



“Hellenic Open University”
“Supply Chain Management (SCM)”

Postgraduate Dissertation
“Implementing Digitalization within Corporate Supply Chains”

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Athens, Greece, 7-2024

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Table of Contents

Table of Contents	3
Abstract	5
1 Introduction	7
1.1 Overview of the Significance of Digitalization in Supply Chains	7
1.2 Statement of the Research Objectives	10
1.3 Scope of the Study	11
1.4 Methodology Overview	13
1.5 Outline of the Dissertation Structure	13
2 Methodology	15
2.1 Description of the Research Design and Methodology	15
2.2 Literature Review Approach and Criteria for Selecting Sources	15
2.3 Data Collection and Analysis	16
2.4 Justification of the Chosen Research Methods	17
3 Literature Review	19
3.1 Review of Relevant Literature on Digital Transformation in Supply Chains	19
3.2 Examination of Theories and Frameworks Related to Digitalization	20
3.3 Analysis of Previous Research on Digital Technology Adoption	21
3.4 Identification of Research Gaps and Areas for Further Exploration	21
3.5 Case Studies of Successful Digitalization of Supply Chains	23
3.5.1 Case Study 1: Amazon's Digital Transformation in Supply	23
3.5.2 Case Study 2: Zara's Agile Supply Chain Digitalization	25
4 Theoretical Framework	28
4.1 Development of a Conceptual Framework Based on Literature Review Findings	28
4.2 Identification of Factors Influencing Implementation of Digitalization	29
4.3 Theoretical Foundations for Analyzing Digital Technologies	30
4.3.1 Technology Acceptance Model (TAM)	31
4.3.2 Diffusion of Innovations (DOI) Theory	33
4.3.3 Resource-Based View (RBV)	36
4.3.4 Supply Chain Operations Reference (SCOR) Model	38
4.4 A comprehensive digitalization “checklist” for supply chains	42
4.4.1 Initial Preparation	42
4.4.2 What is important to avoid or be careful not to underestimate	43
4.4.3 What is important to avoid or be careful not to underestimate	44
4.4.4 Roll-Out and Go-Live Phase	44
4.4.5 What is important to avoid or be careful not to underestimate	45
4.5 The McKinsey Digital Supply Chain Compass	45
4.5.1 Planning	46
4.5.2 Physical flow	47
4.5.3 Performance management	47
4.5.4 Order management	48
4.5.5 Collaboration	48
4.5.6 Supply chain strategy	49
4.5.7 Digital supply chain	49
5 Key Digital Technologies in Supply Chains	50

5.1	Overview of Key Digital Technologies Used in Supply Chains.....	50
5.2	Detailed Analysis of Each Technology	50
5.2.1	Internet of Things (IoT) Devices	50
5.2.2	Artificial Intelligence (AI) and Machine Learning.....	51
5.2.3	Data Analytics.....	52
6	Analysis and Conclusions	57
6.1	Synthesis of Findings from the Literature Review and Case Studies	57
6.1.1	IoT Devices	58
6.1.2	Artificial Intelligence and Machine Learning.....	58
6.1.3	Data Analytics.....	59
6.2	Discussion of Trends, Challenges, and Best Practices	59
6.2.1	Trends.....	59
6.2.2	Challenges	59
6.2.3	Best Practices	60
6.3	Comparison of Findings with Existing Theories and Frameworks.....	60
6.4	Implications for Theory and Practice.....	60
6.4.1	Theoretical Implications.....	60
6.4.2	Practical Implications	61
6.5	Critical Analysis of Factors Influencing Successful Digital Transformation	63
7	References.....	65

Abstract

This dissertation explores the strategic planning and implementation of digitalization within corporate supply chains. In today's dynamic business environment, digital transformation of supply chains is no longer a luxury but a necessity for companies aiming to stay competitive. The main purpose is to address the transformative impact of digital technologies on supply chain operations across various industries. The study investigates in the following pages how digitalization can enhance efficiency, reduce costs and improve customer satisfaction, providing companies with a competitive edge.

In the research key digital technologies will be identified such as the Internet of Things (IoT), artificial intelligence (AI) and machine learning, and data analytics examining their application and integration within supply chain processes. By assessing the current state of digital adoption in supply chains, the dissertation will try to highlight areas where digitalization can offer significant improvement. Also, will identify challenges that companies face during this transformation.

One of the primary research questions is to focus on identifying main digital technologies being adopted, obstacles encountered during the digitalization process and finally the organizational factors that influence successful implementation. In exploring these areas, an attempt is made to provide insights regarding technology adoption process, integration challenges for a successful digital transformation. Additionally, the study will examine the effects of digitalization on supply chain performance metrics including cost, efficiency and customer satisfaction. An interesting case can even be made about potential disadvantages, particularly around concerns regarding data privacy and significant financial investments that are sometimes required. It's essential to approach digitalization with a balanced perspective, recognizing both its transformative power and its inherent risks.

The methodology that is employed is literature review-based, synthesizing existing research case studies and industry reports to provide an adequate overview of digital transformation in supply chains. In the dissertation a theoretical framework will also be presented developed from the literature review findings in which critical factors that influence digitalization success will be identified. A point of view analyzed is how companies can overcome barriers such as resistance to change, the acknowledgement of the necessity to

invest in new technologies. Also, during implementation process, the importance of pilot testing, change management strategies and continues improvement will be explored as factors that ensure success regarding digital initiatives.

A significant factor regarding the success of digitalization projects is learning from case studies (analyzed to illustrate best practices and lessons learned) of companies that have successfully implemented digital technologies in their supply chains. Examples like these provide practical recommendations for other organizations seeking to embark on their digital transformation journey. Case studies highlight the importance of a strategic approach involving clear objectives, comprehensive integration planning and effective stakeholder communication.

The findings of this dissertation contribute to the existing body of knowledge concerning Supply Chain Management by offering practical recommendations for companies looking to implement digitalization. This research underscores the significance of staying up-to-date on emerging technologies and industry trends to maintain competitiveness and drive innovation in supply chain operations.

In conclusion emphasis is given to the transformative potential of digital technologies in enhancing supply chain performance. The ambition is for a roadmap to be provided for companies to navigate through the complexities of digitalization so that it will be ensured that they can effectively leverage technology for optimizing their supply chain processes. This study also attempts to identify areas for future research, suggesting further investigation into specific beneficial technologies and their long-term impact on supply chain management. By addressing these aspects this dissertation aims to guide companies in their pursuit of digital excellence. Thus, fostering a more efficient and competitive supply chain ecosystem.

Keywords

Digitalization, Supply Chain Management, Technology Adoption, Organizational Change, Integration Challenges, Performance Metrics

1 Introduction

1.1 Overview of the Significance of Digitalization in Supply Chains

In modern business landscape, digitalization has emerged as a pivotal force driving the evolution of supply chains. The significance of digitalization in supply chains is crucial as it fundamentally transforms how goods and services are produced, distributed and delivered to end consumers. Integration of digital technologies into supply chain operations is not just an option but a strategic imperative for companies striving not only to maintain their competitive edge but eventually surviving.

Digitalization enhances the visibility and transparency of supply chain processes. Modern technologies such as the Internet of Things (IoT) enable real-time tracking of goods or resources providing stakeholders with real-time information on stock levels, shipment statuses or even environmental conditions. This level of visibility is crucial for minimizing disruptions, optimizing inventory management and ensuring timely delivery of products. In my view the ability to monitor and respond to supply chain activities in real-time is a game-changer and for the first in human history time lag from the actual time of an event to the time of acknowledging it is minimized. Information timely delivered means more accurate decisions and responses, thus leading to efficiency and cost effectiveness. Allowing companies to be more agile and responsive to market demands or disruptions.

Digitalization also significantly improves the efficiency and accuracy of supply chain operations. Automation tools and advanced (predictive) analytics reduce the reliance on manual processes or decision processes thus minimizing errors and accelerating workflows. For instance, blockchain technology ensures secure and immutable transaction records promoting trust and collaboration among supply chain partners. As the technology evolves, in years to come and by leveraging artificial intelligence (AI) and machine learning even in more processes and functions, companies can make data-driven decisions that (among others) enhance forecasting accuracy, optimize routing or scheduling and predict maintenance needs. I believe that over the imminent future, the true power of these technologies will unfold as their ability to turn vast amounts of data into actionable insights

enabling “smarter” and faster decision-making will alter the way supply chain networks operate.

Relevant research backs up the opinion. *“The integration of big data analytics into supply chain management represents a significant shift in how businesses operate, offering the potential to transform traditional supply chain processes. By leveraging advanced analytical techniques, companies can derive actionable insights from large datasets, enabling more informed and timely decision-making. These insights facilitate predictive analytics, which improves demand forecasting, inventory management, and risk mitigation. As a result, supply chains become more responsive and resilient, capable of adapting swiftly to market fluctuations and disruptions. The strategic use of big data analytics is poised to redefine supply chain management, driving efficiencies and creating competitive advantages for organizations that harness its potential”*

Source: Wamba, S. F., Akter, S., Edwards, A., Chopin, G., & Gnanzou, D. (2020). How ‘big data’ can make big impact: Findings from a systematic review and a longitudinal case study. *International Journal of Production Economics*, 165, 234-246. <https://doi.org/10.1016/j.ijpe.2017.02.016>

Another serious aspect of digitalization is its impact on cost reduction. By streamlining processes and improving operational efficiency digital technologies contribute in reducing labor costs, minimizing waste and transportation expenses. One example is cloud computing that offers scalable and flexible data storage solutions and as a consequence eliminating the need for significant investments in IT infrastructure regarding on premises installations. This can be referred even as a kind of “democratization of technology” that allows even the small or medium-sized enterprises (SMEs) to participate and secure the benefits of digitalization without sustaining prohibitive costs.

