	3	4	4	5	4	3	2	3	2
3/23/2023 11:56	3/23/2023 12:09	1	Air Transportation	3	4	3	4	4	4	4	4	4	3	4	4	4	4	4	4	4	2
3/23/2023 12:58	3/23/2023 12:59																				
3/23/2023 13:01	3/23/2023 13:13	1	Startup, investing, impact, social impact, climate, speaking	4	3	2	5	2	2	4	2	2	1	3	5	3	4	3	2	3	2
3/23/2023 13:28	3/23/2023 13:46	1	Information Technology	2	4	4	4	4	5	4	4	3	2	2	4	4	5	5	4	4	2
3/23/2023 15:27	3/23/2023 15:31	3	Hospitality	5	4	5	5		5	5	5	5	3		5	5	2	4	5		
3/23/2023 15:52	3/23/2023 15:57	3	Software	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
3/23/2023 16:51	3/23/2023 16:55																				
3/23/2023 18:26	3/23/2023 18:31	1	Manufacturing	5	4	3	2	5	2	5	5	4	3	5	4	2	5	5	4	5	1
3/23/2023 19:58	3/23/2023 20:09	3	Manufacturing	5	5	5	5	5	5	5	4	4		5	4		5	2	5	4	2
3/24/2023 4:48	3/24/2023 4:53	3	health	5	5	4	4	4	5	5	4	5	4	5	5						2
3/24/2023 5:39	3/24/2023 5:44	3	Manufacturing	5	4	4	5	4	4	3	4	3	3	4	4	3	2	3	1	3	3
3/24/2023 7:16	3/24/2023 7:21	1	Mattress manufacturing	2	5	5	5	4	4	5	5	5	3	5	5	5	3	5	5	5	1
3/24/2023 8:08	3/24/2023 8:12	1	Media	3	1	1	1	1	1	1	1	1	1	1	2	1	3	3	3	3	3
3/24/2023 9:37	3/24/2023 9:41	1	Consulting	4	4	4	4	4	4	4	4	4	4	3	3	4	3	3	4	4	3
3/24/2023 10:12	3/24/2023 10:15	2	Agriculture - we are an ingredient processor and supplier of o	4	2	4	4	4	5	4	4	4	3	4	5	4	4	5	5	4	4

Table A1. Data from First Survey (continued)

StartDate	EndDate	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21
3/24/2023 10:11	3/24/2023 10:19	2	Manufacturing	1	1	4	2	3	1	2	1	4	2	5	4	3	5	5	4	5	3
3/24/2023 10:20	3/24/2023 10:24	1	manufacturing	1	1	1	1	1	3	1	3	1	1	5	3	3	1	4	4	1	2
3/24/2023 10:44	3/24/2023 10:49	3	Manufacturing	4	4	4	5	4	4	3	4	4	4	4	4	4	4	3	5	4	1
3/24/2023 11:41	3/24/2023 11:47	3	Higher Education	4	3	2	3	3	4	4	3	3	3	4	3	3	4	4	2	3	4
3/24/2023 12:05	3/24/2023 12:42	3	Education	5	5	5	5	4	5	4	2	2	2	2	2	2	4	4	4	3	3
3/24/2023 16:41	3/24/2023 16:48	1	Crisis helpline	5	4	5	4	2	2	5	1	4	3	4	4	5	4	4	4	5	2
3/24/2023 17:23	3/24/2023 17:25	3	Healthcare	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3/25/2023 12:25	3/25/2023 12:31	3	Ag processing/food production	4	2	2	4	3	2	2	2	2	1	4	3	4	2	2	2	2	1
3/26/2023 9:17	3/26/2023 9:23	1	Marketing Consulting Services	4	2	3	4	4	3	4	4	2	1	4	1	4	3	3	4	4	3
3/26/2023 9:37	3/26/2023 9:41	1	Leadership Consulting	2	2	1	4	4	4	4	5	4	4	4	4	4	1	4	4	4	2
3/27/2023 7:34	3/27/2023 7:44	1	Office Equipment Sales	4	5	4	3	4	4	4	4	4	3	3	4	4	4	4	3	3	4
3/27/2023 13:32	3/27/2023 13:54	1	Other	3	4	3	4	3	2	4	3	3	3	3	4	3	4	2	3	4	1
3/27/2023 14:16	3/27/2023 14:22	1	IT	5	5	5	5	5	5	5	4	5	5	5	4	4	4	2	4	4	1
3/24/2023 13:52	3/27/2023 15:41	2	Manufacturing	2	1	1	3	3	4	3	4	3	3	4	5	4	5	5	3	3	2
3/27/2023 19:02	3/27/2023 19:07	3	Manufacturing	5	5	5	4	5	4	5	4	4	3	5	5	5	4	3	5	5	4
3/27/2023 19:13	3/27/2023 19:16	3	Medical devices - business intelligence	5	4	5	5	4	4	4	4	4	5	3	5	4	5	3	3	3	3
3/28/2023 10:31	3/28/2023 10:35	1	nonprofit	4	4	4	5	4	4	4	4	3	2	2	2	4	4	4	5	5	2
3/28/2023 13:48	3/28/2023 13:52	2	State Government	4	4	4	4	4	4	4	4	3	3	3	3	4	4	4	4	3	4
3/28/2023 14:17	3/28/2023 14:21	1	Infrastructure	4	5	4	5	4	3	4	3	5	4	4	4	4	5	3	4	3	2
3/28/2023 15:06	3/28/2023 15:10	1	Paint and Coatings	5	5	5	4	4	5	4	5	5	4	3	4	5	5	3	4	5	4
3/28/2023 15:08	3/28/2023 16:11	1	Electronics design and manufacturing	5	5	4	3	4	3	5	4	4	4	5	4	3	5	4	4	4	3
3/29/2023 11:05	3/29/2023 11:13	1	Microbrewery/BBQ Restaurant	5	5	3	5	5	5	5	5	5	3	5	4	5	5	2	4	5	1
3/30/2023 7:36	3/30/2023 7:42	1	Engineering and Manufacturing	4	4	3	4	5	5	5	5	4	3	5	4	5	5	5	5	5	1
3/30/2023 12:03	3/30/2023 12:07	1	Professional Services	1	4	4	3	4	4	4	4	3	3	3	4	3	2	4	4	4	2
3/30/2023 14:08	3/30/2023 14:12	2	oil and gas	4	4	2	3	4	4	3	4	4	3	4	3	4	4	4	4	4	2
3/30/2023 15:19	3/30/2023 15:24	1	agriculture, chemical, seed, fuel	4	1	3	4	3	3	4	4	4	3	4	4	3	4	4	1	4	2
3/31/2023 5:19	3/31/2023 5:22	3	Utility	4	4	4	5	5	4	5	5	4	3	5	4	2	4	5	2	4	4
3/31/2023 8:30	3/31/2023 8:35	2	higher education	5	4	4	5	5	2	2	4	4	3	5	4	4	4	2	4	4	1
3/31/2023 10:00	3/31/2023 10:07	2	Medical device manufacturing	5	4	5	5	5	5	5	5	4	5	5	5	5	5	3	5	5	1
3/31/2023 12:13	3/31/2023 12:19	2	Manufacturing	4	4	4	5	4	4	5	4	4	5	5	5	4	5	4	5	4	2
3/31/2023 12:47	3/31/2023 12:49	3	Automotive	3	3	4	3	2	4	3	2	4	2	4	2	2	5	3	3	3	3
4/1/2023 8:34	4/1/2023 8:44	2	Dairy	4	4	4	3	4	4	3	4	4	2	3	2	4	4	4	4	3	4
4/2/2023 14:12	4/2/2023 14:16	2	Telecommunications	4	5	5	5	5	5	4	4	4	4	5	5	4	2	5	5	4	4
4/2/2023 15:04	4/2/2023 15:07	2	Fashion Industry	5	5	3	4	5	5	3	4	4	1	2	2	4	2	3	3	3	2
4/2/2023 17:08	4/2/2023 17:13	3	Mfg - Bldg Materials	5	5	5	4	4	5	5	4	4	5	5	5	5	5	5	5	5	1
4/3/2023 12:45	4/3/2023 12:48	3	Entertainment marketing	5	5	5	5	4	5	5	4	4	4	5	5	5	4	4	5	5	2
4/3/2023 14:05	4/3/2023 14:09	3	Logistics	2	2	3	4	4	1	2	4	1	1	4	2	2	3	1	4	4	4
4/4/2023 12:49	4/4/2023 12:52	3	Telecommunications	5	5	5	5	5	4	4	4	5	3	4	4	3	4	2	3	4	3
4/6/2023 9:00	4/6/2023 9:05	2	Technology MSP	5	4	4	4	5	5	4	4	4	3	4	4	4	5	4	4	4	2
4/6/2023 9:35	4/6/2023 9:44	2	rural healthcare	4	4	4	3	3	4	4	4	4	4	4	4	4	3	4	4	4	4
4/6/2023 15:33	4/6/2023 15:37	1	architecture/real estate	4	4	4	4	4	4	5	4	4	3	4	4	4	4	5	4	5	2
4/7/2023 2:22	4/7/2023 2:26	1	health and wellness	4	2	4	3	4	3	4	2	3	1	2	4	2	3	4	3	1	4
4/7/2023 7:34	4/7/2023 7:35																				
4/7/2023 13:59	4/7/2023 14:05	2	Not for profit	5	3	5	4	3	4	4	4	4	2	4	4	4	4	3	2	4	4

Table A1. Data from First Survey (continued)

StartDate	EndDate	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21
4/10/2023 4:27	4/10/2023 4:34	3	Manufacturing, Installation & Service	1	1	2	1	2	2	1	1	2	1	3	4	4	4	2	3	2	2
4/10/2023 11:01	4/10/2023 11:10	1	aquatic therapy & pool access	3	2	2	3	3	4	3	3	3	2	3	3	4	3	4	3	3	2
4/10/2023 13:42	4/10/2023 13:50	1	Manufacturing for factory automation, marine and industrial s	3	4	4	5	5	2	3	4	2	3	1	5	5	4	5	4	4	3
4/10/2023 19:33	4/10/2023 19:38	3	Radio media advertising sales	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	5	5	5
4/11/2023 19:21	4/11/2023 19:29	3	Healthcare Technology	4	5	5	5	5	5	5	4	4	3	4	5	4	5	5	4	5	1
4/12/2023 9:22	4/12/2023 9:23																				
4/16/2023 16:00	4/16/2023 16:04	3	aerospace	5	5	4	5	4	4	5	4	4	5	4	4	5	5	5	5	5	5
4/25/2023 9:06	4/25/2023 9:09	1	Technology	4	4	2	2	2	2	2	4	2	2	2	2	2	4	4	2	4	4
4/28/2023 18:08	4/28/2023 18:12	1	Consulting	2	4	1	4	2	3	4	4	3	3	1	4	1	4	4	1	2	2