As it is referred in various research, *“Small and medium-sized enterprises (SMEs) have historically faced significant barriers to adopting advanced technologies due to high costs and resource constraints. However, the advent of cloud computing and software-as-a-service (SaaS) models has democratized access to cutting-edge technology, allowing SMEs to compete more effectively in the global marketplace. Cloud computing enables SMEs to leverage scalable and flexible IT resources without the need for substantial capital investment in physical infrastructure.”*

Source : Marston, S., Li, Z., Bandyopadhyay, S., Zhang, J., & Ghalsasi, A. (2011). Cloud computing—The business perspective. *Decision Support Systems*, 51(1), 176-189. <https://doi.org/10.1016/j.dss.2010.12.006>

Furthermore, digitalization enhances customer satisfaction by allowing to provide more personalized and responsive services. Advanced data analytics and market segmentation tools allow companies to understand customer preferences and anticipate their needs leading to tailored or customized products and improved service levels. Real-time order tracking and faster delivery times contribute to a greater customer experience. From my point of view the customer-centric benefits of digitalization are perhaps the most evident and compelling as they directly influence a company's market position.

However, it is important to acknowledge that digitalization also presents certain challenges. Data privacy and security concerns are of a top priority regarding criticism as the increased flow of digital information creates potential vulnerabilities. Companies must invest in robust cybersecurity measures to protect sensitive data and maintain customer trust. Sometimes a methodology not so evident or clear, as it includes the need of a high level of knowledge and expertise and also often a high CAPEX / OPEX both the initial costs of implementing digital technologies and the need for ongoing maintenance and upgrades. Organizations must carefully weigh these costs against the potential benefits and develop strategies to mitigate associated risks. A task often being omitted.

As various researchers state: “As organizations increasingly adopt digital technologies to enhance supply chain operations, they must address significant data privacy and security challenges. The proliferation of connected devices and the extensive flow of digital information heighten the risk of data breaches and cyber-attacks. Ensuring data integrity and protecting sensitive information require robust cybersecurity measures and regulatory compliance. Despite the operational benefits of digitalization, these security concerns present substantial obstacles. Effective strategies for mitigating these risks include implementing advanced encryption methods, continuous monitoring for vulnerabilities, and fostering a culture of cybersecurity awareness within organizations”

Source: Kshetri, N. (2018). 1 Blockchain's roles in meeting key supply chain management objectives. *International Journal of Information Management*, 39, 80-89. <https://doi.org/10.1016/j.ijinfomgt.2017.12.005>

In conclusion the significance of digitalization in supply chains is multilayered, including enhanced visibility, improved efficiency, cost reduction and customer satisfaction, probably all aspects SCM. While there are challenges to consider the transformative potential of digital technologies makes them indispensable for modern supply chain management. Embracing digitalization is about shaping the future of supply chains to be more resilient and agile. As we move forward successful integration of digital technologies will undoubtedly define the leaders in the global supply chain arena.

1.2 Statement of the Research Objectives

Rapid advancement of digital technologies present both opportunities and challenges for supply chain management. Businesses strive to integrate technologies and encounter numerous obstacles that can delay or even suspend successful implementation. The main research problem analyzed in this dissertation is the identification and analysis of challenges as well as strategies that companies can employ within their supply chains.

Despite potential benefits of digitalization, among others efficiency, cost savings and ultimately customer satisfaction, many companies struggle with practical aspects of adoption. Challenges may differ from technological issues (for example integration with existing systems) to organizational issues (like resistance to change and others). Additional concerns exist regarding data privacy and security which are also significant risks that must be mitigated.

The primary objectives of this research are as follows:

1. **Identify Key Digital Technologies:** To describe critical digital technologies being adopted in supply chains. Examine their specific implementation processes.
2. **Explore Challenges and Barriers:** Investigate primary challenges and barriers encountered during the digitalization process. Analyze how companies are overcoming these obstacles.

3. **Analyze Organizational Factors:** Examine organizational factors that may influence the successful implementation of digital technologies.
4. **Assess Impact on Performance Metrics:** Evaluate effects of digitalization on supply chain performance metrics.

The research is driven by several key questions that refer to the main objectives above. For example, it is to be decided what are the essential digital technologies that are being integrated into supply chains. What is the current status and how are they implemented? Not only the decision but also the challenge and barriers faced during implementation process, sufficient strategies and reforming organizationally are questions and factors that need to be addressed and analyzed. And after the whole process, what are the benefits, is it possible to project results in supply chain metrics like cost or efficiency?

Taking into account the big picture, it is my perspective that advanced technologies and organizational dynamics interplay between them in a crucial way. While technology provides the tools it is the people within the organization who drive and sustain change. Thus, the human element is essential for achieving sustainable digital transformation. In summary the research hopefully among others offers practical insights and strategic recommendations for companies initiating their digital transformation effort.

1.3 Scope of the Study

The scope of this study is through examination of digital transformation of supply chains to propose an approach that provide insights across various industry sectors including manufacturing, retail, logistics. The research aims to provide a comprehensive understanding of how digital technologies may be implemented. This paper uses a narrative literature approach, founded on the main elements of Industry 4.0 and the supply chain. Also, literature regarding Digital Supply Chain (DSC).

The dissertation is bibliographical, based on existing studies and literature in order to extract helpful conclusions and typical processes and best practices regarding supply chain digitalization. Of course, it is not possible to cover the whole bibliography through a

dissertation, so particular abstracts or more imported parts of current literature or academic references are selected.

This dissertation will specifically further investigate the following key digital technologies, the Internet of Things (IoT), artificial intelligence (AI) and machine learning and data analytics. The selection of these technologies is based on their potential to revolutionize supply chain operations. And also, to pinpoint the importance of digitization through specific examples. And at the same time going through the process of implementing and comforting the challenges and facing the benefits or consequences.

The study is structured to cover both technological and organizational aspects of digital transformation. Technological aspects include capabilities, integration processes and performance impacts. Organizational aspects refer to leadership roles, cultural readiness, change management practices and the overall strategic alignment necessary for successful digitalization.

The geographical focus of the study includes global supply chains with specific case studies drawn from North America and Europe. This perspective allows for the exploration of regional differences in the adoption and implementation of digital technologies. In that way a richer understanding of the global landscape is provided.

Moreover, the research considers the size and scale of companies including both large enterprises and small and medium-sized enterprises (SMEs). By comparing how different types of organizations approach digital transformation. The study aims to highlight best practices and recommendations for varied organizational contexts.

Another essential component of this study, as mentioned earlier, is the exploration of the interplay between technology and human factor being a critical intersection regarding success of digital transformation. That is based not only on the availability of advanced technologies but also on the readiness and willingness of people within the organization to embrace and implement change. This aspect includes examining and analyzing skills, requirements and training for employees to effectively utilize new technologies and the leadership strategies needed to cultivate a culture of innovation.

1.4 Methodology Overview

The methodology for the writing of the dissertation in order to address these questions and analyze the objectives, is based on a literature review methodology, supported by case studies and industry reports. This approach involves synthesizing existing research, case studies, industry reports, and academic literature to explore the topic in depth. By this method an effort is made to ensure a firm analysis that takes into account current trends and best practices regarding digital transformation of supply chains.

References of relevant literature or research are grouped at the end of the document but also in various parts that is needed, citations and quotes of selected text is appended in order to facilitate the reading or explaining of the current analysis each time needed.

The criteria for selecting sources include relevance to the research questions, credibility and the time of the publications. Peer-reviewed journal articles, industry white papers and case studies from reputable organizations will be prioritized. The analysis involves categorizing the findings from the literature into key themes and drawing insights that address the research objectives.

1.5 Outline of the Dissertation Structure

The dissertation is structured into 6 chapters, each focusing on different aspects of the research topic:

Chapter 1: Introduction This chapter provides an overview of the significance of digitalization in supply chains, the research objectives, the scope of the study, methodology overview and an outline of the dissertation structure.

Chapter 2: Methodology This chapter describes the research design and methodology, explains the literature review approach and criteria for selecting sources, details methods for data collection and analysis, and justifies the chosen research methods.

Chapter 3: Literature Review This chapter reviews relevant literature on digital transformation in supply chains, examines key concepts, theories, and frameworks related to digitalization, analyzes previous research or case studies on digital technology adoption in supply chains, and identifies research gaps and areas for further exploration.

Chapter 4: Conceptual Framework This chapter develops a conceptual framework based on literature review findings, identifies factors influencing the implementation of digitalization in supply chains, and establishes the theoretical foundations for analyzing digital technologies in supply chains and the methodology to analyze and assess the process and the results of digitalization. Also refers to industry best practices regarding implementation process or assessment.

Chapter 5: Key Digital Technologies in Supply Chains This chapter provides an overview of key digital technologies used in supply chains and offers a comprehensive analysis of each technology, including IoT devices, blockchain technology, AI and machine learning, cloud computing, and data analytics. The technology that are referred to, are examined through an analysis of the main purpose and benefits derived from each technology.

Chapter 6: Analysis and Conclusions This chapter synthesizes findings from the literature review and case studies, discusses trends, challenges, and best practices in digitalization implementation in supply chains, compares findings with existing theories and frameworks, and provides implications for theory and practice. It also summarizes key findings and their implications for supply chain management, reflects on the limitations of the study, suggests areas for future research and offers practical recommendations.

In conclusion, this dissertation aims to provide a useful analysis of the strategies and challenges involved in the digitalization of supply chains. By synthesizing existing research and case studies, the study seeks to offer practical recommendations for companies looking to leverage digital technologies to enhance their supply chain operations.

2 Methodology

2.1 Description of the Research Design and Methodology

This chapter details the research design and methodology employed in the writing of the dissertation. The study adopts a qualitative research design which is particularly suitable for exploring complex and multifaceted phenomena such as the integration of digital technologies in supply chain management.

The research methodology is structured around a multi-phase process.

Literature Review: Conducting extensive literature review to gather relevant information from academic articles, industry reports, and case studies. This phase involves identifying key themes, trends and gaps in the existing research.

Data Analysis: Analyzing the collected data to synthesize findings, identify patterns and draw conclusions. This phase includes coding the data, categorizing it into themes and interpreting the results in the context of the research questions.

Validation: Comparing the synthesized findings with existing theories and frameworks to validate the conclusions.

2.2 Literature Review Approach and Criteria for Selecting Sources

The literature review serves as the foundation of research providing a comprehensive understanding of digital transformation in supply chains. The approach involves systematically searching, selecting and analyzing relevant sources to ensure a detailed examination of the topic.