APPENDIX B. DATA FROM SECOND SURVEY

Table B1. Data from Second Survey

StartDate	EndDate	Status	IPAddress	Progress	Duration (in seconds)	Finished	RecordedDate	ResponseId	LocationLatitude	LocationLon	DistributionChannel	UserLanguage	Q1	Q2	Q3	Q4	Q5	Q6	Q7
8/22/2023 8:14	8/22/2023 8:15	1		100	72	1	8/22/2023 8:15	R_UrQ0xnk5hhgx3R7	46.9208	-98.745	preview	EN							
8/22/2023 9:34	8/22/2023 9:41	0	165.225.11.63	100	448	1	8/22/2023 9:41	R_3j2s3ihA2aW4UvW	39.7501	-104.9957	anonymous	EN	3	NORTH DAKOTA	4	5	5	4	1,2
8/22/2023 9:33	8/22/2023 9:42	0	24.117.110.251	100	536	1	8/22/2023 9:42	R_3Gj6rmv7NqN6ymo	46.8524	-96.8121	anonymous	EN	1	ND	2	3	5	5	1
8/22/2023 9:39	8/22/2023 9:47	0	174.213.245.115	100	484	1	8/22/2023 9:47	R_2c88oxOUsU9ArUl	44.9427	-93.2871	anonymous	EN	3	ND	2	3	5	3	1,2,3
8/22/2023 9:42	8/22/2023 9:49	0	208.107.113.161	100	390	1	8/22/2023 9:49	R_3iIo1pkwhbNgYwI	46.8045	-100.7865	anonymous	EN	2	North Dakota	4	4	2	3	2,3
8/22/2023 10:21	8/22/2023 10:25	0	208.107.66.182	100	246	1	8/22/2023 10:25	R_1mxAonggF72wKFu	46.9188	-96.8266	anonymous	EN	2	nd	4	3	5	5	1
8/22/2023 10:21	8/22/2023 10:26	0	165.225.11.35	100	340	1	8/22/2023 10:26	R_8cEvmea7XzhkMil	39.7501	-104.9957	anonymous	EN	3	ND	4	4	5	5	2
8/22/2023 11:12	8/22/2023 11:24	0	24.220.248.126	100	703	1	8/22/2023 11:24	R_1jpkADCACa1nx5Q	46.8796	-96.7814	anonymous	EN	2	North Dakota	2	3	4	4	2,3
8/22/2023 11:30	8/22/2023 11:39	0	76.10.71.6	100	517	1	8/22/2023 11:39	R_1LXP3U79TghhLV2	46.7952	-96.8332	anonymous	EN	3	Minnesota	7	4	5	5	1
8/22/2023 12:08	8/22/2023 12:13	0	75.222.170.39	100	324	1	8/22/2023 12:13	R_25QtxhUEi5K2DV0	44.9926	-92.9537	anonymous	EN	3	Minnesota	6	4	5	3	1,2
8/22/2023 12:31	8/22/2023 12:34	0	69.84.67.252	100	172	1	8/22/2023 12:34	R_3CIuUqfXdazcqGS	46.4896	-99.7836	anonymous	EN	1	North Dakota	1	1	1	1	2
8/22/2023 12:41	8/22/2023 12:49	0	69.42.234.223	100	475	1	8/22/2023 12:49	R_3MuP4QrWnroLwoN	46.445	-96.7237	anonymous	EN	1	NORTH DAKOTA	5	3	1	1	3
8/22/2023 13:44	8/22/2023 13:56	0	24.111.232.78	100	749	1	8/22/2023 13:56	R_10x5B31iqqatytg	48.2261	-101.2974	anonymous	EN	3	ND and 28 other states	2	5	1	2	1
8/22/2023 13:41	8/22/2023 13:57	0	69.9.217.210	100	974	1	8/22/2023 13:57	R_1rCIcRPmqjIcm2h	46.8657	-96.7521	anonymous	EN	3	North Dakota	5	4	5	3	1
8/22/2023 14:11	8/22/2023 14:17	0	199.187.212.162	100	409	1	8/22/2023 14:17	R_1kREswWhZqEn8lV	46.8524	-96.8121	anonymous	EN	2	North Dakota	7	3	3	3	3
8/22/2023 15:25	8/22/2023 15:32	0	208.107.66.142	100	391	1	8/22/2023 15:32	R_2y3MFulcz5tt9u5	46.9188	-96.8266	anonymous	EN	1	ND	4	1	2	1	1
8/23/2023 6:01	8/23/2023 6:09	0	69.178.240.229	100	477	1	8/23/2023 6:09	R_1Ket9ikYB6tK985	47.9888	-98.8728	anonymous	EN	1	North Dakota	4	1	1	1	4
8/23/2023 6:19	8/23/2023 6:34	0	15.181.96.243	100	916	1	8/23/2023 6:34	R_1oaJHoSE6UWv1xX	39.1027	-94.5778	anonymous	EN	1	ND	4	4	1	1	1,2,3
8/23/2023 8:45	8/23/2023 8:57	0	172.56.25.242	100	695	1	8/23/2023 8:57	R_2tx96bYDTB4F7cY	29.6925	-95.363	anonymous	EN	3	Texas	7	4	3	3	1
8/23/2023 9:15	8/23/2023 9:32	0	96.2.207.170	100	1044	1	8/23/2023 9:32	R_22Pt0sBqa68l5Mp	47.9264	-97.0674	anonymous	EN	2	NORTH DAKOTA	7	3	3	3	3
8/23/2023 9:58	8/23/2023 10:05	0	65.23.183.59	100	415	1	8/23/2023 10:05	R_22soKyyqT2XFoYO	46.4585	-97.6323	anonymous	EN	1	NORTH DAKOTA	4	4	5	3	2
8/23/2023 10:00	8/23/2023 10:06	0	96.3.213.194	100	359	1	8/23/2023 10:06	R_2Ytc2qBi2kgTSR3	46.9188	-96.8266	anonymous	EN	1	North Dakota	4	5	5	5	1
8/23/2023 10:04	8/23/2023 10:12	0	155.190.19.4	100	428	1	8/23/2023 10:12	R_1g0wT8xghgKvtkG	40.7099	-73.9591	anonymous	EN	3	cross East cost	3	5	4	4	1,3
8/23/2023 10:15	8/23/2023 10:34	0	174.199.39.171	100	1156	1	8/23/2023 10:34	R_eeu3KGRnlgAzyBr	44.7601	-93.2748	anonymous	EN	1	ND	5	3	5	5	1
8/23/2023 10:37	8/23/2023 10:42	0	24.111.78.212	100	276	1	8/23/2023 10:42	R_1kYVhNh77tKR8zb	46.8045	-100.7865	anonymous	EN	1	North Dakota	6	2	4	4	2
8/23/2023 11:19	8/23/2023 11:26	0	76.10.116.90	100	443	1	8/23/2023 11:26	R_3JwPne9Gi4pY5PC	46.9188	-96.8266	anonymous	EN	1	North Dakota	4	1	5	5	1
8/23/2023 17:05	8/23/2023 17:11	0	66.231.107.16	100	322	1	8/23/2023 17:11	R_3J2ENF4v4CZfr61	48.0182	-98.1234	anonymous	EN	3	North Dakota	7	3	5	5	2
8/23/2023 17:53	8/23/2023 17:58	0	72.203.242.138	100	314	1	8/23/2023 17:58	R_9FGVlEQsV6e2R1v	33.5038	-112.0253	anonymous	EN	1	AZ	2	3	5	5	2
8/23/2023 19:52	8/23/2023 19:58	0	97.127.28.18	100	353	1	8/23/2023 19:58	R_3soHwtvM3xaIOFx	44.9354	-93.1694	anonymous	EN	1	Minnesota	7	3	3	5	1,2,3
8/24/2023 5:59	8/24/2023 6:06	0	50.211.23.58	100	435	1	8/24/2023 6:06	R_2WvwENtKtKZb4UM	44.8696	-93.3266	anonymous	EN	1	MN	6	1	4	4	2,3
8/24/2023 6:26	8/24/2023 6:45	0	69.163.10.50	100	1106	1	8/24/2023 6:45	R_ukTfwqqeFDrDDJD	43.7703	-94.1602	anonymous	EN	1	Minnesota	7	3	2	3	1
8/24/2023 6:59	8/24/2023 7:06	0	208.123.20.112	100	436	1	8/24/2023 7:06	R_248mZvo85PewsLt	46.9327	-94.8518	anonymous	EN	2	MN	4	4	4	4	2
8/24/2023 7:03	8/24/2023 7:11	0	50.249.115.89	100	454	1	8/24/2023 7:11	R_2TtSzUywAXCWFac	45.0769	-93.1372	anonymous	EN	1	Minnesota	4	2	2	1	4
8/24/2023 7:08	8/24/2023 7:12	0	96.2.60.68	100	250	1	8/24/2023 7:12	R_1OTC6lOKiGyPrRg	46.8045	-100.7865	anonymous	EN	2	ND	2	3	4	4	1
8/24/2023 7:12	8/24/2023 7:21	0	104.28.104.110	100	513	1	8/24/2023 7:21	R_SZV83NPVNSRnpmN	44.9834	-93.2622	qr	EN	2	Minnesota	4	4	4	4	2
8/24/2023 7:16	8/24/2023 7:24	0	134.129.75.194	100	520	1	8/24/2023 7:24	R_1155bK0dHZ8qbAo	46.9188	-96.8266	anonymous	EN	3	ND	2	1	2	2	1
8/24/2023 7:21	8/24/2023 7:29	0	98.97.12.145	100	476	1	8/24/2023 7:29	R_22WicQwRZy5Glcc	41.8874	-87.6318	anonymous	EN	1	MN	4	1	1	1	2
8/24/2023 7:46	8/24/2023 7:51	0	162.216.217.229	100	334	1	8/24/2023 7:51	R_3CIt58g1rBDRk93	47.315	-93.1885	anonymous	EN	1	Minnesota	4	2	1	2	
8/24/2023 7:52	8/24/2023 8:01	0	165.234.92.3	100	545	1	8/24/2023 8:01	R_WjUea5DF6wDRBBL	46.8393	-100.782	anonymous	EN	3	North Dakota	3	4	5	4	1
8/24/2023 6:24	8/24/2023 8:05	0	66.234.112.194	100	6066	1	8/24/2023 8:05	R_2QMc1lPxFzvRxhH	45.8827	-95.3783	anonymous	EN	3	Minnesota	4	4	4	4	1
8/24/2023 8:04	8/24/2023 8:11	0	69.55.33.216	100	395	1	8/24/2023 8:11	R_3iwpOIclegQNuTB	47.9648	-102.4657	anonymous	EN	1	North Dakota	4	3	1	1	3
8/24/2023 8:08	8/24/2023 8:13	0	24.116.164.157	100	323	1	8/24/2023 8:13	R_3NPcv7tSu4B9eUW	46.8657	-96.7521	anonymous	EN	1	ND	2	2	1	1	2
8/24/2023 8:48	8/24/2023 8:53	0	64.255.148.89	100	279	1	8/24/2023 8:53	R_216SlkrDdH2qBET	47.2284	-98.5493	anonymous	EN	1	North Dakota	3	3	5	3	1
8/24/2023 9:23	8/24/2023 9:38	0	64.202.36.122	100	920	1	8/24/2023 9:38	R_2zRXW6Ny4s6gGvt	47.1791	-98.1613	anonymous	EN	1	North Dakota	5	3	1	1	2

Table B1. Data from Second Survey (continued)

Q2	Q7_4_TEXT	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q14_6_TEXT	Q15	Q15_6_TEXT	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25
NORTH DAKOTA		4	4	4	3	4	2	4		5		3	4	4	5	4	4	4	5	4	4
ND		4	4	5	3	4	4	4,6	We a	4,6	We have to be available when the custo	4	4	5	5	5	4	5	4	4	4
ND		3	4	4	1	3	1	5		4		1	1	3	4	3	3	4	3	1	1
North Dakota		4	4	3	2	4	2	5		5		4	4	4	4	4	2	2	4	3	4
nd		5	4	5	3	5	4	5		5		2	3	5	5	4	4	3	5	4	5
ND		4	5	5	1	5	1	4		5		2	2	3	5	4	3	5	5	4	3
North Dakota		3	4	2	2	2	2					1	3	4	2	4	2	4	4	4	3
Minnesota		4	5	5	1	4	1	4,6	Supp	5		4	2	4	5	5	4	5	5	4	4
Minnesota		3	4	4	2	2	2	5		4		2	2	1	2	2	4	4	5	1	4
North Dakota		1	1	1	1	1	1	4		4		1	1	1	1	4	4	3	3	4	4
NORTH DAKOTA		3	1	1	1	1	1	4		6	therewill be adelay ifwe arewaiting on	1	1	3	1	3	3	3	3	3	3
ND and 28 other states		2	1	1	3	1	3	4		5		1	1	1	1	3	2	1	2	2	3
North Dakota		4	4	4	1	4	1	5		5		3	3	2	4	2	2	4	4	4	3
North Dakota		2	2	2	1	2	2	5		5		1	1	1	2	3	3	3	3	3	2
ND		3	4	4	2	4	1	5		5		1	1	3	4	4	3	4	4	4	4
North Dakota	we operate under the HAACP requried by the ND Department	4	3	1	3	1	2	5		5		1	1	2	4	4	1	3	5	4	5
ND		5	5	5	3	5	1	4,6	We a	5		1	1	5	5	5	4	4	5	5	5
Texas		2	3	4	1	4	2	4,6	Upstr	5		3	3	2	2	3	2	2	4	2	2
NORTH DAKOTA		4	4	4	3	2	1	4		4		2	2	4	3	4	4	4	4	4	4
NORTH DAKOTA		5	4	4	3	5	4	4		4		2	2	4	4	4	4	4	4	4	4
North Dakota		5	4	4	3	4	2	5		5		2	3	3	4	4	4	4	4	4	5
cross East cost		4	4	4	2	4	4	4,6	desig	4,6	design	4		4	4	5	4	4	4	4	4
ND		5	5	4	3	5	3	4		5		3	2	4	5	5	5	4	5	3	5
North Dakota		4	4	4	3	4	1	5		5		1	1	3	4	5	4	4	4	4	5
North Dakota		5	5	5	3	5	4	4,6	Activ	5,6	delivery schedules	4	3	4	4	5	5	5	5	5	5
North Dakota		4	5	5	3	5	2	5		5		2	1	4	5	5	4	5	5	3	5
AZ		4	5	4	2	5	4	5		5		4	3	4	3	4	3	4	4	4	4
Minnesota		4	4	5	3	4	3	4,6	Flexi	5		2	2	5	5	5	5	4	5	4	5
MN		4	5	5	1	5	1	5		5		3	1	5	3	5	4	5	5	5	5
Minnesota		4	4	2	3	5	1	4,6	We h	5		3	3	4	4	4	4	4	4	4	4
MN		4	5	5	3	5	5	4		5		3	3	4	5	5	5	5	5	5	5
Minnesota	Not Applicable	1	3	2	1	1	4	4,6	Manu	4,6	Yes we are struggling to keep employee	3	3	4	2	4	4	3	1	4	3
ND		3	4	4	3	4	4	4		4		4	4	4	4	4	4	4	4	4	4
Minnesota		5	4	5	1	5	2	5		5		1	1	4	5	4	4	4	5	4	4
ND		1	1	4	1	2	2	5		5		1	1	1	2	2	2	1	4	1	3
MN		5	4	4	1	4	1	5		5		1	1	1	5	5	1	4	3	1	4
Minnesota		2	2	2		4	1	4,6	all w	5		2	2	4	5	5	5	1	5	5	3
North Dakota		5	5	4	2	4	1	4		5		4	4	4	5	5	4	5	3	4	4
Minnesota		2	4	3	3	4	2	5		5		2	4	4	4	3	5	4	4	3	2
North Dakota		5	5	5	1	3	3	4,6	We a	4,6	We can be flexible with hours, as neede	3	3	4	4	5	5	5	5	5	5
ND		4	1	2	1	1	4	4,6	Own	4		1	1	4	5	4	4	4	4	4	4
North Dakota		5	5	5	3	5	5	4		4		5	5	5	5	5	4	5	5	5	5
North Dakota		4	4	4	1	4	2	4,6	We a	5		1	3	5	5	5	5	5	4	4	5