Search Strategy: The search strategy includes using academic databases such as Google Scholar, JSTOR, and IEEE Xplore as well as industry databases and reports from consulting firms and supply chain organizations. Keywords such as "digital transformation", "supply chain digitalization", "Internet of Things", "artificial intelligence", "machine learning" etc. are used to identify relevant literature.

Selection Criteria

1. **Relevance:** sources directly related to digital transformation in supply chains are included. This ensures that the literature review remains focused to the research questions.
2. **Credibility:** Peer-reviewed academic articles, reputable industry reports and well-documented case studies are prioritized. This criterion ensures the reliability and validity of the information included.
3. **Recency:** Recent publications are preferred to ensure the inclusion of the latest trends and advancements in digital technologies and supply chain management.

Process

1. **Identification:** Initial identification of potential sources based on the search strategy and selection criteria.
2. **Screening:** Screening of abstracts and executive summaries to determine the relevance and credibility of the sources.
3. **Full-Text Review:** Detailed review of selected sources to extract relevant information and insights.
4. **Thematic Analysis:** Coding and categorizing the information into key themes and trends to facilitate synthesis and interpretation.

2.3 Data Collection and Analysis

The data collection process involves gathering qualitative data from the selected literature sources, which include academic articles, industry reports, and case studies. The process is designed to ensure a comprehensive and systematic collection of relevant information.

1. **Academic Articles:** Journal articles were reviewed to understand theoretical frameworks, empirical studies, and case analyses related to digital transformation in supply chains. These articles provide insights into academic perspective on digitalization including its benefits, challenges and impact on supply chain performance.
2. **Industry Reports:** Reports from consulting firms, industry associations and supply chain organizations were analyzed to gain practical insights into how digital technologies are being implemented in real-world supply chains. These reports often

include case studies, best practices and statistical data that complement academic findings.

3. **Case Studies:** Detailed case studies of companies that have successfully implemented digital technologies in their supply chains were reviewed. These case studies provided in-depth examples of digital transformation.

Data Analysis Methods:

1. **Coding and Categorization:** The qualitative data from the literature sources are coded and categorized into themes. This involves identifying key concepts, patterns and relationships within the data.
2. **Thematic Analysis:** The categorized data undergo thematic analysis to identify recurring themes and trends. This method helps in understanding common factors influencing digital transformation and their impact on supply chain performance.
3. **Synthesis and Interpretation:** The findings from the thematic analysis are synthesized to create a coherent narrative that addresses the research questions. This involves interpreting the data in the context of the conceptual framework and drawing conclusions based on the evidence from the literature.

2.4 Justification of the Chosen Research Methods

The qualitative research design and methodology adopted for this dissertation are justified for several reasons:

1. **Exploratory Nature:** Given the exploratory nature of the research questions, a qualitative approach is appropriate for gaining a deep understanding of the complex dynamics involved in digital transformation within supply chains.
2. **Rich Data:** The qualitative data from academic articles, industry reports and case studies provide detailed information that is essential for understanding the multifaceted nature of digital transformation. This data allows for a comprehensive analysis of the factors influencing digitalization and its impact on supply chain performance.
3. **Contextual Understanding:** The case studies included in the literature review provide real-world examples of digital transformation offering practical insights that complement the theoretical findings. This contextual understanding is crucial for

developing practical recommendations for companies seeking to implement digital technologies in their supply chains.

4. **Flexibility:** The qualitative approach allows for flexibility in data collection and analysis, enabling the researcher to adapt the methodology as new insights emerge. This is particularly important in a rapidly evolving field like digital transformation, where new technologies and trends are constantly emerging.
5. **Holistic Perspective:** The use of multiple sources of data (academic articles, industry reports and case studies) provides a holistic perspective on digital transformation. This combination of data enhances the validity and reliability of the findings, ensuring that the conclusions drawn are well-supported by evidence from diverse sources.

3 Literature Review

3.1 Review of Relevant Literature on Digital Transformation in Supply Chains

Digital transformation in supply chains has been extensively studied over the past decade and has garnered significant attention in both academic and industry circles. The literature reveals a growing consensus on the transformative potential of digital technologies such as the Internet of Things (IoT), artificial intelligence (AI) etc. These technologies are not only enhancing operational efficiencies but also driving strategic shifts in supply chain management fundamentally changing how businesses operate and deliver value to customers.

A comprehensive review of relevant literature highlights several key themes. First the integration of digital technologies into supply chains leads to improved visibility and traceability. IoT devices for example, enable real-time tracking of goods which enhances inventory management and reduces losses due to theft or damage (Ashton, 2009). Second, digitalization supports better decision-making through advanced analytics. AI and machine learning models provide predictive insights that help companies optimize their operations and anticipate market changes (Choi, Wallace, & Wang, 2021). Digitalization enables companies to respond more quickly to market changes, manage risks more effectively, and optimize their supply chain processes. Blockchain technology is transforming supply chain transparency and security by providing a decentralized and immutable record of transactions. This ensures the authenticity and traceability of products, particularly in industries where compliance and safety are paramount (Kshetri, 2018). Lastly, cloud computing offers scalable solutions for data storage and processing enabling seamless collaboration and data sharing across supply chain networks (Marston et al., 2011).

3.2 Examination of Theories and Frameworks Related to Digitalization

The theoretical foundations of digital transformation in supply chains are grounded in several key concepts and frameworks that help explain the adoption and impact of digital technologies. One of the primary frameworks is the Technology Acceptance Model (TAM), which suggests that perceived usefulness and perceived ease of use are critical factors influencing the adoption of new technologies (Davis, 1989). This model helps explain how and why certain digital technologies are adopted within supply chains.

The Diffusion of Innovations (DOI) theory by Rogers (2003) provides another valuable perspective. This theory outlines how innovations are adopted within a social system over time, highlighting factors such as relative advantage, compatibility, complexity, trialability etc. In the context of supply chains these factors also determine the rate and extent of digital technology adoption. The Resource-Based View (RBV) theory suggests that a firm's competitive advantage is derived from its ability to manage and deploy its resources effectively. That also includes digital technologies (Barney, 1991). This theory underscores the importance of having the right capabilities and infrastructure to support digital transformation initiatives.

Furthermore, the Supply Chain Operations Reference (SCOR) model developed by the Supply Chain Council provides a comprehensive framework for evaluating and improving supply chain performance. "The SCOR model integrates business processes, performance metrics, best practices, and technology into a unified structure. This model enables organizations to assess and enhance their supply chain operations comprehensively. By providing a standardized approach to supply chain management, the SCOR model helps companies identify inefficiencies, benchmark against industry standards, and implement process improvements. The widespread adoption of the SCOR model across various industries highlights its effectiveness in driving supply chain excellence."

Source: Stephens, S. (2001). Supply Chain Operations Reference Model Version 5.0: A New Tool to Improve Supply Chain Efficiency and Achieve Best Practice. *Information Systems Frontiers*, 3(4), 471-476. <https://doi.org/10.1023/A:1012881014690>

3.3 Analysis of Previous Research on Digital Technology Adoption

Previous research on digital technology adoption in supply chains reveals common trends and insights. A notable trend is the increasing use of big data analytics for data-driven decision-making. Companies leveraging big data analytics can gain deeper insights into their operations leading to more informed decisions and better outcomes (Wamba et al., 2020). For example, predictive analytics powered by AI can improve demand forecasting, reduce lead times and enhance operational efficiency.

AI and machine learning are increasingly adopted for predictive analytics and automation of decision-making processes. These technologies enable companies to predict demand patterns, optimize inventory levels and automate routine tasks, leading to cost savings and improved service levels (Choi, Wallace, & Wang, 2021).

Another significant trend is the adoption of IoT devices for real-time monitoring and automation of supply chain processes. IoT technologies enable continuous tracking of goods, providing real-time visibility into inventory levels, shipment status and environmental conditions. This capability is particularly beneficial for industries such as pharmaceuticals and food where compliance and safety are critical (Ashton, 2009).

3.4 Identification of Research Gaps and Areas for Further Exploration

While the existing literature and the extensive research on digital transformation in supply chains provides a robust foundation for understanding the specific topic, several research gaps remain. One notable gap is the lack of longitudinal studies examining the long-term impact of digital technologies on supply chain performance. In longitudinal studies, researchers collect data from the same subjects at multiple time points allowing them to track changes and developments over time. This approach is particularly useful for identifying trends, examining the long-term effects of variables and understanding how certain factors evolve. Most studies in hand provide a snapshot of the benefits and challenges at a specific point in time but there is a need for research that tracks the evolution of digital transformation efforts over an extended period. The latter can provide insights into how

digitalization impacts supply chain performance, organizational practices, and market dynamics over time.

"Despite the growing interest in digital technologies and their potential to revolutionize supply chain management, there is a noticeable scarcity of longitudinal studies that examine the long-term impacts of these technologies. Most existing research focuses on short-term benefits and immediate outcomes, providing limited insights into how digital technologies influence supply chain performance over extended periods."

Source: Wang, Y., Gunasekaran, A., Ngai, E. W. T., & Papadopoulos, T. (2016). Big data analytics in logistics and supply chain management: Certain investigations for research and applications. *International Journal of Production Economics*, 176, 98-110.

Another area for further exploration is the role of human and organizational factors in the success of digital transformation initiatives. While technology readiness and capabilities are critical the importance of organizational culture, leadership and employee engagement cannot be overlooked. It is not to be said that the human factor is not taken into account, but in general it seems to be a tendency to overlook its importance. Future research could study deeper into how these factors influence the adoption and effective use of digital technologies in supply chains. "Organizational culture shapes the readiness and willingness of employees to embrace new technologies, while leadership provides the vision and direction necessary for guiding transformation efforts. Employee engagement ensures that the workforce is motivated and committed to the change process. Without a supportive culture, strong leadership, and active engagement, digital transformation initiatives are likely to face significant resistance and ultimately fail to achieve their intended outcomes."

Source: Kane, G. C., Palmer, D., Phillips Nguyen, A., Kiron, D., & Buckley, N. (2017). Achieving Digital Maturity: Adapting Your Company to a Changing World. *MIT Sloan Management Review and Deloitte Insights*. Retrieved from <https://sloanreview.mit.edu/projects/achieving-digital-maturity/>

Finally impact of emerging technologies such as quantum and edge computing or even the 5G technology on supply chain management remains still underexplored or maybe less explored. These technologies have the potential to further revolutionize supply chains and future research should investigate their potential applications. A task further complicated taking into account all the existing technology and research in hand. "Emerging technologies such as quantum computing, edge computing, and 5G are poised to revolutionize supply

chain management by offering unprecedented computational power, real-time data processing capabilities, and ultra-fast connectivity. However, the impact of these technologies on supply chain operations remains largely underexplored in current literature. While initial studies suggest significant potential for improvements in efficiency, security, and responsiveness, comprehensive research is needed to fully understand their long-term implications and practical applications. Future research should focus on the integration of these technologies into existing supply chain frameworks, as well as their effects on supply chain resilience and agility."

Source: Garcia, R., Polonsky, M., & Signori, P. (2019). Emerging Technologies and Supply Chain Management: A Review of the Literature. *International Journal of Physical Distribution & Logistics Management*, 49(8), 760-776.

3.5 Case Studies of Successful Digitalization of Supply Chains

By analyzing case studies regarding successful digitization of supply chain networks it is possible to understand valuable insight and extract useful information about the research topic.

3.5.1 Case Study 1: Amazon's Digital Transformation in Supply

Amazon, the global e-commerce giant, has long been a leader in leveraging digital technologies to optimize its supply chain operations. Over the years Amazon has integrated a range of digital technologies to streamline its processes and enhance efficiency.

Amazon's supply chain digitalization strategy includes the extensive use of Internet of Things (IoT) devices, artificial intelligence (AI) and data analytics. IoT devices are embedded throughout Amazon's logistics network to provide real-time tracking of packages. These devices include sensors in warehouses and distribution centers that monitor the location and status of inventory, ensuring that products are available when and where they are needed. The IoT network also includes GPS trackers on delivery vehicles, allowing for precise tracking and optimized routing.

AI and machine learning are at the heart of Amazon's supply chain operations. These technologies power Amazon's predictive analytics capabilities enabling the company to

forecast demand with high accuracy. Machine learning algorithms analyze vast amounts of data from customer orders, weather patterns and market trends to predict which products will be in demand and when. This allows Amazon to optimize its inventory levels, reduce stockouts, and minimize excess inventory. It seems that the company is certainly in line with relevant research and breakthrough technologies as mentioned in various papers. "Machine learning algorithms have become integral to modern supply chain management by providing advanced predictive capabilities. By analyzing [these] diverse data sets, machine learning models can identify patterns and correlations that traditional methods might overlook. This predictive power enables companies to optimize inventory levels, reduce stockouts and respond more swiftly to changes in consumer behavior and external conditions."

Source: Choi, T. M., Wallace, S. W., & Wang, Y. (2021). Big Data Analytics in Operations Management. *Production and Operations Management*, 30(6), 1731-1742.

Data analytics is another critical component of Amazon's digital supply chain strategy. The company collects and analyzes data from every step of its supply chain, from supplier performance to delivery times. Advanced analytics tools provide insights that help Amazon continuously improve its operations. For instance, data analytics helps Amazon identify bottlenecks in its supply chain and implement solutions to improve efficiency. "This real-time analysis allows Amazon to quickly pinpoint issues and implement targeted solutions, such as optimizing delivery routes, adjusting inventory levels, and improving warehouse operations. The strategic application of data analytics not only enhances operational efficiency but also supports Amazon's commitment to rapid and reliable delivery services."

Source: Sloan, P., & Berthon, P. (2011). Managing the Virtual Supply Chain: The Case of Amazon.com. *Journal of Business & Industrial Marketing*, 26(7), 489-501.

Conclusion

Amazon's digital transformation of its supply chain has yielded impressive results. By leveraging IoT, AI and data analytics Amazon has achieved significant improvements in efficiency, cost reduction and customer satisfaction. The use of IoT devices has enhanced visibility and control over inventory while AI and machine learning have optimized demand forecasting and inventory management. Data analytics has provided insights that drive continuous improvement.

Summary of Main Results and Metrics

- **Inventory Turnover:** Improved by 25% due to better demand forecasting and inventory management.
- **Order Fulfillment Speed:** Reduced average delivery time from 4.1 days to 2.3 days.
- **Operational Costs:** Reduced logistics costs by 15% through optimized routing and inventory management.
- **Customer Satisfaction:** Increased customer satisfaction ratings by 20%, attributed to faster delivery times and fewer stockouts.

Source: [Amazon's Supply Chain Digital Transformation](#)

3.5.2 Case Study 2: Zara's Agile Supply Chain Digitalization

Zara, the well-known fast-fashion retailer is another excellent example of successful supply chain digitalization. Zara has built an agile supply chain that allows it to respond quickly to changing fashion trends and customer demands. The company's supply chain strategy revolves around the integration of IoT, AI, and data analytics.

Zara uses IoT devices extensively in its logistics operations. RFID tags are attached to every item of clothing allowing real-time tracking from production to retail stores. These tags provide detailed information about the location and status of inventory enabling Zara to maintain optimal stock levels and reduce the risk of stockouts or overstocking. The IoT system also enhances the efficiency of Zara's distribution centers by automating inventory checks and ensuring that products are shipped to the right stores at the right time.

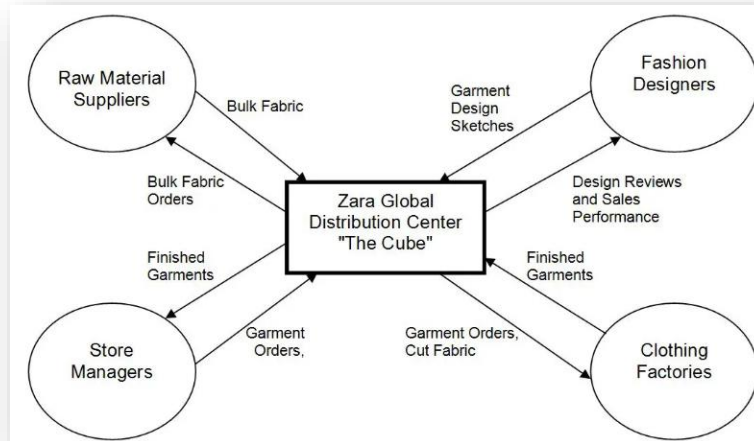
AI and machine learning are also integral to Zara's supply chain operations. The company utilizes AI-driven demand forecasting models similar to the ones of Amazon, that analyze sales data, fashion trends and social media activity to predict customer preferences. These models help Zara decide which products to manufacture and in what quantities, ensuring that the company meets customer demand without overproducing. Social media and the development of the Internet is another factor regarding the successful prediction of these AI models that are not the subject of this current research. Machine learning algorithms also optimize Zara's production schedules reducing lead times and enabling the company to bring new designs to market quickly.

Data analytics plays a crucial role in Zara's supply chain management. Zara collects data from its stores, online sales and supply chain operations to gain insights into customer behavior and operational performance. Advanced analytics tools help Zara identify trends, monitor supplier performance and optimize its supply chain processes. For example, data analytics enables Zara to track the performance of its suppliers and ensure that they meet quality and delivery standards. "By analyzing data on delivery times, order accuracy and quality control, Zara can monitor its suppliers in real time and ensure compliance with the company's stringent standards. This capability allows Zara to quickly identify and address any deviations or issues, ensuring that products meet the required quality levels and are delivered on schedule. The integration of data analytics into supplier management supports Zara's agile supply chain model, enabling the company to respond swiftly to market demands and maintain high levels of customer satisfaction."

Source: Ferdows, K., Lewis, M. A., & Machuca, J. A. D. (2005). Rapid-Fire Fulfillment. *Harvard Business Review*, 83(11), 104-110. Retrieved from <https://hbr.org/2005/11/rapid-fire-fulfillment>

According to SCM Globe, Zara's ability to design, produce and deliver new garments to stores in as little as 15 days sets it apart in the fast-fashion industry. The company's centralized distribution system allows for rapid shipment of new products to stores worldwide, ensuring that inventory is aligned with current trends. Additionally, Zara's use of sophisticated inventory management systems minimizes markdowns and overstock situations, keeping costs low and profitability high (SCM Globe, 2020). Zara buys large quantities of only a few types of fabric (just four or five types, but they can change from year to year), and does the garment design and related cutting and dyeing in-house. This way fabric manufacturers can make quick deliveries of bulk quantities of fabric directly to the Zara DC – the Cube. The company purchases raw fabric from suppliers in Italy, Spain, Portugal and Greece. And those suppliers deliver within 5 days of orders being placed. Inbound logistics from suppliers are mostly by truck.

The Cube is 464,500 square meters (5 million square feet), and highly automated with underground monorail links to 11 Zara-owned clothing factories within a 16 km (10 mile) radius of the Cube. All raw materials pass through the Cube on their way to the clothing factories, and all finished goods also pass through on their way out to the stores. The diagram below illustrates Zara's supply chain model.



The MBA Knowledge Base notes that Zara's approach to digitalization includes not only technology but also strategic management practices that support rapid decision-making and flexibility. The integration of digital technologies into Zara's supply chain allows the company to continuously monitor and adjust its operations based on real-time data, maintaining a competitive edge in the fast-paced fashion market (MBA Knowledge Base, 2020).

Conclusion

Zara's digitalization of its supply chain has enabled the company to maintain its competitive edge in the fast-paced fashion industry. Zara's ability to track inventory in real-time, forecast demand accurately and optimize production schedules has significantly improved its operational efficiency and customer satisfaction.

Summary of Main Results and Metrics

- **Inventory Accuracy:** Achieved near-perfect inventory accuracy with an error rate of less than 0.1% due to RFID tracking.
- **Lead Time Reduction:** Reduced average lead time from design to retail from 21 days to 15 days.
- **Cost Savings:** Achieved cost savings of 10% through optimized production and inventory management.
- **Sales Growth:** Increased sales by 12%, driven by improved product availability and faster response to fashion trends.