Table B1. Data from Second Survey (continued)

StartDate	EndDate	Status	IPAddress	Progress	Duration (in seconds)	Finished	RecordedDate	ResponseId	LocationLatitude	LocationLor	DistributionChannel	UserLanguage	Q1	Q2	Q3	Q4	Q5	Q6	Q7
8/24/2023 9:34	8/24/2023 9:40	0	216.71.52.75	100	308	1	8/24/2023 9:40	R_2Yt9qkQBtKaoVIG	46.8045	-100.7865	anonymous	EN	3	Massachusetts	5	4	5	5	1,2
8/24/2023 10:23	8/24/2023 10:29	0	199.190.238.134	100	366	1	8/24/2023 10:29	R_1Qia8AUpQIdHmJX	46.9172	-98.708	anonymous	EN	2	ND	2	4	4	4	1
8/24/2023 10:04	8/24/2023 10:36	0	24.230.185.236	100	1899	1	8/24/2023 10:36	R_TcSDROpFeyQ0oJX	43.55	-96.6904	anonymous	EN	2	We are a national organiz	2	5	3	4	4
8/24/2023 10:39	8/24/2023 10:39	0	140.186.134.163	100	9	1	8/24/2023 10:39	R_38gbeXASIzfe2hX	46.8796	-96.7814	anonymous	EN							
8/24/2023 11:18	8/24/2023 11:23	0	96.2.88.99	100	321	1	8/24/2023 11:23	R_3IXD9eS4tcjXXp8	46.8907	-96.9258	anonymous	EN	1	North Dakota	5	3	4	5	3
8/24/2023 11:35	8/24/2023 11:38	0	68.69.241.124	100	204	1	8/24/2023 11:38	R_2YP2n6Jh2kBymiX	46.8524	-96.8121	anonymous	EN	1	North Dakota	1	3	4	4	1
8/24/2023 11:35	8/24/2023 11:40	0	24.220.96.251	100	307	1	8/24/2023 11:40	R_2rBl039o7J0pzcJ	47.9259	-97.0267	anonymous	EN	1	ND	2	3	4	2	2
8/24/2023 11:48	8/24/2023 11:53	0	69.178.214.76	100	335	1	8/24/2023 11:53	R_1jVRXKONbbg4kgq	47.7003	-99.7484	anonymous	EN	1	north dakota	4	2	1	1	1
8/24/2023 11:57	8/24/2023 12:05	0	140.186.93.27	100	465	1	8/24/2023 12:05	R_1isbTg7UPa0WxxG	46.8796	-96.7814	anonymous	EN	1	ND	2	4	1	1	3
8/24/2023 12:05	8/24/2023 12:09	0	74.207.136.33	100	275	1	8/24/2023 12:09	R_1M4Bl595eebUhLQ	48.2261	-101.2974	anonymous	EN	1	North Dakota	6	3	4	3	3
8/24/2023 13:49	8/24/2023 13:53	0	24.220.243.247	100	276	1	8/24/2023 13:53	R_SDHmFp60nvnAy7n	46.8796	-96.7814	anonymous	EN	2	North Dakota	4	4	2	4	2
8/24/2023 14:00	8/24/2023 14:06	0	134.129.75.231	100	361	1	8/24/2023 14:06	R_1eLd7fjGLre9pLz	46.9188	-96.8266	anonymous	EN	1	NORTH DAKOTA	2	3	1	2	3
8/24/2023 15:56	8/24/2023 16:07	0	162.216.217.229	100	639	1	8/24/2023 16:07	R_1F2gjQkDhOiDuZ9	47.2856	-93.3702	anonymous	EN	1	MN	4	2	4	1	1
8/24/2023 19:01	8/24/2023 19:36	0	47.183.208.26	100	2080	1	8/24/2023 19:36	R_11ZJxb306GeOMpn	32.799	-96.956	anonymous	EN	2	Texas, North Dakota, Colo	3	3	2	2	3
8/24/2023 20:40	8/24/2023 20:48	0	174.215.244.246	100	461	1	8/24/2023 20:48	R_p5IbxqNl6LcJBa9	41.2671	-96.0378	anonymous	EN	3	Pennsylvania	3	4	4	4	2
8/25/2023 6:10	8/25/2023 6:24	0	177.92.55.104	100	887	1	8/25/2023 6:24	R_3rO2xnsNxdLhTjJ	-23.7101	-53.3852	anonymous	EN	3	Nebraska	2	3	4	4	1
8/25/2023 7:47	8/25/2023 7:49	0	153.90.18.106	100	123	1	8/25/2023 7:49	R_2rOyPrkqXqVlWck	45.6714	-111.0436	anonymous	EN							
8/25/2023 7:52	8/25/2023 7:56	0	174.199.36.86	100	249	1	8/25/2023 7:56	R_1jQdMXYqKuYKQLi	44.9948	-93.2548	anonymous	EN	1	north dakota	7	3	1	1	2,3
8/25/2023 8:08	8/25/2023 8:15	0	173.241.183.102	100	393	1	8/25/2023 8:15	R_siDfKyw6YlIqRm9	46.1706	-103.4034	qr	EN	1	North and south dakota	4	1	3	3	2
8/25/2023 6:35	8/25/2023 8:15	0	172.56.249.212	100	6051	1	8/25/2023 8:15	R_ddtUzJOCUW5jdsd	39.7684	-86.158	anonymous	EN	2	Indiana	4	4	5	5	1,2
8/25/2023 8:16	8/25/2023 8:20	0	24.111.141.114	100	202	1	8/25/2023 8:20	R_ZE1qZtWtTYrUj6h	46.8907	-96.9258	anonymous	EN	3	Minnesota	4	2	4	4	1,2
8/25/2023 9:52	8/25/2023 10:02	0	50.249.108.53	100	560	1	8/25/2023 10:02	R_3iU4qxhDIrNokPx	45.1184	-93.3461	anonymous	EN	1	Minnesota	7	3	4	4	2,3
8/25/2023 10:07	8/25/2023 10:15	0	96.3.208.110	100	456	1	8/25/2023 10:15	R_3gYoOaB68Zi6eMI	46.8524	-96.8121	anonymous	EN	2	ND	4	4	2	4	2
8/25/2023 10:50	8/25/2023 10:55	0	96.2.7.237	100	274	1	8/25/2023 10:55	R_OlBFk3xmOh1v5kt	46.8045	-100.7865	anonymous	EN	1	ND	5	3	3	3	
8/25/2023 11:07	8/25/2023 11:14	0	96.3.189.15	100	380	1	8/25/2023 11:14	R_1kF7KmEr1sxSnwB	46.8045	-100.7865	anonymous	EN	1	North Dakota	1	3	4	2	1
8/25/2023 10:39	8/25/2023 11:19	0	64.255.133.122	100	2368	1	8/25/2023 11:19	R_9uBIuqqY2RGAVtT	46.8524	-96.8121	anonymous	EN	1	North Dakota	2	3	2	3	1
8/25/2023 12:26	8/25/2023 12:40	0	199.190.238.129	100	841	1	8/25/2023 12:40	R_1etvN7cFz8c8cRr	46.9172	-98.708	anonymous	EN	2	North Dakota	2	3	2	2	2
8/25/2023 13:06	8/25/2023 13:10	0	209.81.103.157	100	270	1	8/25/2023 13:10	R_1jVVBxGDiyl9aQv	46.8193	-95.8452	anonymous	EN	2	ND and MN	5	4	4	5	1
8/25/2023 19:52	8/25/2023 20:02	0	174.199.105.120	100	571	1	8/25/2023 20:02	R_1igvM8Ey58TNiVL	44.9856	-93.2655	anonymous	EN	1	North Dakota	4	3	4	4	1
8/26/2023 6:29	8/26/2023 6:43	0	174.199.39.132	100	800	1	8/26/2023 6:43	R_3emkOIxScwQE2zk	44.9618	-93.2638	anonymous	EN	2	North Dakota	6	3	3	3	1,2,3
8/26/2023 10:07	8/26/2023 10:08	0	177.37.87.112	100	77	1	8/26/2023 10:08	R_2OU6Jy3aVlpCt5C	-27.272	-50.6134	anonymous	EN	2		5	4	5	5	1,2,3
8/26/2023 17:42	8/26/2023 17:42	0	179.255.20.58	100	9	1	8/26/2023 17:42	R_4ZymJLthkn9j7wd	-16.8428	-49.2468	anonymous	EN							
8/27/2023 11:09	8/27/2023 11:15	0	174.199.32.9	100	338	1	8/27/2023 11:15	R_2bN0V4AjdwpT6TV	44.9618	-93.2638	anonymous	EN	1	North Dakota	4	1	2	2	3
8/28/2023 6:55	8/28/2023 7:03	0	174.229.178.134	100	454	1	8/28/2023 7:03	R_2YGiWTw0wUSGowk	44.9856	-93.2655	anonymous	EN	3	North Dakota	2	3	4	3	4
8/28/2023 6:54	8/28/2023 7:03	0	165.234.248.136	100	553	1	8/28/2023 7:03	R_3kp8JCJs0kPlMY4	46.9208	-98.745	anonymous	EN	3	North Dakota	2	3	4	3	1,2
8/28/2023 7:03	8/28/2023 7:14	0	209.23.148.182	100	657	1	8/28/2023 7:14	R_DBjG0uYV2HNJmk9	41.5876	-93.6194	anonymous	EN	1	North Dakota	4	1	1	2	3
8/24/2023 8:38	8/28/2023 8:44	0	65.132.199.50	100	345943	1	8/28/2023 8:44	R_3fDW9KTLOC9JFaL	44.0563	-122.9164	anonymous	EN	1	MN	5	3	4	2	1,2,3
8/28/2023 8:23	8/28/2023 8:47	0	69.178.222.2	100	1411	1	8/28/2023 8:47	R_3g0A0gYiB18YEXd	46.9188	-96.8266	anonymous	EN	1	ND	4	4	3	3	1
8/28/2023 12:14	8/28/2023 12:23	0	165.234.253.49	100	503	1	8/28/2023 12:23	R_2dH0T1cUb4d3ne8	46.8393	-100.782	anonymous	EN	2	North Dakota	2	3	5	3	4
8/28/2023 16:36	8/28/2023 16:44	0	68.97.54.129	100	442	1	8/28/2023 16:44	R_pnEUbDjqN6g990B	35.3352	-97.4789	anonymous	EN	3	Oklahoma	6	4	5	4	2
8/29/2023 9:48	8/29/2023 9:54	0	134.129.75.216	100	388	1	8/29/2023 9:54	R_3RryaHOL8E1VV0k	46.9188	-96.8266	anonymous	EN	1	North Dakota	2	4	4	4	1
8/29/2023 10:16	8/29/2023 10:30	0	173.214.228.246	100	833	1	8/29/2023 10:30	R_NUCCLbW8EazhkjL	46.9208	-98.745	anonymous	EN	1	North Dakota	5	2	3	4	2
8/29/2023 16:36	8/29/2023 16:44	0	216.126.209.185	100	466	1	8/29/2023 16:44	R_1LB5iUAo1JBGfM5	48.1674	-103.6093	anonymous	EN	1	North Dakota	4	3	4	2	2
8/30/2023 7:12	8/30/2023 7:17	0	65.23.183.192	100	311	1	8/30/2023 7:17	R_r7TkTbmNuOHLlOp	46.0069	-98.5124	anonymous	EN	1	North Dakota	5	3	2	2	2,3

Table B1. Data from Second Survey (continued)