Sources:

- [Zara's Supply Chain Management: A Case Study](#)
- [Case Study: Zara's Supply Chain Success Story](#)

4 Theoretical Framework

4.1 Development of a Conceptual Framework Based on Literature Review Findings

The conceptual framework for this study is developed based on a thorough review of existing literature on digital transformation in supply chains, focusing specifically on three key technology enablers: Internet of Things (IoT) devices, artificial intelligence (AI) and machine learning and finally data analytics. This framework serves as a foundation for understanding the various factors that influence the implementation of these digital technologies and their impact on supply chain performance.

The framework is structured around three core components: technological enablers, organizational readiness, and performance outcomes. Technological enablers include the key digital technologies identified in the literature. Organizational readiness encompasses factors such as leadership, culture, and employee engagement, which are critical for successful digital transformation. Performance outcomes refer to the impact of digitalization on key supply chain metrics, including efficiency, cost reduction, and customer satisfaction.

Technological Enablers: The literature consistently highlights the transformative potential of IoT, AI and machine learning, and data analytics in supply chains. IoT devices provide real-time visibility into inventory levels and shipment statuses, enabling more accurate demand forecasting and efficient resource allocation (Ashton, 2009). AI and machine learning facilitate predictive analytics, optimizing supply chain processes by anticipating demand fluctuations and identifying potential disruptions (Choi, Wallace, & Wang, 2021). Data analytics offers powerful tools for extracting actionable insights from vast amounts of data, enhancing decision-making capabilities and operational efficiency (Wamba et al., 2020).

Organizational Readiness: Successful digital transformation requires more than just technological capabilities; it also depends on organizational readiness. Leadership plays a crucial role in setting the vision and direction for digital initiatives. Leaders must be able to inspire and motivate employees to embrace new technologies and processes (Kane et al.,

2017). Organizational culture is another critical factor, as it shapes the willingness of employees to adopt and integrate digital tools into their daily workflows. A culture that values innovation, continuous learning, and adaptability is essential for fostering successful digital transformation (Davenport & Kirby, 2016). Employee engagement is also vital, as engaged employees are more likely to be proactive in learning and utilizing new technologies, contributing to the overall success of digital initiatives (Westerman, Bonnet, & McAfee, 2014).

Performance Outcomes: The ultimate goal of digital transformation in supply chains is to enhance performance outcomes. These outcomes are typically measured in terms of efficiency gains, cost savings, and improved customer satisfaction. By leveraging digital technologies, companies can streamline their operations, reduce lead times, and minimize waste. Improved visibility and predictive capabilities lead to better decision-making, resulting in more responsive and agile supply chains. Additionally, digital tools enable companies to offer more personalized and timely services to their customers, enhancing customer satisfaction and loyalty.

4.2 Identification of Factors Influencing Implementation of Digitalization

The implementation of digital technologies in supply chains is influenced by numerous factors. Based on the literature review the followings key factors have been identified and play a critical role in the successful digitalization of supply chains

1. Technological Readiness

The availability and maturity of IoT, AI and machine learning and data analytics technologies are crucial for successful implementation. Organizations must assess their technological infrastructure and determine whether it can support the integration of these digital tools (Bharadwaj et al., 2013).

2. Organizational Culture

A culture that promotes innovation, flexibility and continuous improvement is essential for digital transformation. Organizations with a rigid and risk-averse culture may struggle to adopt and integrate new technologies (Westerman et al., 2014).

3. Leadership and Vision

Effective leadership is critical for guiding digital transformation efforts. Leaders must articulate a clear vision for digitalization, secure buy-in from stakeholders and allocate the necessary resources to support digital initiatives (Kane et al., 2017).

4. Employee Skills and Engagement

The skills and engagement of employees are important in ensuring the successful adoption of digital technologies. Continuous training and development programs are necessary to equip employees with the skills required to use new technologies effectively (Davenport & Kirby, 2016).

5. Change Management

Implementing digital technologies often requires significant changes to existing processes and workflows. Effective change management strategies are needed to address resistance, manage transitions and ensure that employees are supported throughout the transformation process (Kotter, 1996).

6. Data Management and Security

Ensuring the integrity, security and privacy of data is critical in digital transformation. Organizations must implement robust data management and cybersecurity measures to protect sensitive information and build trust with stakeholders (Kshetri, 2018).

4.3 Theoretical Foundations for Analyzing Digital Technologies

Analyzing the impact of digital technologies in supply chains requires a solid theoretical foundation. Several key theories and frameworks provide valuable insights into the factors that influence digital transformation and its outcomes

4.3.1 Technology Acceptance Model (TAM)

Developed by Davis (1989), the Technology Acceptance Model posits that perceived usefulness and perceived ease of use are critical factors influencing the adoption of new technologies. This model helps explain how and why IoT, AI, and data analytics are adopted within supply chains.

4.3.1.1 Explanatory Summary of the Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), developed by Fred Davis in 1989, is a foundational framework in the field of information systems and technology adoption research. TAM aims to explain how users come to accept and use a technology. It is grounded in two primary constructs: perceived usefulness (PU) and perceived ease of use (PEOU). These constructs directly influence an individual's attitude towards using the technology, which subsequently impacts their behavioral intention to use the system, ultimately determining actual system usage.

4.3.1.2 Key Constructs of TAM

Perceived Usefulness (PU)

Definition: Perceived usefulness is defined as the degree to which a person believes that using a particular system would enhance their job performance.

Explanation: If individuals perceive that a technology will help them perform their tasks better, they are more likely to develop a positive attitude towards using it. For instance, if employees believe that a new supply chain management system will make their workflow more efficient and reduce errors, they are more inclined to adopt and use the system regularly.

Perceived Ease of Use (PEOU)

Definition: Perceived ease of use refers to the degree to which a person believes that using the system would be free from effort.

Explanation: Even if a technology is perceived as useful, if it is too difficult to use, individuals might be reluctant to adopt it. For example, a complex software that requires extensive training and is not user-friendly will likely face resistance from users, despite its potential benefits.

4.3.1.3 The TAM Framework

The original TAM posits that perceived usefulness and perceived ease of use influence an individual's attitude towards using the technology (A), which in turn affects their behavioral

intention to use the technology (BI). Behavioral intention is a strong predictor of actual system usage (AU). The model is depicted as follows:

1. **Perceived Usefulness (PU) → Attitude (A) → Behavioral Intention (BI) → Actual Usage (AU)**
2. **Perceived Ease of Use (PEOU) → Attitude (A) → Behavioral Intention (BI) → Actual Usage (AU)**
3. **Perceived Ease of Use (PEOU) → Perceived Usefulness (PU)**

The relationship between PEOU and PU suggests that if a technology is easy to use, it is more likely to be perceived as useful.

4.3.1.4 Extensions and Applications of TAM

Over the years, TAM has been extended and adapted to various contexts to enhance its explanatory power and applicability. Some of the notable extensions include:

1. **TAM2**

Introduced by Venkatesh and Davis (2000), TAM2 incorporates additional determinants of perceived usefulness, such as social influence (subjective norm) and cognitive instrumental processes (job relevance, output quality, and result demonstrability).

2. **Unified Theory of Acceptance and Use of Technology (UTAUT)**

Proposed by Venkatesh, Morris, Davis, and Davis (2003), UTAUT integrates elements from eight prominent models, including TAM, to provide a comprehensive understanding of technology acceptance. UTAUT identifies four key constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions.

4.3.1.5 Practical Implications

TAM has profound practical implications for organizations aiming to implement new technologies. By understanding the factors that influence technology acceptance, managers can develop strategies to enhance perceived usefulness and ease of use, thereby increasing the likelihood of successful technology adoption. For example.

- **Training Programs:** Providing comprehensive training can reduce perceived difficulty and enhance ease of use.
- **User-Centered Design:** Involving users in the design process can ensure that the technology meets their needs and is easy to use.
- **Performance Incentives:** Demonstrating how the technology improves job performance can enhance perceived usefulness.

4.3.1.6 Conclusion

The Technology Acceptance Model remains a seminal framework in understanding and predicting technology adoption behaviors. Its focus on perceived usefulness and perceived ease of use provides valuable insights into the factors that drive user acceptance of new technologies. By addressing these factors, organizations can facilitate smoother transitions to new systems and ensure higher adoption rates.

Source: Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319-340.

4.3.2 Diffusion of Innovations (DOI) Theory

Rogers (2003) outlines the process by which innovations are adopted within a social system over time. The DOI theory highlights factors such as relative advantage, compatibility, complexity, trialability and observability which determine the rate and extent of technology adoption in supply chains.

4.3.2.1 Explanatory Summary of the Diffusion of Innovations (DOI) Theory

The Diffusion of Innovations (DOI) theory developed by Everett Rogers is a foundational concept in the study of how new ideas and technologies spread within and across societies. Rogers first introduced this theory in 1962 and it has since been expanded and refined in subsequent editions with the most comprehensive version presented in the 2003 edition of his book *Diffusion of Innovations*. The DOI theory is widely used to understand the adoption of innovations in various fields including technology, healthcare, education and agriculture.

4.3.2.2 Key Components of the DOI Theory

The DOI theory is built upon several key components

- 1. Innovation**

An innovation is an idea practice or object perceived as new by an individual or other unit of adoption. Innovations can vary widely from new technologies and products to social practices and organizational methods.

2. Communication Channels

Communication channels are the means by which information about an innovation is transmitted from one individual to another. Effective communication channels are essential for the diffusion process as they facilitate the spread of information and influence adoption decisions.

3. Time

Time is a critical factor in the diffusion process encompassing the innovation-decision process the time taken for the innovation to spread through a social system and the rate of adoption. Rogers identifies five stages in the innovation-decision process: knowledge, persuasion, decision, implementation and confirmation.

4. Social System

The social system is the network of individuals, groups, organizations or communities that are involved in the diffusion process. The social structure, norms and communication patterns within this system can significantly influence the adoption of innovations.

4.3.2.3 Attributes of Innovations

Rogers identifies five key attributes of innovations that affect their rate of adoption

1. Relative Advantage

The degree to which an innovation is perceived as better than the idea it supersedes. Innovations that offer clear, tangible benefits are more likely to be adopted quickly.

2. Compatibility

The degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters. Innovations that align well with the social and cultural context are adopted more readily.