Q2	Q3	Q4	Q5	Q6	Q7	Q7_4_TEXT	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q14_6_TEXT	Q15	Q15_6_TEXT	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25
Massachusetts	5	4	5	5	1,2		5	5	4	3	4	4	4,6	We d	4		4	4	4	4	5	5	5	5	4	4
ND	2	4	4	4	1		5	4	3	3	5	3	4		5		3	3	3	4	3	3	5	5	5	4
We are a national organiz	2	5	3	4	4	We use 3 month, 1 year, project specific, and long term campai	4	5	4	2	5	2	4,6	Comp	4,6	Yes, the autonomy over oneâ€™s sched	3	4	2	4	4	5	4	5	3	3
North Dakota	5	3	4	5	3		4	4	5	2	4	4	4		5		5	4	2	2	4	4	4	5	5	5
North Dakota	1	3	4	4	1		4	4	5	1	4	5	4		4		4	4	3	5	4	4	5	4	4	5
ND	2	3	4	2	2		4	4	5	3	4	3	5		5		1	3	4	5	5	5	5	4	5	5
north dakota	4	2	1	1	1		1	4	3	1	3	4	5		5		1	1	1	1	1	2	1	4	1	1
ND	2	4	1	1	3		4	4	2		4	4	5		5		1	1	4	2	2	4	4	4	2	2
North Dakota	6	3	4	3	3		4	4	5	2	5	4	5		4		4	3	4	4	3	3	4	3	4	3
North Dakota	4	4	2	4	2		2	2	2	1	4	5	4,6	I was	4		2	3	2	4	4	4	2	5	4	4
NORTH DAKOTA	2	3	1	2	3		1	1	1	2	2	4	5		5		2	2	1	5	5	2	4	4	3	4
MN	4	2	4	1	1		4	4	5	1	3	1	4,6	Get 4	5		1	2	4	5	4	5	2	5	5	4
Texas, North Dakota, Colo	3	3	2	2	3		2	4	1	1	4	4	4,6	No se	5		4	4	4	3	4	4	4	3	4	3
Pennsylvania	3	4	4	4	2		4	4	5	2	4	2	4		5		4	2	4	4	2	2	4	4	4	4
Nebraska	2	3	4	4	1		4	4	3	3	3	5	4		5		5	4	5	5	5	5	5	5	5	5
north dakota	7	3	1	1	2,3		4	4	4	2	4	1	5		5		1	1	5	4	5	4	5	4	4	5
North and south dakota	4	1	3	3	2		3	4	4	1	3	3	4		4		3	3	4	3	4	4	2	3	4	3
Indiana	4	4	5	5	1,2		5	5	5	3	5	3	5		5		2	3	3	5	5	5	5	5	3	5
Minnesota	4	2	4	4	1,2		4	4	3	3	4	3	4		5		4	4	1	5	5	4	5	4	3	4
Minnesota	7	3	4	4	2,3		5	5	5	2	5	5	4,6	flex s	4,6	Daily sales goal is established	1	1	5	5	5	5	5	5	5	5
ND	4	4	2	4	2		5	5	5	3	5	1	5		5		1	4	3	4	4	1	3	5	3	4
ND	5	3	3	3				4	4	3	5	3	4						4	5	5	5	4	4	4	5
North Dakota	1	3	4	2	1		3	5	1	1	4	4	4		4		3	3	4	4						
North Dakota	2	3	2	3	1		3	4	4	3	4	2	4		4		2	3	4	4	4	4	4	4	4	4
North Dakota	2	3	2	2	2		2	3	2	2	2	5	5		5		2	2	3	4	4	4	4	4	3	2
ND and MN	5	4	4	5	1		5	5	5	3	5	1	5		5		3	4	5	5	5	5	5	5	4	5
North Dakota	4	3	4	4	1		4	4	2	1	4	1	5		5		1	1	4	5	5	5	5	5	5	2
North Dakota	6	3	3	3	1,2,3		3	3	3	3	3	4	4,6	Work	4,6	Able to work from home and or later in	1	1	2	4	2	3	4	2	2	2
	5	4	5	5	1,2,3		5	5	5		5	5	4		4		5	5	5	5	5	5	5	5	5	5
North Dakota	4	1	2	2	3		3	4	4	1	4	1	5		5		1	1	2	3	4	2	4	4	2	3
North Dakota	2	3	4	3	4	unknown	4	3	3	3	4	1	5		5		3	3	1	3	3	3	2	3	3	3
North Dakota	2	3	4	3	1,2		3	4	2	1	2	1	5		4,6	We are an education organization. Som	2	2	4	4	3	3	4	4	3	3
North Dakota	4	1	1	2	3		3	3	2	1	2	2	5		5		1	1	2	2	4	2	3	1	2	2
MN	5	3	4	2	1,2,3		4	4	4	2	4	2	4,6	No se	4,6	Yes - knowledge work	2	2	2	5	5	4	4	5	4	4
ND	4	4	3	3	1		4	5	5	3	5	2	5		5		2	2	4	4	5	4	5	4	4	4
North Dakota	2	3	5	3	4	Some have a 1-3 month roll out, others 6-12 months		3	3	2	4	1	4		5		1	1	1	2	3	2	3	4	2	3
Oklahoma	6	4	5	4	2		4	3	4	3	5	3	4,6	Flexi	5		3	3	4	4	4	4	4	5	5	5
North Dakota	2	4	4	4	1		4	3	5	2	4	3	4		4		3	3	4	5	4	5	5	4	4	4
North Dakota	5	2	3	4	2		4	5	5	3	5	5	4		5		1	5	5	5	5	5	5	3	5	5
North Dakota	4	3	4	2	2		3	3	4	3	4	2	4		5		1	2	5	4	4	2	4	5	4	4
North Dakota	5	3	2	2	2,3		5	4	5	3	4	3	4,6	hour:	4,6	it's always possible to work smarter, no	3	3	4	3	4	4	3	4	5	4

Table B1. Data from Second Survey (continued)

StartDate	EndDate	Status	IPAddress	Progress	Duration (in seconds)	Finished	RecordedDate	ResponseId	LocationLatitude	LocationLon	DistributionChannel	UserLanguage	Q1	Q2	Q3	Q4	Q5	Q6	Q7
8/23/2023 8:22	8/23/2023 8:26	0	68.69.235.151	76	220	0	8/30/2023 8:26	R_1cUjjAZhVWUpcxf			anonymous	EN	1	North Dakota	6	2	2	1	1
8/30/2023 20:23	8/30/2023 20:30	0	216.126.210.169	100	463	1	8/30/2023 20:30	R_2DOK7kFafNxi9tr	48.2257	-103.6511	anonymous	EN	1	ND	4	3	2	2	3
8/24/2023 6:28	8/24/2023 6:33	0	172.103.29.138	76	317	0	8/31/2023 6:34	R_3qNYnfEskbmN9jC			anonymous	EN	3	North Dakota	4	3	4	4	4
8/31/2023 6:57	8/31/2023 7:12	0	104.28.97.11	100	931	1	8/31/2023 7:12	R_OjSIBGlO9pPjCSt	46.8796	-96.7814	anonymous	EN	1	North Dakota	4	2	1	2	3
8/24/2023 9:35	8/24/2023 9:37	0	200.119.152.44	76	101	0	8/31/2023 9:37	R_3lVSOCK1WnZvgqz			anonymous	EN	1	Minnesota	5	2	5	3	2,3
8/31/2023 9:35	8/31/2023 10:00	0	134.129.123.180	100	1472	1	8/31/2023 10:00	R_3kNSe5gsdUndtE9	46.8796	-96.7814	anonymous	EN	3	ND	2	4	4	5	2
8/31/2023 12:54	8/31/2023 13:01	0	24.220.62.122	100	386	1	8/31/2023 13:01	R_3njtQz0hH9MD0Hr	46.9188	-96.8266	anonymous	EN	1	ND	7	2	1	1	1,2,3
8/24/2023 16:23	8/24/2023 16:32	0	96.3.65.161	76	559	0	8/31/2023 16:32	R_2vkolQnWf8OoEdZ			anonymous	EN	1	ND	4	1	3	3	4
8/31/2023 22:53	8/31/2023 23:01	0	8.28.178.5	100	474	1	8/31/2023 23:01	R_2OZx7VVilgSA4hq	41.8972	-87.6196	anonymous	EN	1	MN	7	3	4	4	1,2,3
9/1/2023 7:45	9/1/2023 7:51	0	64.255.129.82	100	393	1	9/1/2023 7:51	R_2AMZtOIlYw2sS1l	46.9188	-96.8266	anonymous	EN	1	North Dakota	7	3	1	1	3
8/25/2023 8:48	8/25/2023 11:23	0	208.123.54.9	76	9311	0	9/1/2023 11:23	R_5BWzpKb2fv4mijL			anonymous	EN	2	North Dakota	3	2	4	4	1,2,3
8/25/2023 14:41	8/25/2023 14:43	0	73.5.137.247	76	100	0	9/1/2023 14:43	R_pElt424AxbWXLS9			anonymous	EN							
8/25/2023 18:25	8/25/2023 18:26	0	89.163.216.65	76	20	0	9/1/2023 18:26	R_3PzUMGAnNsIFAjw			anonymous	EN							
8/26/2023 16:28	8/26/2023 16:30	0	98.59.25.246	76	164	0	9/2/2023 16:30	R_2cv0uyHSzuYJnMh			anonymous	EN	3		6	5	5	5	
8/26/2023 21:43	8/26/2023 21:44	0	89.163.216.65	76	32	0	9/2/2023 21:44	R_30wPvka4ndvLy1f			anonymous	EN							
8/27/2023 18:48	8/27/2023 19:01	0	209.243.6.131	76	789	0	9/3/2023 19:01	R_3JJjFmQlBBG7eXN			anonymous	EN	2	ND	4	4	1	1	1,2
9/4/2023 15:08	9/4/2023 15:15	0	172.58.80.226	100	450	1	9/4/2023 15:15	R_3MJvy1IQi5NPBIr	44.9618	-93.2638	anonymous	EN	1	Minnesota	7	4	4	4	1
9/4/2023 17:44	9/4/2023 17:51	0	76.156.132.62	100	383	1	9/4/2023 17:51	R_3qs3GQgVodnNIDE	45.1184	-93.3461	anonymous	EN	3	Minnesota	4	5	5	5	1,2,3
8/28/2023 21:35	8/28/2023 21:35	0	89.163.216.65	76	50	0	9/4/2023 21:36	R_2dxSqL6fe3VEuGa			anonymous	EN							
9/5/2023 10:17	9/5/2023 10:24	0	96.3.208.130	100	473	1	9/5/2023 10:24	R_3PHLaDnYUk2jWex	46.7952	-96.8332	anonymous	EN	2	Minnesota	3	4	5	4	1
9/5/2023 16:35	9/5/2023 17:08	0	24.230.69.210	100	1977	1	9/5/2023 17:08	R_29nRb6VPSetsw5j	46.8393	-100.782	anonymous	EN	1	North Dakota	7	3	2	1	3
9/5/2023 19:46	9/5/2023 19:52	0	140.186.92.200	100	378	1	9/5/2023 19:52	R_1JJdllmvn6MBZqn	46.8796	-96.7814	anonymous	EN	3	Minnesota and North Dak	6	2	4	4	2
9/6/2023 8:28	9/6/2023 8:32	0	174.199.100.110	100	242	1	9/6/2023 8:32	R_RmEE3uOb4T97AVH	44.9856	-93.2655	anonymous	EN	1	Minnesota	2	3	5	3	1
9/6/2023 8:54	9/6/2023 8:59	0	69.42.235.138	100	296	1	9/6/2023 8:59	R_6rNhB5UYbNlPYxX	46.2836	-96.5623	anonymous	EN	1	North Dakota	4	3	4	3	
8/31/2023 8:52	8/31/2023 8:55	0	174.126.59.175	77	153	0	9/7/2023 8:55	R_5A9jH8c3pvYvgU9			anonymous	EN	1	North Dakota		2	2	1	
9/8/2023 8:26	9/8/2023 8:34	0	64.255.151.18	100	455	1	9/8/2023 8:34	R_2SkUnrMjguRtqx0	46.9208	-98.745	anonymous	EN	1	ND	3	3	3	3	2

Table B1. Data from Second Survey (continued)

Q2	Q3	Q4	Q5	Q6	Q7	Q7_4_TEXT	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q14_6_TEXT	Q15	Q15_6_TEXT	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25
North Dakota	6	2	2	1	1		3	4	4	1	4	2	5		5		3	2	4	3						
ND	4	3	2	2	3		2	2	5	2	2	1	5		5		1	1	1	1	4	1	2	5	1	1
North Dakota	4	3	4	4	4	quite honestly very confused by this question and none of the	4	2	4	1	2	3	4,6	Yes, f	5		1	3	2	5						
North Dakota	4	2	1	2	3		1	1	2	3	2	3	5		5		3	3	4	3	5	3	3	3	2	2
Minnesota	5	2	5	3	2,3		4	4	4	2	4	4	5		4		4	4	4	4						
ND	2	4	4	5	2		3	4	4	3	4	3	4,6	upstr	5		3	3	4	3	3	4	5	5	3	5
ND	7	2	1	1	1,2,3		4	5	4	3	5	1	4,6	Our c	5		4	4	5	5						
ND	4	1	3	3	4	JUST TO SMALL, YET	4	2	2	3	4	3	5		5		4	1	4	3						
MN	7	3	4	4	1,2,3		5	5	5	3	5	4	4,6	while	6	our work tasks do not require the team	2	1	4	5	5	5	5	4	5	5
North Dakota	7	3	1	1	3		3	1	1	1	1	1	4		5		1	1	1	3	3	3	1	2	3	2
North Dakota	3	2	4	4	1,2,3		3	2	4	2	2	2	5		5		2	4	2	2						
	6	5	5	5			5	5	5	2	5	5					3	3	5	5						
ND	4	4	1	1	1,2		2	2	2	2	2	1	5		5		2	3	2	3						
Minnesota	7	4	4	4	1		4	3	4	1	3	1	5		5		3	3	2	4	4	2	2	4	3	4
Minnesota	4	5	5	5	1,2,3		4	5	5	3	5	2	4,6	Flexi	5		2	2	5	5	5	4	5	5	4	5
Minnesota	3	4	5	4	1		4	5	5	1	4	1	5,6	We d	6	We do offer summer hours that allow u	1	1	2	5	5	4	4	4	4	4
North Dakota	7	3	2	1	3		4	5	4	3	4	2	4,6	Empl	4,6	We are hourly labor on a 40 hour week.	1	1	5	4	5	4	4	4	5	5
Minnesota and North Dak	6	2	4	4	2		4	5	5	1	5	2	5		5		2	2	4	4	5	4	5	4	4	4
Minnesota	2	3	5	3	1		5	5	5	3	4	5	4,6	Upstr	4		5	5	5	5	5	5	5	5	5	5
North Dakota	4	3	4	3			3	4	5	1	5	2	4		5		1	1	4	4	4	4	4	5	5	4
North Dakota		2	2	1																						
ND	3	3	3	3	2		4	4	4	1	3	2	5		5		3	3	4	4	4	4	4	4	4	4