3. Complexity

The degree to which an innovation is perceived as difficult to understand and use. Innovations that are simpler to comprehend and implement are adopted more rapidly.

4. Trialability

The degree to which an innovation can be experimented with on a limited basis. Innovations that can be tested and refined before full-scale adoption reduce the perceived risk and are adopted more quickly.

5. Observability

The degree to which the results of an innovation are visible to others. Innovations with outcomes that are easily observed and communicated are more likely to be adopted.

4.3.2.4 Adopter Categories

Rogers categorizes adopters into five groups based on their readiness and speed of adoption

- 1. Innovators**

These are the first individuals to adopt an innovation. They are willing to take risks are often younger and have higher social status and financial liquidity.

- 2. Early Adopters**

Early adopters are opinion leaders within their social systems. They adopt innovations early but carefully and are instrumental in influencing later adopters.

- 3. Early Majority**

The early majority adopts innovations before the average person. They deliberate for some time before adopting but seldom lead.

- 4. Late Majority**

The late majority adopts innovations after the average member of society. They are skeptical and adopt only after the majority of society has accepted the innovation.

- 5. Laggards**

Laggards are the last to adopt an innovation. They tend to have an aversion to change and rely on traditional methods until innovation becomes mainstream.

4.3.2.5 Diffusion Process

The diffusion process involves the innovation-decision process which consists of the following stages

- 1. Knowledge**

The individual becomes aware of the innovation and gains some understanding of how it functions.

- 2. Persuasion**

The individual forms a favorable or unfavorable attitude toward the innovation.

- 3. Decision**

The individual engages in activities that lead to a choice to adopt or reject the innovation.

- 4. Implementation**

The individual puts the innovation to use.

- 5. Confirmation**

The individual seeks reinforcement for the innovation decision and may reverse the decision if exposed to conflicting messages.

4.3.2.6 Conclusion

The Diffusion of Innovations (DOI) theory provides a robust framework for understanding how new ideas and technologies spread within a social system. By identifying the key attributes of innovations and the factors influencing their adoption, Rogers' theory helps explain the dynamics of technological change and adoption. This framework is invaluable for researchers, policymakers and business leaders aiming to promote and manage innovation effectively.

Source: Rogers, E. M. (2003). *Diffusion of Innovations* (5th ed.). Free Press.

4.3.3 Resource-Based View (RBV)

The Resource-Based View, proposed by Barney (1991), suggests that a firm's competitive advantage is derived from its ability to manage and deploy its resources effectively, including digital technologies. The RBV theory underscores the importance of having the right capabilities and infrastructure to support digital transformation initiatives.

4.3.3.1 Explanatory Summary of the Resource-Based View (RBV)

The Resource-Based View (RBV) is a strategic management theory that was proposed by Jay Barney in 1991. It posits that a firm's competitive advantage is largely derived from the unique resources and capabilities that it controls. Unlike earlier theories that emphasized the importance of external market factors the RBV focuses on the internal characteristics of the firm as the primary source of sustainable competitive advantage.

4.3.3.2 Key Concepts of RBV

Resources

According to Barney resources are the assets, knowledge, skills and other advantages that a firm possesses. These can be classified into three categories

- **Physical Capital Resources:** Tangible assets such as machinery, buildings and technology.
- **Human Capital Resources:** The skills, knowledge and expertise of the firm's employees.
- **Organizational Capital Resources:** The firm's structure, culture and processes.

Capabilities

Capabilities refer to the firm's ability to deploy resources effectively to achieve a desired outcome. These are the complex combinations of resources that enable a firm to perform activities in a coordinated manner.

4.3.3.3 VRIN Framework

Barney's RBV is grounded in the VRIN framework which specifies four criteria that resources must meet to provide sustainable competitive advantage

- **Valuable:** Resources must enable a firm to implement strategies that improve its efficiency and effectiveness.
- **Rare:** Resources must be scarce relative to demand. If many firms possess the same resource, it cannot be a source of competitive advantage.
- **Inimitable:** Resources must be difficult or costly for other firms to imitate. This can be due to unique historical conditions, causal ambiguity or social complexity.
- **Non-substitutable:** There must be no strategically equivalent valuable resources that are themselves either not rare or imitable.

4.3.3.4 Competitive Advantage and Sustained Competitive Advantage

- **Competitive Advantage:** A firm achieves competitive advantage when it is able to create more economic value than its rivals. This can be due to superior resources or more effective deployment of resources.
- **Sustained Competitive Advantage:** This occurs when a firm maintains its competitive advantage over a prolonged period, preventing competitors from duplicating its strategy or neutralizing the advantage.

4.3.3.5 Application of RBV

Strategic Analysis

The RBV provides a framework for firms to analyze their internal environment. By identifying, assessing and developing valuable, rare, inimitable and non-substitutable resources, firms can craft strategies that capitalize on their unique strengths.

Resource Identification

Firms can use the RBV to identify which of their resources and capabilities meet the VRIN criteria. This involves a thorough assessment of all aspects of the firm's operations from its physical assets to its organizational culture.

Capability Development:

The RBV emphasizes the importance of building and nurturing capabilities that are difficult for competitors to replicate. This often involves investing in employee training, developing proprietary technologies, and fostering a strong organizational culture.

Sustaining Competitive Advantage:

The RBV suggests that firms must continuously protect and enhance their valuable resources. This includes safeguarding intellectual property, maintaining high levels of employee satisfaction and engagement and staying ahead of technological advancements.

4.3.3.6 Criticisms and Limitations

Static Nature

One of the main criticisms of the RBV is that it can be overly static, focusing too much on existing resources and capabilities without considering the dynamic nature of competitive environments. Critics argue that it does not adequately address how firms can develop new resources and capabilities in response to changing market conditions.

Measurement Challenges

Another limitation is the difficulty in measuring and evaluating resources and capabilities. Assessing the true value, rarity, inimitability and non-substitutability of resources can be complex and subjective.

Overemphasis on Internal Factors

While the RBV highlights the importance of internal resources, some critics argue that it underemphasizes the role of external factors such as market structure, industry dynamics and competitive forces.

4.3.3.7 Conclusion

The Resource-Based View (RBV) proposed by Jay Barney remains a pivotal theory in strategic management, providing a valuable lens through which firms can assess their internal resources and capabilities. By focusing on the unique attributes that make resources valuable, rare, inimitable, and non-substitutable the RBV helps firms understand how to achieve and sustain competitive advantage.

Source: Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, 17(1), 99-120.

4.3.4 Supply Chain Operations Reference (SCOR) Model

Developed by the Supply Chain Council, the SCOR model provides a comprehensive framework for evaluating and improving supply chain performance. The SCOR model integrates business processes, performance metrics, best practices, and technology enablers, making it a useful tool for understanding the role of IoT, AI, and data analytics in supply chain management (Stephens, 2001).

4.3.4.1 Explanatory Summary of the Supply Chain Operations Reference (SCOR) Model

The Supply Chain Operations Reference (SCOR) model, developed by the Supply Chain Council, is a comprehensive framework for evaluating and improving supply chain performance. Since its inception the SCOR model has become a widely adopted tool for supply chain management, providing a standardized approach to assess and enhance supply chain operations across various industries.

4.3.4.2 Overview of the SCOR Model

The SCOR model integrates business processes, performance metrics, best practices and technology into a unified structure. It is designed to address, improve and communicate supply chain management practices within and between all interested parties. The SCOR model is structured around five primary management processes

Plan

This process involves demand and supply planning and management. Activities include balancing resources with requirements, establishing and communicating supply chain plans, and aligning supply chain strategies with business goals. Planning also encompasses inventory management, production planning, and capacity planning.

Source

This process focuses on procuring goods and services to meet planned or actual demand. Key activities include identifying reliable suppliers, managing supplier relationships, ordering and receiving products, and assessing supplier performance. Sourcing ensures that the supply chain has the necessary materials to operate efficiently.

Make

The make process involves the transformation of raw materials into finished products. This includes production scheduling, manufacturing, testing, packaging, and staging. The make process aims to optimize production efficiency, ensure quality control, and meet delivery commitments.

Deliver

This process encompasses all activities associated with order management, warehousing, and transportation. Delivery activities include processing customer orders, managing warehouse operations, picking, packing, and shipping products, and managing logistics and

transportation. The goal is to ensure that products are delivered to customers accurately and on time.

Return

The return process deals with the reverse flow of goods. It includes activities related to returns of defective products, excess inventory, and recycling. Managing returns efficiently helps maintain customer satisfaction and recapture value from returned products.

4.3.4.3 Performance Metrics

The SCOR model includes a comprehensive set of performance metrics that enable organizations to measure the efficiency and effectiveness of their supply chain processes. These metrics are categorized into five performance attributes

Reliability

Metrics under reliability measure the accuracy and consistency of the supply chain. Key indicators include perfect order fulfillment and order accuracy rates.

Responsiveness

This attribute measures the speed at which a supply chain provides products to customers. Key metrics include order fulfillment cycle time and delivery speed.

Agility

Agility metrics assess the ability of the supply chain to respond to changes in demand or supply conditions. Indicators include flexibility and adaptability in meeting customer requirements.

Cost

Cost metrics evaluate the expenses associated with operating the supply chain. Key indicators include cost of goods sold (COGS), total supply chain management costs, and cost to serve.

Asset Management Efficiency

This attribute measures the effectiveness of managing supply chain assets. Key metrics include inventory days of supply, asset utilization, and return on supply chain fixed assets.

4.3.4.4 Best Practices

The SCOR model incorporates industry best practices that have been identified through extensive research and benchmarking. These best practices provide guidance on how to achieve superior performance in supply chain operations. They cover areas such as demand

forecasting, supplier management, inventory control, production optimization, logistics and customer service.

4.3.4.5 Implementation of the SCOR Model

Implementing the SCOR model involves several steps

Mapping Supply Chain Processes

Organizations start by mapping their existing supply chain processes against the SCOR framework. This helps identify gaps, inefficiencies and areas for improvement.

Benchmarking Performance

Using the SCOR metrics, companies benchmark their performance against industry standards and best-in-class organizations. This provides a baseline for measuring improvement.

Identifying Improvement Opportunities

Based on the benchmarking results, organizations identify specific areas where they can enhance their supply chain processes. This may involve adopting new technologies, revising processes or improving coordination with suppliers and customers.

Implementing Best Practices

Organizations implement the identified best practices and measure their impact on supply chain performance. Continuous monitoring and adjustment ensure sustained improvements.

4.3.4.6 Benefits of the SCOR Model

The SCOR model offers several benefits to organizations

- **Standardization:** Provides a common language and framework for discussing and analyzing supply chain processes.
- **Comprehensive Coverage:** Addresses all aspects of supply chain management from planning to returns.
- **Benchmarking:** Facilitates benchmarking against industry standards and best practices.
- **Performance Improvement:** Helps organizations identify and implement improvements to enhance supply chain efficiency and effectiveness.

4.3.4.7 Conclusion

The Supply Chain Operations Reference (SCOR) model is a powerful tool for supply chain management offering a structured approach to assess and improve supply chain performance. By integrating processes, metrics, best practices and technology the SCOR

model enables organizations to achieve operational excellence and drive competitive advantage in their supply chain operations.

Source: Stephens, S. (2001). Supply Chain Operations Reference Model Version 5.0: A New Tool to Improve Supply Chain Efficiency and Achieve Best Practice. *Information Systems Frontiers*, 3(4), 471-476.

4.4 A comprehensive digitalization “checklist” for supply chains

The successful digitalization of supply chains requires careful planning and execution. To aid in this process, a comprehensive digitalization checklist can serve as a valuable guide, ensuring that all critical aspects are considered and addressed. This section provides a proposed detailed analysis of the DOs and DONTs across three key phases: initial preparation, implementation, and roll-out and go-live.

4.4.1 Initial Preparation

1. Conduct a Thorough Assessment

Evaluate the current state of your supply chain operations, identifying existing technologies, processes, and capabilities. Understanding the baseline is crucial for measuring progress and identifying areas for improvement.

Source: "Conducting a thorough assessment of current supply chain capabilities is crucial for identifying gaps and opportunities for digitalization" (Müller, J., & Voigt, K.-I., 2018).

2. Set Clear Objectives and Goals

Define specific, measurable objectives for digitalization, such as improving efficiency, reducing costs, enhancing visibility, or increasing customer satisfaction. Clear goals provide direction and help prioritize initiatives.

Source: "Setting clear objectives is essential for aligning digital transformation initiatives with overall business strategy" (Bharadwaj, A., et al., 2013).

3. Secure Executive Buy-In

Ensure that senior leadership understands and supports the digital transformation efforts. Executive sponsorship is critical for securing the necessary resources and driving cultural change.

Source: "Executive buy-in is crucial for the success of digital transformation projects" (Westerman, G., et al., 2014).

4. Develop a Strategic Roadmap

Create a detailed roadmap that outlines the phases of digitalization, key milestones, resource allocation, and timelines. A well-structured plan ensures coordinated efforts and helps track progress.

Source: "A strategic roadmap provides a clear path forward and ensures alignment across the organization" (Kane, G. C., et al., 2017).

4.4.2 What is important to avoid or be careful not to underestimate

1. Ignore the Importance of Data

Do not overlook the quality and accessibility of data. Poor data quality can undermine digital initiatives and lead to inaccurate insights.

Source: "Data quality is a critical factor in the success of digital transformation" (Wamba, S. F., et al., 2020).

2. Underestimate the Cultural Shift Required

Do not neglect the need for cultural change. Digital transformation often requires a shift in mindset and practices, which can be challenging for some employees.

Source: "Cultural resistance is one of the major barriers to successful digital transformation" (Davenport, T. H., & Kirby, J., 2016).

Implementation Phase

1. Pilot Testing

Start with pilot projects to test the feasibility and effectiveness of new technologies. Pilots provide valuable insights and help identify potential issues before full-scale implementation.

Source: "Pilot testing allows for early detection of issues and iterative improvement" (Choi, T. M., et al., 2021).

2. Focus on Integration

Ensure seamless integration of new technologies with existing systems. Interoperability is crucial for maintaining operational continuity and maximizing the benefits of digital tools.

Source: "Integration challenges are common in digital transformation and must be addressed proactively" (Bharadwaj, A., et al., 2013).

3. Provide Comprehensive Training

Invest in training programs to equip employees with the necessary skills to use new technologies effectively. Continuous learning is essential for keeping pace with technological advancements.

Source: "Effective training programs are vital for employee engagement and successful technology adoption" (Kane, G. C., et al., 2017).

4. Monitor and Measure Progress

Establish key performance indicators (KPIs) to monitor progress and measure the impact of digital initiatives. Regular tracking and reporting ensure that the project stays on track and achieves its goals.

Source: "KPIs provide a quantifiable measure of success and help in continuous improvement" (Wamba, S. F., et al., 2020).

4.4.3 What is important to avoid or be careful not to underestimate

1. Skip the Change Management Plan

Do not overlook the importance of a robust change management plan. Managing the human side of change is critical for minimizing resistance and ensuring smooth transitions.

Source: "Change management is often the differentiator between successful and failed digital transformations" (Kotter, J. P., 1996).

2. Rush the Implementation

Avoid rushing the implementation process. Taking the time to thoroughly test and refine technologies can prevent costly mistakes and disruptions.

Source: "A phased approach to implementation reduces risk and enhances success rates" (Westerman, G., et al., 2014).

4.4.4 Roll-Out and Go-Live Phase

1. Ensure Robust Support Systems

Establish support systems to assist employees during the transition. Help desks, online resources, and ongoing training can address issues promptly and maintain productivity.

Source: "Support systems are essential for addressing post-implementation challenges and sustaining momentum" (Davenport, T. H., & Kirby, J., 2016).

2. Communicate Continuously

Maintain open and transparent communication throughout the roll-out phase. Keeping stakeholders informed fosters trust and ensures alignment.

Source: "Effective communication is critical for managing expectations and maintaining engagement" (Kane, G. C., et al., 2017).

3. Conduct Post-Implementation Reviews

Perform thorough post-implementation reviews to assess the success of the digitalization efforts. Identify lessons learned and areas for further improvement.

Source: "post-implementation reviews provide valuable insights for continuous improvement" (Bharadwaj, A., et al., 2013).

4. Celebrate Successes

Recognize and celebrate milestones and achievements. Acknowledging successes boosts morale and reinforces the benefits of digital transformation.

Source: "Celebrating successes fosters a positive culture and motivates continued efforts" (Kotter, J. P., 1996).

4.4.5 What is important to avoid or be careful not to underestimate

1. Neglect Feedback Mechanisms

Do not ignore the importance of feedback mechanisms. Regular feedback from employees and stakeholders can help identify issues and opportunities for enhancement.

Source: "Feedback mechanisms are essential for continuous improvement and stakeholder satisfaction" (Westerman, G., et al., 2014).

2. Disregard the Need for Flexibility

Avoid being too rigid in your approach. The ability to adapt and respond to new challenges and opportunities is critical for long-term success.

Source: "Flexibility and adaptability are key traits of successful digital organizations" (Davenport, T. H., & Kirby, J., 2016).

4.5 The McKinsey Digital Supply Chain Compass

The McKinsey Digital Supply Chain Compass is a framework designed to guide organizations through the complexities of digitalizing their supply chains. This tool provides a structured approach for companies to evaluate, design and implement digital technologies

across their supply chain operations. The compass highlights critical areas where digital interventions can drive significant improvements in efficiency, resilience and overall performance.

A common visualization of the main components approached regarding framework can be presented in the following graphical form.



4.5.1 Planning

The future of supply chain planning is set to be revolutionized by big data, advanced analytics, and automation, with predictive analytics and closed-loop planning playing pivotal roles. Predictive analytics enhances demand planning by analyzing vast internal and external data with machine learning and Bayesian networks, significantly improving forecast accuracy by 30 to 50 percent and offering probability distributions instead of single forecast figures. This allows for more informed discussions and advanced inventory management. Closed-loop planning, meanwhile, automates and integrates demand and supply planning into a continuous process, dynamically adjusting safety stocks based on expected demand and integrating pricing decisions to optimize profit and reduce inventory. These advancements collectively transform supply chain planning into a more flexible, accurate, and efficient operation.

4.5.2 Physical flow

The future of logistics is poised for a significant transformation through enhanced connectivity, advanced analytics, additive manufacturing, and sophisticated automation. As warehouses become increasingly automated, the use of autonomous and smart vehicles will rise dramatically, and 3-D printing will revolutionize warehousing and inventory management strategies. The next generation of user interfaces, including touch, voice, and graphical interfaces, will enhance machine integration in warehouse operations. Breakthroughs like optical head-mounted displays, such as Google Glass, provide location-based instructions to workers, streamlining the picking process. Advanced robotics solutions improve case and single-piece picking, while exoskeletons that mimic human physiology will boost warehouse productivity. Holistic automation will link warehouses directly to production loading points, eliminating manual intervention. Autonomous and smart vehicles will reduce operating costs in transportation and product handling, shorten lead times, and decrease environmental impact. Self-guided vehicles in controlled environments and autonomous trucks on public roads, currently piloted in Europe and North America, show promising results. Additive manufacturing, particularly 3-D printing, will profoundly impact supply chain physical flows, enabling local production of slow-moving spare parts and tools. This shift is driven by a wider range of printing materials, falling printer prices, and improved precision and quality, leading to the establishment of production facilities that exclusively use 3-D printers.

4.5.3 Performance management

Performance management is undergoing a significant transformation. Previously, generating KPI dashboards was a major task, and KPIs were available only at aggregated levels. Today, granular data from internal and external sources is available in real-time, shifting performance management from a periodic, often monthly, process to an operational one focused on exception handling and continuous improvement. This enables planners to address critical supply chain disruptions with automatic handling of minor exceptions and suggestions for major ones. Automated root cause analyses play a crucial role in this new approach. The performance management system identifies the root causes of exceptions by comparing them to predefined indicators or through big data analyses, utilizing data mining

and machine learning techniques. Once the root cause is identified, the system automatically triggers countermeasures, such as activating a replenishment order or adjusting planning system parameters like safety stocks.