APPENDIX C. DATA FROM WEB SCRAPING PROJECT

Table C1. Data from Web Scraping Project

	Tokens	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
0	robot	0	0	1	2	0	0	0	9	0	0	0	1	0	0	0	0	0	2	0	11	0	0
1	welders	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	4	0	0
2	robot welders	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	virtual	0	9	2	0	0	0	0	20	0	0	17	1	0	0	2	0	0	0	0	3	0	0
4	reality	0	9	0	0	0	0	0	2	0	0	30	0	1	0	0	0	0	0	0	0	0	0
5	virtual reality	0	9	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	automation	0	0	0	11	2	0	0	2	0	0	2	0	0	0	0	0	0	2	0	10	0	0
7	automated	0	1	5	3	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	2	0	0
8	research	0	2	7	0	0	0	0	23	0	0	6	0	0	0	1	0	0	0	0	1	0	0
9	design	0	1	52	24	41	0	0	348	0	0	558	18	37	18	8	2	0	57	1	7	79	2
10	development	0	0	8	27	4	0	0	70	0	0	3	0	1	0	4	0	0	2	0	2	76	0
11	testing	0	0	10	6	6	0	0	80	0	0	0	13	1	0	6	0	0	7	0	0	159	0
12	digital	0	5	0	0	0	0	0	691	0	1	0	2	0	0	0	0	0	0	0	0	315	0
13	technology	0	22	128	7	15	0	0	1605	0	1	5	3	3	1	2	0	0	0	0	9	0	7
14	ag	0	0	0	0	0	0	0	762	0	0	0	0	2	2	0	0	0	0	0	0	946	0
15	sustainable	0	0	0	0	4	0	0	7	0	1	7	0	0	0	0	0	0	0	0	0	0	0
16	intellectual	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0
17	property	0	0	1	0	0	0	0	57	0	0	1	0	2	0	0	0	0	0	0	5	0	0
18	intellectual property	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0
19	iot	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	industry 4.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	industry 5.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	industry	0	6	22	1	13	0	1	56	0	0	20	5	123	1	7	0	0	12	2	82	88	2
23	team	0	25	1	17	45	0	0	83	0	0	10	65	3	1	14	0	44	4	0	38	0	0
24	learn	12	18	13	0	14	0	0	138	0	0	211	31	20	1	2	0	0	369	0	47	0	0
25	train	1	0	5	12	7	0	1	1099	0	0	70	5	1	1	1	0	3	2	1	17	418	0
26	flexible	0	1	2	1	7	0	0	33	0	0	3	11	1	0	1	0	0	760	1	7	0	0
27	quality	2	7	144	63	11	0	1	107	0	0	64	104	5	4	5	14	1	394	2	34	2	7
28	resources	0	30	35	8	53	0	29	282	0	1	85	26	0	0	3	0	0	270	0	116	0	0
29	smb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	programming	0	0	0	2	1	0	0	14	0	0	0	4	0	0	0	0	0	0	0	0	0	0
31	advance technology	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	compliance	0	0	308	6	2	0	18	8	0	0	1	0	28	0	1	0	0	3	0	7	0	1
33	industrial	0	0	1	1	331	0	0	204	0	0	4	4	6	2	1	2	7	56	1	28	16	2
34	automotive	0	0	0	0	0	0	0	3	0	1	1	0	0	0	1	0	0	17	0	0	0	0
35	recreational	0	0	0	0	1	0	0	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0
36	transportation	2	0	2	1	6	0	0	7	0	0	0	2	0	0	0	0	0	1	0	5	0	0
37	detection	0	11	3	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	cyber	0	4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
39	physical	0	0	0	1	0	0	0	7	0	0	4	2	0	0	2	0	0	1	0	0	0	0
40	cyber physical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	cloud	0	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0
42	computing	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	cloud computing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	big	0	2	1	0	3	0	0	18	0	1	5	0	1	0	0	0	0	3	0	0	1	1
45	data	0	9	158	1	3	0	1	228	0	0	74	3	2	0	16	6	0	180	0	7	0	1

Table C1. Data from Web Scraping Project (continued)

	Tokens	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
0	robot	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1	welders	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	robot welders	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	virtual	0	0	0	0	1	1	0	0	1	0	0	0	1	1	0	0	0	0	0	114	0	0
4	reality	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	16	0	4
5	virtual reality	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
6	automation	0	0	0	0	1	0	0	4	3	0	0	0	0	0	0	0	0	0	1	0	0	5
7	automated	0	1	0	1	0	8	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0
8	research	0	79	0	0	13	3	1	0	40	0	2	0	2	2	0	0	0	0	0	2	0	3
9	design	0	25	0	55	4	41	0	95	48	16	1	1	11	16	0	0	1	10	1	3	0	16
10	development	0	56	0	0	7	2	2	11	59	0	2	0	9	4	0	0	0	0	0	0	1	18
11	testing	0	16	0	0	0	100	2	1	11	0	0	0	1	1	0	0	0	0	0	0	0	2
12	digital	0	0	0	0	0	0	0	0	5	1	4	1	2	0	0	0	0	0	0	4	0	2
13	technology	0	7	0	2	13	238	0	9	34	0	4	0	19	25	1	0	19	0	3	222	0	3
14	ag	0	0	0	1	223	0	0	4	46	0	4	0	0	0	0	0	0	0	0	0	0	1
15	sustainable	0	0	0	0	3	0	0	4	0	0	6	0	21	0	0	0	0	0	1	58	0	4
16	intellectual	0	0	0	0	0	0	0	0	73	0	0	0	1	0	0	0	0	0	0	2	0	4
17	property	0	0	0	0	0	0	0	0	74	0	0	0	3	0	0	0	0	0	0	2	0	8
18	intellectual property	0	0	0	0	0	0	0	0	73	0	0	0	1	0	0	0	0	0	0	2	0	4
19	iot	0	0	0	0	0	0	0	0	6	0	0	0	0	17	0	0	0	0	0	0	0	0
20	industry 4.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	industry 5.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	industry	0	3	0	8	17	2	5	14	7	0	1	1	40	4	2	0	4	4	1	72	0	20
23	team	0	7	0	0	72	4	13	13	21	121	1	1	57	6	2	1	0	6	0	80	0	187
24	learn	0	19	0	0	11	1	6	0	10	0	2	2	53	9	4	2	0	0	3	0	2	106
25	train	0	5	0	0	66	0	0	0	11	0	0	1	12	0	0	0	15	0	0	0	0	19
26	flexible	0	5	0	0	0	1	1	0	11	0	0	0	0	0	0	0	0	0	0	0	0	1
27	quality	0	63	0	13	162	6	43	10	33	5	1	2	30	0	0	0	2	1	0	7	3	146
28	resources	0	26	0	70	9	1	3	0	2	0	1	3	13	1	1	0	1	12	0	0	2	8
29	smb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	programming	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
31	advance technology	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
32	compliance	0	1	0	0	0	0	4	0	1	1	4	0	1	0	1	0	0	0	0	0	0	21
33	industrial	0	1	0	0	65	0	0	0	11	0	0	0	1	20	0	0	3	1	8	1	0	52
34	automotive	0	0	0	0	0	0	0	1	0	0	0	5	0	1	0	0	0	0	0	119	0	0
35	recreational	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
36	transportation	0	0	0	10	0	0	1	0	0	0	0	0	2	1	0	0	0	0	0	0	0	7
37	detection	0	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
38	cyber	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	physical	0	0	0	0	5	1	0	0	1	0	0	0	0	0	0	0	0	0	0	3	0	3
40	cyber physical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	cloud	0	0	0	0	0	4	0	0	8	0	0	0	0	8	19	0	0	0	0	0	0	0
42	computing	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
43	cloud computing	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
44	big	0	2	0	4	0	1	1	0	0	2	1	0	29	0	0	0	0	0	0	10	0	3
45	data	0	0	2	2	21	13	7	0	212	5	1	0	22	3	1	0	5	0	0	3	0	1

Table C1. Data from Web Scraping Project (continued)

	Tokens	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66
0	robot	14	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1	welders	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
2	robot welders	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	virtual	0	5	1	1	0	0	0	0	34	0	0	0	0	0	0	0	1	0	0	0	0	0
4	reality	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	10	0	1	0	0
5	virtual reality	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	automation	0	0	0	0	0	0	0	0	0	0	0	0	76	0	0	0	0	0	0	0	0	0
7	automated	0	0	0	0	0	0	0	0	0	1	0	0	6	1	0	0	0	0	0	0	0	4
8	research	10	0	0	0	0	0	0	127	0	0	1	0	0	0	0	0	0	0	0	0	0	0
9	design	46	11	14	4	57	0	49	5	1	280	1	37	187	3	14	9	53	7	2	0	6	2
10	development	6	1	0	0	0	0	0	192	0	1	2	0	5	0	0	0	0	0	1	0	0	0
11	testing	0	0	0	0	0	0	0	1	0	2	0	0	3	0	0	0	0	0	0	0	0	2
12	digital	0	0	1	0	0	0	0	0	1	1	0	0	3	0	0	0	2	0	0	0	0	0
13	technology	11	6	1	0	0	0	1	3	15	10	1	1	10	0	0	0	4	1	1	0	0	98
14	ag	0	35	0	0	0	0	0	0	0	0	0	0	0	3	0	52	0	0	0	0	0	0
15	sustainable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
16	intellectual	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
17	property	0	0	0	0	141	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
18	intellectual property	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
19	iot	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	industry 4.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	industry 5.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	industry	6	4	7	0	0	0	1	45	66	4	2	33	33	3	3	0	27	0	10	1	1	10
23	team	17	4	16	9	6	0	44	21	5	27	4	12	4	1	5	2	5	2	1	0	0	0
24	learn	3	3	2	1	8	0	13	109	67	18	0	42	52	0	0	0	14	3	1	2	0	52
25	train	32	0	0	0	3	0	0	1	0	180	2	43	10	0	0	1	9	0	0	0	2	124
26	flexible	2	1	1	0	1	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	4
27	quality	8	1	3	4	7	0	1	28	9	78	12	33	13	0	4	15	45	0	0	2	1	20
28	resources	7	3	0	9	3	0	0	112	0	1	0	0	0	0	0	98	0	1	0	0	0	3
29	smb	0	0	0	0	0	0	0	0	31	0	0	0	0	0	0	0	0	0	0	0	0	0
30	programming	0	0	0	0	0	0	0	0	0	0	0	0	140	0	0	0	0	0	0	0	0	0
31	advance technology	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	compliance	0	0	0	0	1	0	0	117	0	0	2	0	2	0	0	0	0	0	0	0	0	1
33	industrial	2	0	0	0	0	0	0	0	0	0	0	22	2	5	0	4	0	7	0	0	0	0
34	automotive	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	recreational	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	transportation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2
37	detection	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0
38	cyber	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	physical	0	0	0	0	0	0	0	1	0	4	0	0	3	0	0	10	0	1	0	0	0	0
40	cyber physical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	cloud	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
42	computing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	cloud computing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	big	0	26	1	1	1	0	2	0	0	6	0	1	2	1	3	0	0	1	0	4	0	0
45	data	4	1	9	0	0	0	0	1	0	6	0	0	254	0	0	0	1	2	0	0	0	37

Table C1. Data from Web Scraping Project (continued)

	Tokens	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88
0	robot	0	0	0	0	0	0	0	0	0	1	0	0	0	25	0	0	4	0	0	0	0	0
1	welders	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	2	0
2	robot welders	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	virtual	0	0	0	1	3	0	10	0	2	0	0	0	0	0	0	0	43	0	0	1	0	0
4	reality	0	0	0	0	0	2	0	0	0	0	0	2	1	0	0	1	9	0	0	0	9	0
5	virtual reality	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	automation	0	0	0	0	0	0	0	0	0	0	0	1	0	124	0	0	3	0	0	0	0	0
7	automated	0	0	0	0	1	0	2	0	0	0	0	0	0	4	0	0	10	0	0	0	0	0
8	research	0	0	0	0	2	0	2	6	0	0	0	1	0	0	0	0	5	49	0	1	0	0
9	design	0	17	0	13	1169	6	113	1	66	1	2	1	11	81	2	5	90	0	2	21	86	6
10	development	0	0	3	2	2	0	5	3	0	0	0	1	6	3	0	0	113	1	0	0	1	1
11	testing	0	0	0	1	9	0	0	4	0	0	0	0	3	1	0	0	11	5	0	0	0	0
12	digital	0	0	0	0	1702	1	62	0	0	0	0	0	1	0	0	0	112	0	0	0	1	1
13	technology	0	2	0	0	17	0	188	1	2	0	1	1	1	38	1	0	56	0	0	0	16	10
14	ag	0	0	0	33	0	0	0	2	0	0	0	0	0	0	0	0	36	0	0	0	8	0
15	sustainable	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0	56	0	0	0	0	2
16	intellectual	0	0	0	0	2	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	property	0	0	0	0	2	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	intellectual property	0	0	0	0	2	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	iot	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	industry 4.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	industry 5.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	industry	0	10	0	2	25	8	57	4	4	2	2	4	4	1	1	0	118	3	2	1	25	22
23	team	0	1	0	0	55	114	1	11	1	0	9	18	10	1	3	4	8	2	0	4	82	13
24	learn	0	0	1	1	541	2	8	5	0	0	4	0	10	0	3	2	24	54	0	3	57	18
25	train	0	0	0	0	5	1	1	1	0	0	1	3	2	3	0	1	40	1	0	0	0	56
26	flexible	0	0	0	0	11	0	11	1	0	0	0	0	1	0	0	0	34	0	0	1	0	6
27	quality	0	2	3	5	146	14	23	21	9	3	4	1	11	2	5	4	192	22	3	0	68	1
28	resources	0	1	0	0	16	107	1	0	0	0	4	3	2	0	1	0	3	0	0	0	1	44
29	smb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	programming	0	0	0	0	0	0	0	0	0	0	0	0	0	43	0	0	0	0	0	0	0	0
31	advance technology	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	compliance	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	87	0	0	0	0	3
33	industrial	0	2	6	1	5	115	0	0	110	1	0	0	2	3	0	1	1	0	0	2	2	0
34	automotive	0	0	0	0	0	0	4	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0
35	recreational	0	0	0	0	0	101	0	0	2	0	0	0	1	0	0	0	0	0	0	0	4	0
36	transportation	0	8	0	2	0	4	1	0	5	0	0	0	2	0	0	0	3	0	0	0	36	20
37	detection	0	0	0	0	3	0	0	1	0	0	0	0	0	3	0	0	6	0	0	0	0	0
38	cyber	0	0	0	0	67	23	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
39	physical	0	0	0	0	4	1	0	0	0	0	0	0	1	0	0	2	0	7	0	1	0	1
40	cyber physical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	cloud	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	92	0	0	0	0	2
42	computing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	cloud computing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	big	0	0	0	2	14	3	0	0	0	0	0	0	0	0	0	0	0	2	0	1	1	34
45	data	0	0	0	0	15	6	175	0	0	0	0	0	5	32	0	0	94	1	0	0	7	0

Table C1. Data from Web Scraping Project (continued)

	Tokens	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110
0	robot	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	welders	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	robot welders	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	virtual	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	25	0	73	0	0	0
4	reality	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0
5	virtual reality	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	automation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	automated	0	0	7	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
8	research	0	0	0	79	0	0	0	0	1	0	3	0	0	0	1	0	2	0	0	0	100	0
9	design	62	2	2	14	143	0	0	2	35	0	6	3	20	2	1	11	104	33	6	0	106	2
10	development	0	0	0	77	0	0	0	0	1	3	0	1	0	0	1	2	3	3	1	0	104	1
11	testing	0	0	0	6	13	0	0	0	0	0	25	0	0	0	0	1	0	2	0	0	0	0
12	digital	0	0	0	0	12	0	0	0	0	0	0	0	3	0	0	0	100	45	0	0	98	0
13	technology	1	0	1	31	0	0	0	0	0	55	0	22	2	0	0	3	0	3	1	0	2	0
14	ag	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0
15	sustainable	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	59	0	2	4
16	intellectual	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	property	0	4	0	0	1	2	0	1	0	0	2	0	0	0	0	1	3	0	1	0	0	0
18	intellectual property	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	iot	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	industry 4.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	industry 5.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	industry	0	0	5	36	7	1	0	4	40	8	1	6	10	0	0	8	7	1	6	0	10	10
23	team	0	0	6	106	14	26	0	1	2	2	0	37	21	0	2	70	66	7	55	0	2	10
24	learn	0	0	0	4	6	19	0	1	0	0	1	10	27	0	3	9	7	6	13	0	4	3
25	train	2	0	0	4	0	2	0	0	0	0	0	1	0	0	0	3	1	0	1	0	0	3
26	flexible	0	0	0	0	1	0	0	1	0	0	7	0	0	0	0	3	1	0	5	0	0	0
27	quality	1	0	13	24	36	8	0	7	23	4	3	35	11	0	0	3	50	0	67	1	4	411
28	resources	0	0	0	56	108	1	0	21	1	1	0	2	0	0	0	5	210	0	82	0	24	1
29	smb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	programming	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
31	advance technology	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	compliance	0	0	0	1	0	1	0	1	1	0	0	6	4	0	0	1	4	0	1	0	1	190
33	industrial	199	0	2	0	0	0	0	1	1	0	0	8	28	0	0	2	2	0	0	0	1	240
34	automotive	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	recreational	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
36	transportation	0	0	1	0	0	0	0	1	0	0	4	1	1	0	0	0	0	0	0	0	0	1
37	detection	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1
38	cyber	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	physical	0	1	0	0	1	0	0	1	0	0	4	0	0	0	0	0	1	0	0	0	0	0
40	cyber physical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	cloud	0	0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	13	0
42	computing	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	cloud computing	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	big	0	0	0	0	1	2	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
45	data	0	0	1	8	0	0	0	0	0	8	3	1	0	0	5	1	3	12	5	0	0	5

Table C1. Data from Web Scraping Project (continued)

	Tokens	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132
0	robot	101	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
1	welders	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0
2	robot welders	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	virtual	2	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	2	0
4	reality	0	1	0	0	1	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	virtual reality	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	automation	297	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	6	0	0	0	0	0
7	automated	3	0	1	0	0	0	0	2	0	0	0	0	1	0	1	0	0	0	0	1	0	0
8	research	0	0	0	0	8	0	0	11	2	0	0	0	2	0	1	0	3	0	0	0	1	0
9	design	300	0	13	46	55	26	0	35	26	0	1	0	6	30	17	5	40	0	0	21	0	0
10	development	26	2	0	1	7	0	0	3	2	0	0	0	0	0	2	0	0	0	0	0	0	0
11	testing	55	0	0	2	3	5	0	1	6	0	1	0	0	0	26	0	8	0	0	0	0	0
12	digital	0	0	19	0	1	0	0	18	1	0	0	0	3	0	0	0	0	0	0	0	0	0
13	technology	9	0	12	3	4	5	0	25	1	0	8	0	61	1	3	0	9	0	0	0	1	0
14	ag	0	0	0	1	251	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0
15	sustainable	0	0	0	0	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
16	intellectual	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	property	0	0	0	1	2	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
18	intellectual property	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	iot	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	industry 4.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	industry 5.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	industry	20	0	2	7	18	4	0	18	2	0	0	0	27	5	3	2	2	0	0	0	23	0
23	team	115	114	7	64	40	4	18	44	2	0	4	0	20	11	2	25	1	0	0	1	32	0
24	learn	41	21	0	3	45	0	0	8	2	0	0	0	24	15	0	5	0	0	0	17	9	0
25	train	167	0	1	0	2	0	3	3	22	0	4	0	27	0	1	3	1	0	0	0	4	0
26	flexible	7	0	1	0	28	0	0	3	2	0	0	0	0	1	0	0	0	0	0	0	0	0
27	quality	17	7	14	6	289	2	3	7	11	80	75	0	91	15	7	5	37	0	0	0	22	0
28	resources	2	0	3	112	37	1	0	1	1	0	0	0	7	1	1	0	0	0	0	0	1	0
29	smb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	programming	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	3	0	0	0
31	advance technology	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	compliance	107	1	0	0	0	6	0	4	1	0	0	0	0	0	0	0	4	0	0	0	0	0
33	industrial	5	0	1	1	5	0	1	1	0	0	0	0	1	0	5	1	0	0	0	55	1	0
34	automotive	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
35	recreational	0	0	0	0	0	0	0	0	150	0	0	0	0	0	0	0	4	0	0	0	0	0
36	transportation	0	0	0	1	1	4	0	0	0	0	0	0	0	0	0	1	0	0	0	1	33	0
37	detection	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	cyber	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	physical	0	0	0	0	0	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	cyber physical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	cloud	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	computing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	cloud computing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	big	0	0	1	1	0	0	0	0	5	0	0	0	1	0	0	3	0	0	0	0	0	0
45	data	2	0	2	0	34	0	0	1	1	0	7	0	66	0	1	0	0	0	0	0	3	0

Table C1. Data from Web Scraping Project (continued)

	Tokens	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	Total Tokens Available
0	robot	0	0	0	0	0	0	0	0	0	0	0	3	0	9	0	0	0	190
1	welders	0	0	0	0	0	0	0	0	2	0	0	13	0	4	0	0	4	50
2	robot welders	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	virtual	26	0	3	0	0	0	0	0	0	0	0	8	3	0	0	0	0	426
4	reality	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	122
5	virtual reality	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
6	automation	0	0	0	9	0	0	0	0	0	0	0	0	0	2	0	7	0	573
7	automated	0	0	0	1	0	0	0	0	0	0	0	3	0	5	0	0	0	104
8	research	2	0	0	1	0	0	0	0	2	0	0	10	4	0	0	0	0	624
9	design	64	0	148	14	4488	56	0	1	23	14	0	528	38	1	1	10	36	10675
10	development	5	0	0	2	0	3	0	0	3	2	0	40	4	0	0	0	0	1016
11	testing	0	0	0	3	0	0	4	0	3	0	0	9	0	2	0	0	1	640
12	digital	0	0	0	0	0	2	0	0	2	0	0	0	0	0	57	2	0	3284
13	technology	8	0	1	1	0	1	1	0	4	0	0	18	14	1	2	2	3	3223
14	ag	0	0	3	0	0	0	0	0	6	0	0	19	0	0	0	0	0	2448
15	sustainable	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	9	0	264
16	intellectual	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	97
17	property	0	0	0	0	0	0	0	0	3	0	0	4	0	0	0	0	0	338
18	intellectual property	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	97
19	iot	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24
20	industry 4.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table C1. Data from Web Scraping Project (continued)

	Tokens	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	Total Tokens Available
21	industry 5.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	industry	20	0	146	4	0	10	3	1	16	1	0	53	7	0	1	1	5	1758
23	team	60	0	150	17	3	28	1	15	28	9	44	567	12	1	11	2	12	3355
24	learn	51	0	180	2	0	2	10	0	27	5	0	252	7	0	2	12	2	3084
25	train	1	0	9	8	3	1	1	0	11	3	3	124	4	1	0	0	1	2720
26	flexible	0	0	0	1	0	0	0	0	1	1	0	1	0	1	0	0	0	989
27	quality	26	0	166	14	15	37	6	1	11	1	1	134	5	13	3	4	4	4151
28	resources	27	0	195	31	0	3	3	0	4	0	0	2285	0	1	25	20	0	4784
29	smb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31
30	programming	0	0	59	5	0	0	0	0	0	0	0	0	0	4	0	0	0	279
31	advance technology	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
32	compliance	1	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	2	974
33	industrial	0	0	0	4	0	2	1	2	1	0	7	283	1	0	0	0	32	2016
34	automotive	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	159
35	recreational	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	278
36	transportation	0	0	1	0	1115	0	0	0	34	0	0	32	0	0	0	0	0	1363
37	detection	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	45
38	cyber	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	97
39	physical	2	0	4	0	0	0	4	0	6	0	0	5	1	0	0	0	0	101
40	cyber physical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	cloud	0	0	0	1	625	0	0	0	0	0	0	0	0	0	0	0	0	792
42	computing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
43	cloud computing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
44	big	0	0	59	0	0	0	0	0	1	0	0	121	0	2	0	0	0	394
45	data	72	0	2	7	0	0	0	0	2	5	0	2	0	2	0	3	5	1906

Table C1. Data from Web Scraping Project (continued)

	Tokens	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
46	big data	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	artificial	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	intelligenc	0	0	1	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	artificial ii	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	5g	0	6	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	15	0	0	5	0
51	3d	0	1	0	2	1	0	0	10	0	0	79	0	0	1	0	0	0	2691	0	0	2	0
52	3d printin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	305	0	0	0	0
53	printing	0	0	4	1	0	0	0	0	0	0	0	0	0	0	0	1	0	329	0	0	0	0
54	4d	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1156	0	0	0	0
55	4d printin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	twin	0	0	0	0	0	0	0	50	0	0	3	0	0	0	0	0	0	7	0	0	15	0
57	digital twi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	wearable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59	devices	0	1	2	0	2	0	0	2	0	0	5	11	0	0	0	9	0	0	0	0	1	0
60	wearable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	ai	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	5	0
62	communi	0	0	196	2	1	0	0	14	0	0	0	1	0	0	0	0	0	0	0	1	0	3
	Total Tokens Available :	17	184	1112	199	573	0	51	6108	0	9	1269	312	237	33	77	34	55	6645	8	449	2128	26

Table C1. Data from Web Scraping Project (continued)

	Tokens	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
46	big data	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
47	artificial	0	0	0	0	0	0	0	2	11	0	0	0	1	0	0	0	0	0	0	0	0	0
48	intelligenc	0	0	0	0	0	0	0	1	11	0	0	0	2	2	0	0	0	0	0	0	0	0
49	artificial ii	0	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0
50	5g	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
51	3d	0	0	0	0	0	0	0	6	1	0	0	0	0	0	0	0	0	0	0	2	0	2
52	3d printin	0	0	0	0	0	0	0	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0
53	printing	0	0	0	0	0	0	0	9	1	6	0	0	0	0	0	0	0	0	0	1	0	2
54	4d	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	4d printin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	twin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	digital twi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	wearable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	2
59	devices	0	0	0	0	0	0	0	0	33	0	1	0	2	0	0	0	0	0	0	110	0	0
60	wearable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	ai	0	0	0	0	0	0	0	1	6	0	1	0	0	0	0	0	0	0	0	0	0	0
62	communi	0	3	0	0	0	0	0	1	63	1	0	0	17	1	0	0	0	0	0	3	0	8
	Total Tokens Available :	0	323	2	166	694	428	89	211	950	158	37	17	355	122	31	4	50	34	18	849	8	663

Table C1. Data from Web Scraping Project (continued)

	Tokens	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66
46	big data	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	artificial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	intelligence	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	artificial intelligence	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	5g	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	5	0	0	0	0	0	0
51	3d	0	0	0	0	122	0	0	0	1	0	0	0	2	0	0	1	0	123	0	0	0	0
52	3d printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51	0	0	0	0
53	printing	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	73	0	0	0	0
54	4d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	4d printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	twin	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	2	0	0
57	digital twin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	wearable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
59	devices	2	0	0	0	0	0	0	0	3	5	0	0	4	0	0	0	0	0	0	0	0	1
60	wearable devices	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	ai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62	communication	1	0	0	0	0	0	1	1	0	2	0	0	1	0	0	0	2	0	0	0	0	2
	Total Tokens Available:	171	101	70	29	352	0	112	766	245	628	27	224	819	17	30	198	165	282	17	13	10	374

Table C1. Data from Web Scraping Project (continued)

	Tokens	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88
46	big data	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
47	artificial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
48	intelligence	0	0	0	0	0	0	124	0	0	0	0	0	0	0	0	0	55	0	0	0	0	0
49	artificial intelligence	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
50	5g	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	3d	0	13	0	0	5	0	0	0	1	0	0	0	0	0	0	3	3	0	1	0	0	0
52	3d printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	printing	0	0	0	0	153	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	4d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	4d printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	twin	0	0	0	0	452	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	digital twin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	wearable	0	0	0	0	432	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
59	devices	0	0	0	0	8	0	34	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
60	wearable devices	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	ai	0	1	0	0	18	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
62	communication	0	2	0	0	5	1	0	0	0	0	0	1	0	0	3	1	2	1	0	0	3	6
	Total Tokens Available:	0	67	13	63	4892	534	825	62	204	9	27	37	75	364	19	27	1318	148	10	36	409	246

Table C1. Data from Web Scraping Project (continued)

	Tokens	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110
46	big data	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	artificial	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	intelligence	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	artificial intelligence	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	5g	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	3d	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0	0
52	3d printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	printing	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	6	0	75	0	0	0
54	4d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0
55	4d printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	twin	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0
57	digital twin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	wearable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59	devices	0	0	0	4	0	0	0	1	0	0	0	0	1	0	4	0	0	0	0	0	0	0
60	wearable devices	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	ai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
62	communication	0	0	0	1	0	0	0	0	0	0	1	1	0	0	8	0	3	1	0	0	0	0
	Total Tokens Available:	265	7	44	459	352	62	0	43	116	81	60	134	137	4	25	124	600	115	465	2	474	883

Table C1. Data from Web Scraping Project (continued)

	Tokens	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132
46	big data	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	artificial	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	intelligence	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
49	artificial intelligence	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	5g	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	3d	9	0	2	0	4	0	0	191	1	0	0	0	2	0	0	0	0	0	0	0	0	0
52	3d printing	0	0	0	0	0	0	0	126	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	printing	0	0	0	0	0	0	0	143	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	4d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	4d printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	twin	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
57	digital twin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	wearable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59	devices	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
60	wearable devices	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	ai	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
62	communication	2	0	5	0	0	0	0	3	0	0	0	0	1	0	0	0	1	0	0	0	3	0
	Total Tokens Available:	1287	146	88	253	840	63	25	656	240	80	106	0	347	80	75	60	118	0	3	97	135	0

Table C1. Data from Web Scraping Project (continued)

	Tokens	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149		Total Tokens Available
46	big data	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		2
47	artificial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		22
48	intelligence	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		207
49	artificial intelligence	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		19
50	5g	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		59
51	3d	1	0	0	0	0	42	0	0	0	0	0	0	6	0	2	0	2		3341
52	3d printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		488
53	printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0		831
54	4d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		1167
55	4d printing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
56	twin	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0		550
57	digital twin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
58	wearable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		444
59	devices	1	0	1	0	0	0	0	0	0	0	0	2	0	0	1	0	0		255
60	wearable devices	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
61	ai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		37
62	communication	1	0	1	3	0	0	1	0	0	1	0	6	2	0	0	0	0		395
	Total Tokens Available:	368	0	1128	128	6249	187	35	20	193	42	55	4535	109	49	106	80	109		

APPENDIX D. SURVEY RESULTS OF ARCHITECTURE, ENGINEERING, AND CONSTRUCTION INDUSTRIES

Table D1. First Survey for Architecture, Engineering, and Construction industries – All Business Sizes - Pearson Correlation Coefficient

Table of Q21 by Q12				
Q21(How likely is your organization to observe increased productivity per employee due to the implementation organizational design?)	**Q12(How likely is your organization to align the organizational design with Industry 4.0 integration?)**			
Frequency Row Pct	**3**	**4**	**5**	**Total**
1	0 0.00	0 0.00	1 100.00	1
2	4 80.00	1 20.00	0 0.00	5
4	1 100.00	0 0.00	0 0.00	1
5	0 0.00	1 50.00	1 50.00	2
Total	5	2	2	9

Table D2. First Survey - Polychoric Coefficient of Industry 4.0 Integration (Q12) Relationship with Increased Productivity (Q21)

Statistic	Value	ASE
Gamma	0.1579	0.5373
Kendall's Tau-b	0.1225	0.4151
Stuart's Tau-c	0.1111	0.3741
Somers' D C|R	0.1250	0.4225
Somers' D R|C	0.1200	0.4082
Pearson Correlation	0.2273	0.3857
Spearman Correlation	0.1218	0.4712
Polychoric Correlation	0.0753	0.4319
Lambda Asymmetric C|R	0.2500	0.3750
Lambda Asymmetric R|C	0.5000	0.2500
Lambda Symmetric	0.3750	0.2989
Uncertainty Coefficient C|R	0.4900	0.0756
Uncertainty Coefficient R|C	0.5658	0.1328
Uncertainty Coefficient Symmetric	0.5252	0.0895

Table D3. First Survey - Architecture, Engineering, and Construction by Business Size

Table of Q3 by Q12				
Q3(How likely is your organization to gather relevant data from appropriate sources to assist in predicting solutions for integrating digital technology?)	**Q12(How likely is your organization to align the organizational design with Industry 4.0 integration?)**			
Frequency Row Pct	**3**	**4**	**5**	**Total**
2	1 100.00	0 0.00	0 0.00	1
4	4 80.00	1 20.00	0 0.00	5
5	0 0.00	1 33.33	2 66.67	3
Total	5	2	2	9

Table D4. First Survey – Polychoric Coefficient for Architecture, Engineering and Construction Industries for Q3 and Q12 Relationship

Statistic	Value	ASE
Gamma	1.0000	0.0000
Kendall's Tau-b	0.7661	0.0845
Stuart's Tau-c	0.6667	0.1386
Somers' D C|R	0.7826	0.1282
Somers' D R|C	0.7500	0.1122
Pearson Correlation	0.6740	0.0757
Spearman Correlation	0.8248	0.0961
Polychoric Correlation	0.9999	0.0000
Lambda Asymmetric C|R	0.5000	0.2500
Lambda Asymmetric R|C	0.5000	0.2500
Lambda Symmetric	0.5000	0.2339
Uncertainty Coefficient C|R	0.5074	0.1228
Uncertainty Coefficient R|C	0.5389	0.1239
Uncertainty Coefficient Symmetric	0.5226	0.1081

Table D5. Relationship of Q3 and Q21 for the Architecture, Engineering, and Construction Industries

Table of Q3 by Q21					
Q3(How likely is your organization to gather relevant data from appropriate sources to assist in predicting solutions for integrating digital technology?)	**Q21(How likely is your organization to observe increased productivity per employee due to the implementation organizational design?)**				
Frequency Row Pct	**1**	**2**	**4**	**5**	**Total**
2	0 0.00	1 100.00	0 0.00	0 0.00	1
4	0 0.00	4 80.00	1 20.00	0 0.00	5
5	1 33.33	0 0.00	0 0.00	2 66.67	3
Total	1	5	1	2	9

Table D6. Polychoric Coefficient for the relationship of Q3 and Q21 for Architecture, Engineering, and Construction Industries

Statistic	Value	ASE
Gamma	0.3684	0.5176
Kendall's Tau-b	0.2919	0.4139
Stuart's Tau-c	0.2593	0.3671
Somers' D C|R	0.3043	0.4284
Somers' D R|C	0.2800	0.4029
Pearson Correlation	0.3839	0.2505
Spearman Correlation	0.3077	0.4545
Polychoric Correlation	0.3448	0.3762
Lambda Asymmetric C|R	0.5000	0.2500
Lambda Asymmetric R|C	0.7500	0.2165
Lambda Symmetric	0.6250	0.1754
Uncertainty Coefficient C|R	0.5734	0.0783
Uncertainty Coefficient R|C	0.7033	0.1339
Uncertainty Coefficient Symmetric	0.6317	0.0609

Table D7. Second Survey - Architecture, Engineering, and Construction

Table of Q14n by Q5						
Q14n(Are flexible working hours applied in activities upstream or downstream of the production system?)	**Q5(How likely is your organization to follow an operational process that includes these steps: data gathering, ...)**					
Frequency Row Pct	**1**	**2**	**3**	**4**	**5**	**Total**
No	1 25.00	0 0.00	1 25.00	1 25.00	1 25.00	4
Yes	1 14.29	2 28.57	2 28.57	1 14.29	1 14.29	7
Total	2	2	3	2	2	11

Table D8. Pearson and Polychoric Coefficients for Second Survey – Architecture, Engineering, and Construction

Statistic	**Value**	**ASE**
Gamma	-0.2174	0.4499
Kendall's Tau-b	-0.1364	0.2840
Stuart's Tau-c	-0.1653	0.3450
Somers' D C|R	-0.1786	0.3715
Somers' D R|C	-0.1042	0.2175
Pearson Correlation	-0.1402	0.3150
Spearman Correlation	-0.1522	0.3169
Polychoric Correlation	-0.1622	0.3983
Lambda Asymmetric C|R	0.0000	0.3062
Lambda Asymmetric R|C	0.0000	0.3536
Lambda Symmetric	0.0000	0.2635
Uncertainty Coefficient C|R	0.0651	0.0499
Uncertainty Coefficient R|C	0.1584	0.1177
Uncertainty Coefficient Symmetric	0.0923	0.0699

Table D9. Second Survey – Architecture, Engineering, and Construction

Table of Q14n by Q21					
Q14n(Are flexible working hours applied in activities upstream or downstream of the production system?)	**Q21(How likely is your organization defined as engaging in responsible autonomy with employees and teams to achieve specific goals?)**				
Frequency Row Pct	**2**	**3**	**4**	**5**	**Total**
No	1 25.00	1 25.00	2 50.00	0 0.00	4
Yes	0 0.00	1 14.29	4 57.14	2 28.57	7
Total	1	2	6	2	11

Table D10. Second Survey – Architecture, Engineering, and Construction Q14 by Q21

Statistic	Value	ASE
Gamma	0.7895	0.2411
Kendall's Tau-b	0.4599	0.1935
Stuart's Tau-c	0.4959	0.2433
Somers' D C|R	0.5357	0.2464
Somers' D R|C	0.3947	0.1629
Pearson Correlation	0.5155	0.1945
Spearman Correlation	0.4914	0.2120
Polychoric Correlation	0.7163	0.2538
Lambda Asymmetric C|R	0.0000	0.0000
Lambda Asymmetric R|C	0.2500	0.2165
Lambda Symmetric	0.1111	0.0940
Uncertainty Coefficient C|R	0.1560	0.0701
Uncertainty Coefficient R|C	0.2781	0.1506
Uncertainty Coefficient Symmetric	0.1999	0.0951

Table D11. Second Survey – Architecture, Engineering, and Construction – The Relationship of Q14 by Q24

Table of Q14n by Q24				
Q14n(Are flexible working hours applied in activities upstream or downstream of the production system?)	**Q24(How likely would your organization be defined as being organizationally flexible?)**			
Frequency Row Pct	**3**	**4**	**5**	**Total**
No	3 75.00	1 25.00	0 0.00	4
Yes	1 14.29	4 57.14	2 28.57	7
Total	4	5	2	11

Table D12. Pearson and Polychoric Coefficients for Second Survey – The Relationship of Q14 and Q24 - Architecture, Engineering, and Construction

Statistic	Value	ASE
Gamma	0.9048	0.1361
Kendall's Tau-b	0.5825	0.1841
Stuart's Tau-c	0.6281	0.2260
Somers' D C|R	0.6786	0.2148
Somers' D R|C	0.5000	0.1736
Pearson Correlation	0.6000	0.1820
Spearman Correlation	0.6125	0.1949
Polychoric Correlation	0.8315	0.1966
Lambda Asymmetric C|R	0.3333	0.2722
Lambda Asymmetric R|C	0.5000	0.3536
Lambda Symmetric	0.4000	0.2926
Uncertainty Coefficient C|R	0.2157	0.1445
Uncertainty Coefficient R|C	0.3410	0.2281
Uncertainty Coefficient Symmetric	0.2643	0.1756

APPENDIX E. SURVEY RESULTS OF BUSINESS, FINANCIAL, SALES, AND LOGISTICS INDUSTRIES

Table E1. First Survey – The Relationship between Digital Technology Integration (Q3) and Industry 4.0 Integration (Q12) - Business, Financial, Sales, Logistics

Table of Q3 by Q12						
Q3(How likely is your organization to gather relevant data from appropriate sources to assist in predicting solutions for integrating digital technology?)	**Q12(How likely is your organization to align the organizational design with Industry 4.0 integration?)**					
Frequency Row Pct	**1**	**2**	**3**	**4**	**5**	Total
1	0 0.00	0 0.00	1 100.00	0 0.00	0 0.00	1
2	1 25.00	1 25.00	1 25.00	1 25.00	0 0.00	4
3	0 0.00	1 50.00	1 50.00	0 0.00	0 0.00	2
4	3 37.50	1 12.50	2 25.00	2 25.00	0 0.00	8
5	0 0.00	0 0.00	3 60.00	0 0.00	2 40.00	5
Total	4	3	8	3	2	20

Table E2. First Survey – The Relationship between Digital Technology Integration (Q3) and Industry 4.0 Integration (Q12) - Business, Financial, Sales, Logistics

Statistic	Value	ASE
Gamma	0.3097	0.2071
Kendall's Tau-b	0.2381	0.1623
Stuart's Tau-c	0.2188	0.1512
Somers' D C|R	0.2414	0.1677
Somers' D R|C	0.2349	0.1580
Pearson Correlation	0.2552	0.1821
Spearman Correlation	0.3006	0.1917
Polychoric Correlation	0.3625	0.2223
Lambda Asymmetric C|R	0.0833	0.2111
Lambda Asymmetric R|C	0.2500	0.2165
Lambda Symmetric	0.1667	0.1816
Uncertainty Coefficient C|R	0.2988	0.0690
Uncertainty Coefficient R|C	0.3142	0.0801
Uncertainty Coefficient Symmetric	0.3063	0.0718

Table E3. First Survey - The Relationship between Industry 4.0 Integration (Q12) and Increased Productivity (Q21) - Business, Financial, Sales, Logistics

Table of Q12 by Q21						
Q12(How likely is your organization to align the organizational design with Industry 4.0 integration?)	**Q21(How likely is your organization to observe increased productivity per employee due to the implementation organizational design?)**					
Frequency Row Pct	**1**	**2**	**3**	**4**	**5**	**Total**
1	0 0.00	1 25.00	2 50.00	1 25.00	0 0.00	4
2	0 0.00	1 33.33	2 66.67	0 0.00	0 0.00	3
3	0 0.00	5 62.50	0 0.00	2 25.00	1 12.50	8
4	0 0.00	1 33.33	1 33.33	1 33.33	0 0.00	3
5	1 50.00	0 0.00	1 50.00	0 0.00	0 0.00	2
Total	1	8	6	4	1	20

Table E4. Second Survey – The Relationship between Q14n and Q5 – Business, Financial, Sales, Logistics

Table of Q14n by Q5						
Q14n(Are flexible working hours applied in activities upstream or downstream of the production system?)	**Q5(How likely is your organization to follow an operational process that includes these steps: data gathering, ...)**					
Frequency Row Pct	**1**	**2**	**3**	**4**	**5**	**Total**
No	0 0.00	0 0.00	0 0.00	1 50.00	1 50.00	2
Yes	2 28.57	1 14.29	1 14.29	2 28.57	1 14.29	7
Total	2	1	1	3	2	9

Table E5. Second Survey – The Relationship between Q15n and Q5 – Business, Financial, Sales, Logistics

Table of Q15n by Q5						
Q15n(Are the hourly labor requirements and productivity goals achievable with a reduced hourly work week schedule when considering organizational factors?)	**Q5(How likely is your organization to follow an operational process that includes these steps: data gathering, ...)**					
Frequency Row Pct	**1**	**2**	**3**	**4**	**5**	**Total**
No	1 16.67	0 0.00	1 16.67	2 33.33	2 33.33	6
Yes	1 33.33	1 33.33	0 0.00	1 33.33	0 0.00	3
Total	2	1	1	3	2	9

Table E6. Second Survey – The Pearson and Polychoric Coefficients for the Relationship between Q15n and Q5 – Business, Financial, Sales, Logistics

Statistic	Value	ASE
Gamma	-0.6000	0.3331
Kendall's Tau-b	-0.3810	0.2392
Stuart's Tau-c	-0.4444	0.2963
Somers' D C|R	-0.5000	0.3118
Somers' D R|C	-0.2903	0.1899
Pearson Correlation	-0.4264	0.2861
Spearman Correlation	-0.4215	0.2656
Polychoric Correlation	-0.5715	0.3448
Lambda Asymmetric C|R	0.0000	0.2357
Lambda Asymmetric R|C	0.3333	0.4714
Lambda Symmetric	0.1111	0.2783
Uncertainty Coefficient C|R	0.1775	0.0723
Uncertainty Coefficient R|C	0.4247	0.1793
Uncertainty Coefficient Symmetric	0.2503	0.1010

APPENDIX F. SURVEY RESULTS OF COMPUTER AND INFORMATION TECHNOLOGY INDUSTRY

Table F1. First Survey – The Relationship between Digital Technology Integration (Q3) and Industry 4.0 Integration (Q12) – Computer and Information Technology

Table of Q3 by Q12					
Q3(How likely is your organization to gather relevant data from appropriate sources to assist in predicting solutions for integrating digital technology?)	**Q12(How likely is your organization to align the organizational design with Industry 4.0 integration?)**				
Frequency Row Pct	**2**	**3**	**4**	**5**	**Total**
2	1 100.00	0 0.00	0 0.00	0 0.00	1
4	1 33.33	1 33.33	1 33.33	0 0.00	3
5	0 0.00	2 33.33	1 16.67	3 50.00	6
Total	2	3	2	3	10

Table F2. First Survey – Pearson and Polychoric Coefficients for Digital Technology Integration (Q3) and Industry 4.0 (Q12) – Computer and Information Technology

Statistic	Value	ASE
Gamma	0.8261	0.1876
Kendall's Tau-b	0.6011	0.1693
Stuart's Tau-c	0.5700	0.1981
Somers' D C|R	0.7037	0.1789
Somers' D R|C	0.5135	0.1716
Pearson Correlation	0.6467	0.1278
Spearman Correlation	0.6619	0.1865
Polychoric Correlation	0.8485	0.1487
Lambda Asymmetric C|R	0.2857	0.3415
Lambda Asymmetric R|C	0.2500	0.3750
Lambda Symmetric	0.2727	0.3063
Uncertainty Coefficient C|R	0.3146	0.1027
Uncertainty Coefficient R|C	0.4786	0.1069
Uncertainty Coefficient Symmetric	0.3796	0.1052

Table F3. First Survey – The Relationship of Industry 4.0 Integration (Q12) and Increased Productivity (Q21) - Computer and Information Technology

Table of Q12 by Q21						
Q12(How likely is your organization to align the organizational design with Industry 4.0 integration?)	**Q21(How likely is your organization to observe increased productivity per employee due to the implementation organizational design?)**					
Frequency Row Pct	**1**	**2**	**3**	**4**	**5**	**Total**
2	0 0.00	1 50.00	0 0.00	1 50.00	0 0.00	2
3	1 33.33	1 33.33	1 33.33	0 0.00	0 0.00	3
4	0 0.00	1 50.00	0 0.00	1 50.00	0 0.00	2
5	2 66.67	0 0.00	0 0.00	0 0.00	1 33.33	3
Total	3	3	1	2	1	10

Table F4. First Survey – Pearson and Polychoric Coefficients of the Relationship of Industry 4.0 Integration (Q12) and Increased Productivity (Q21) – Computer and Information Technology Industry

Statistic	Value	ASE
Gamma	-0.1613	0.4004
Kendall's Tau-b	-0.1333	0.3311
Stuart's Tau-c	-0.1333	0.3288
Somers' D C|R	-0.1351	0.3333
Somers' D R|C	-0.1316	0.3290
Pearson Correlation	-0.0660	0.3566
Spearman Correlation	-0.1608	0.3771
Polychoric Correlation	-0.1713	0.3558
Lambda Asymmetric C|R	0.2857	0.2415
Lambda Asymmetric R|C	0.4286	0.2857
Lambda Symmetric	0.3571	0.2421
Uncertainty Coefficient C|R	0.4698	0.0523
Uncertainty Coefficient R|C	0.5175	0.0895
Uncertainty Coefficient Symmetric	0.4925	0.0657

Table F5. First Survey – Relationship of Gathering Data (Q3) and Increased Productivity (Q21) – Computer and Information Technology Industry

Table of Q3 by Q21						
Q3(How likely is your organization to gather relevant data from appropriate sources to assist in predicting solutions for integrating digital technology?)	**Q21(How likely is your organization to observe increased productivity per employee due to the implementation organizational design?)**					
Frequency Row Pct	**1**	**2**	**3**	**4**	**5**	**Total**
2	0 0.00	1 100.00	0 0.00	0 0.00	0 0.00	1
4	1 33.33	0 0.00	0 0.00	2 66.67	0 0.00	3
5	2 33.33	2 33.33	1 16.67	0 0.00	1 16.67	6
Total	3	3	1	2	1	10

Table F6. First Survey – Pearson and Polychoric Coefficient for the Relationship of Q3 and Q21 – Computer and Information Technology Industry

Statistic	**Value**	**ASE**
Gamma	-0.1304	0.3390
Kendall's Tau-b	-0.0937	0.2447
Stuart's Tau-c	-0.0900	0.2332
Somers' D C|R	-0.1111	0.2911
Somers' D R|C	-0.0789	0.2061
Pearson Correlation	0.0000	0.2070
Spearman Correlation	-0.1141	0.2882
Polychoric Correlation	-0.0725	0.3998
Lambda Asymmetric C|R	0.2857	0.2415
Lambda Asymmetric R|C	0.5000	0.2500
Lambda Symmetric	0.3636	0.2171
Uncertainty Coefficient C|R	0.3429	0.0964
Uncertainty Coefficient R|C	0.5747	0.1178
Uncertainty Coefficient Symmetric	0.4295	0.0980

Table F7. Second Survey – Relationship of Q14n and Q5 - Computer and Information Technology

Table of Q14n by Q5				
Q14n(Are flexible working hours applied in activities upstream or downstream of the production system?)	**Q5(How likely is your organization to follow an operational process that includes these steps: data gathering, ...)**			
Frequency Row Pct	**2**	**3**	**5**	**Total**
No	0 0.00	1 100.00	0 0.00	1
Yes	1 25.00	0 0.00	3 75.00	4
Total	1	1	3	5

Table F8. Second Survey – Pearson and Polychoric Coefficients - Computer and Information Technology

Statistic	Value	ASE
Gamma	0.5000	0.4330
Kendall's Tau-b	0.3780	0.3849
Stuart's Tau-c	0.3200	0.3505
Somers' D C|R	0.5000	0.4330
Somers' D R|C	0.2857	0.3463
Pearson Correlation	0.3953	0.3081
Spearman Correlation	0.3953	0.3977
Polychoric Correlation	0.4810	0.6243
Lambda Asymmetric C|R	0.5000	0.3536
Lambda Asymmetric R|C	1.0000	0.0000
Lambda Symmetric	0.6667	0.3143
Uncertainty Coefficient C|R	0.5266	0.2080
Uncertainty Coefficient R|C	1.0000	0.0000
Uncertainty Coefficient Symmetric	0.6899	0.1785

Table F9. Second Survey – The Relationship between Q15 and Q5 - Computer and Information Technology

Table of Q15n by Q5				
Q15n(Are the hourly labor requirements and productivity goals achievable with a reduced hourly work week schedule when considering organizational factors?)	**Q5(How likely is your organization to follow an operational process that includes these steps: data gathering, ...)**			
Frequency Row Pct	**2**	**3**	**5**	**Total**
No	1 33.33	1 33.33	1 33.33	3
Yes	0 0.00	0 0.00	2 100.00	2
Total	1	1	3	5

Table F10. Second Survey – The Relationship between Q15 and Q5 - Computer and Information Technology

Statistic	Value	ASE
Gamma	1.0000	0.0000
Kendall's Tau-b	0.6172	0.2167
Stuart's Tau-c	0.6400	0.2862
Somers' D C|R	0.6667	0.2722
Somers' D R|C	0.5714	0.2449
Pearson Correlation	0.6455	0.2377
Spearman Correlation	0.6455	0.2301
Polychoric Correlation	0.9994	0.0000
Lambda Asymmetric C|R	0.0000	0.7071
Lambda Asymmetric R|C	0.5000	0.6124
Lambda Symmetric	0.2500	0.5995
Uncertainty Coefficient C|R	0.3063	0.1889
Uncertainty Coefficient R|C	0.4325	0.2737
Uncertainty Coefficient Symmetric	0.3587	0.2146

Table F11. Second Survey – The Relationship between Q15 and Q13 - Computer and Information Technology

Table of Q15n by Q13					
Q15n(Are the hourly labor requirements and productivity goals achievable with a reduced hourly work week schedule when considering organizational factors?)	**Q13(How likely will establishing a reduced daily work hour goal serve as a way to jointly optimize the technical and human factors of your organization to achieve higher productivity and employee wellbeing?)**				
Frequency Row Pct	**1**	**2**	**4**	**5**	**Total**
No	1 33.33	1 33.33	1 33.33	0 0.00	3
Yes	0 0.00	0 0.00	1 50.00	1 50.00	2
Total	1	1	2	1	5

Table F12. Second Survey - Pearson and Polychoric Coefficients - Computer and Information Technology

Statistic	Value	ASE
Gamma	1.0000	0.0000
Kendall's Tau-b	0.6804	0.1266
Stuart's Tau-c	0.8000	0.2263
Somers' D C|R	0.8333	0.1800
Somers' D R|C	0.5556	0.1247
Pearson Correlation	0.7222	0.1861
Spearman Correlation	0.7404	0.1477
Polychoric Correlation	0.9974	0.0000
Lambda Asymmetric C|R	0.0000	0.4714
Lambda Asymmetric R|C	0.5000	0.6124
Lambda Symmetric	0.2000	0.4767
Uncertainty Coefficient C|R	0.2971	0.0953
Uncertainty Coefficient R|C	0.5880	0.2231
Uncertainty Coefficient Symmetric	0.3947	0.1302