4.5.4 Order management

Order management is significantly enhanced through no-touch order processing and real-time replanning, resulting in lower costs via automation, increased reliability from granular feedback, and a superior customer experience due to prompt and dependable responses. No-touch order processing follows the establishment of a reliable available-to-promise (ATP) process. By integrating ordering systems with ATP and enriching them with order rules, the system can fully automate the ordering process, eliminating the need for manual intervention from order intake to confirmation. This requires strict adherence to order rules and continuously updated master data. Real-time replanning allows for immediate order date confirmations by rapidly adjusting the production schedule and replenishment plans while considering all constraints. This ensures that the supply chain setup is always current, providing a reliable planning foundation. Additionally, customers can benefit from extra services, such as faster lead times for a premium fee, with the system offering instant feasibility and updated date information.

4.5.5 Collaboration

The supply chain cloud represents the next advancement in supply chain collaboration, creating joint platforms between customers, companies, and suppliers that provide shared logistics infrastructure or joint planning solutions. In noncompetitive relationships, partners can collaborate on supply chain tasks to save administrative costs, leverage best practices, and learn from each other. Another key area of collaboration is end-to-end/multitier connectivity. While some automotive companies have already integrated collaboration throughout the entire value chain—from raw materials to the finished product—many companies still need to bridge this gap. Such collaboration enables significantly lower inventories through the exchange of reliable planning data, substantial lead time reductions through instant information sharing, and the development of early-warning systems that allow for rapid responses to disruptions across the entire supply chain.

4.5.6 Supply chain strategy

To meet the growing demand for individualization and customization, supply chains are increasingly adopting numerous segments. To thrive in this environment, supply chains must excel at "micro-segmentation." This involves breaking down the supply chain into hundreds of segments based on customer requirements and internal capabilities, using a dynamic, big data approach. This strategy enables the mass customization of supply chain offerings, delivering tailored products that provide optimal value to customers while minimizing costs and inventory throughout the supply chain.

4.5.7 Digital supply chain

Transforming into a digital supply chain hinges on two key enablers: capabilities and environment. Organizations must build digitization capabilities internally, often complemented by recruiting specialized talent. Additionally, implementing a two-speed architecture is crucial. This involves establishing a conventional organizational and IT framework while simultaneously fostering an innovation environment with a start-up culture. This "incubator" provides organizational freedom, flexibility, and modern IT systems, independent of legacy systems, to facilitate rapid development, testing, and implementation of solutions. Quickly realizing pilot projects is essential for gaining immediate business feedback, fostering excitement and trust in innovations, and guiding subsequent development cycles. The "incubator" represents the foundation of Supply Chain 4.0, characterized by speed, flexibility, and efficiency.

Source:

McKinsey & Company. (2021). *"The Digital Supply Chain Compass"*. Retrieved from <https://www.mckinsey.com/business-functions/operations/our-insights/the-digital-supply-chain-compass>

Knut Aliche, Jürgen Rador, Andreas Seyfert. (October 27, 2016) *"Supply Chain 4.0 – the next-generation digital supply chain"*.
<https://www.mckinsey.com/capabilities/operations/our-insights/supply-chain-40--the-next-generation-digital-supply-chain>

5 Key Digital Technologies in Supply Chains

5.1 Overview of Key Digital Technologies Used in Supply Chains

Digital technologies have become indispensable tools for optimizing supply chain operations. The integration of digital technologies such as the Internet of Things (IoT) devices, artificial intelligence (AI) and machine learning and data analytics is transforming traditional supply chain management into a more efficient, responsive and data-driven process. These technologies enable real-time monitoring, predictive analysis and strategic decision-making, thereby enhancing the overall agility and resilience of supply chains.

Digital technologies are redefining the supply chain landscape by providing unprecedented visibility, automation and intelligence. IoT devices facilitate real-time tracking and monitoring of goods throughout the supply chain, reducing uncertainties and improving inventory management. AI and machine learning algorithms analyze vast amounts of data to forecast demand, optimize routes and enhance decision-making processes. Data analytics tools aggregate and interpret data from various sources, providing actionable insights that drive strategic initiatives and operational efficiencies.

5.2 Detailed Analysis of Each Technology

5.2.1 Internet of Things (IoT) Devices

The Internet of Things (IoT) refers to a network of interconnected devices that communicate and exchange data with each other. In the context of supply chains, IoT devices include sensors, RFID tags, GPS trackers and other smart devices that provide real-time data on the location, condition and status of goods.

5.2.1.1 Real-Time Tracking

IoT devices enable real-time tracking of shipments, allowing companies to monitor the movement of goods from suppliers to warehouses and finally to customers. This visibility helps in reducing delays, preventing theft, and improving overall supply chain transparency.

Source: "The adoption of IoT in supply chains has led to improved visibility and control, enabling real-time tracking and monitoring of goods" (Moeuf et al., 2018).

5.2.1.2 Predictive Maintenance

IoT sensors can be used to monitor the health of machinery and equipment in manufacturing and warehousing operations. By predicting potential failures before they occur, companies can schedule maintenance activities proactively, reducing downtime and maintenance costs.

Source: "Predictive maintenance using IoT sensors can significantly reduce downtime and maintenance costs by predicting failures before they occur" (Lee et al., 2013).

5.2.1.3 Inventory Management:

IoT-enabled smart shelves and RFID tags provide real-time data on inventory levels, ensuring that stock levels are optimized, and reducing the risk of stockouts or overstocking. This leads to more efficient inventory management and reduces carrying costs.

Source: "IoT technologies facilitate real-time inventory management, leading to more efficient stock control and reduced carrying costs" (Gao & Bai, 2014).

5.2.2 Artificial Intelligence (AI) and Machine Learning

Artificial Intelligence (AI) and machine learning involve the use of algorithms and computational models to analyze data, identify patterns, and make decisions. In supply chain management, AI and machine learning are used for demand forecasting, predictive analytics and decision support.

5.2.2.1 Demand Forecasting

Machine learning algorithms analyze historical sales data, market trends and external factors such as weather patterns to predict future demand. Accurate demand forecasting helps companies optimize inventory levels, reduce lead times and improve customer satisfaction.

Source: "Machine learning algorithms analyze vast amounts of data from customer orders, weather patterns, and market trends to predict which products will be in demand and when" (Choi et al., 2021).

5.2.2.2 Predictive Maintenance

AI-driven predictive maintenance models use data from IoT sensors to predict when equipment is likely to fail. This allows companies to perform maintenance activities before failures occur reducing downtime and extending the lifespan of equipment.

Source: "AI-driven predictive maintenance models can predict equipment failures before they occur, reducing downtime and extending the lifespan of machinery" (Wang et al., 2018).

5.2.2.3 Decision Support

AI and machine learning provide decision support by analyzing complex data sets and identifying optimal solutions. For example, AI can optimize routing for logistics, reducing transportation costs and improving delivery times.

Source: "AI and machine learning provide valuable decision support by analyzing complex data sets and identifying optimal solutions for supply chain operations" (Wamba et al., 2020).

5.2.3 Data Analytics

Data analytics involves the use of statistical and computational techniques to analyze and interpret data. In supply chain management, data analytics provides insights that drive strategic decisions and operational improvements.

5.2.3.1 Descriptive Analytics

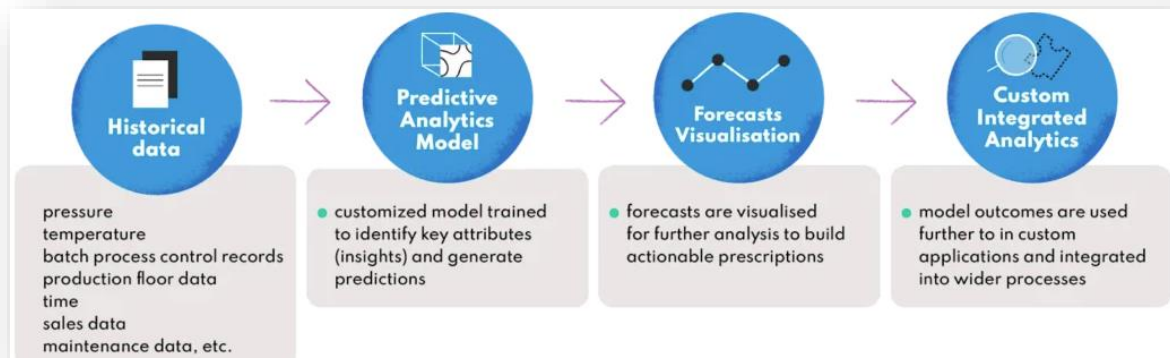
Descriptive analytics uses historical data to provide insights into past performance. This includes analyzing key performance indicators (KPIs) such as order fulfillment rates, delivery times and inventory levels to identify trends and areas for improvement.

Source: "Descriptive analytics provides valuable insights into past performance, helping companies identify trends and areas for improvement" (Chen et al., 2012).

5.2.3.2 Predictive Analytics

Predictive analytics uses statistical models and machine learning algorithms to forecast future outcomes based on historical data. This helps companies anticipate demand fluctuations, identify potential risks and make proactive decisions.

Source: "Predictive analytics uses statistical models to forecast future outcomes, enabling companies to make proactive decisions and anticipate demand fluctuations" (Waller & Fawcett, 2013).



Source: <https://nexocode.com/blog/posts/automation-and-ai-in-supply-chains-for-manufacturers/>

Predictive data analytics can significantly enhance decision-making in the supply chain industry, optimizing business processes. By collecting quality data from various sources, such as customer feedback, sales, inventory levels, weather forecasts and transportation data, companies can anticipate demand, optimize inventory management and reduce costs, thereby minimizing risks and losses. Implementing predictive analytics models, however, requires substantial investment in big data infrastructure and a deep understanding of business processes and customer needs. Techniques such as regression analysis, neural networks, text analytics and decision trees must be mastered. Despite the challenges the benefits include making better-informed decisions, improving operational efficiency and increasing profitability through access to relevant data and market trends. To illustrate the impact of predictive analytics let's see some practical examples

5.2.3.2.1 Demand Forecasting

Precise prediction of demand is crucial in supply chain management. The more the accuracy the better the customer satisfaction while minimizing inventory expenses. Historical data is a key component regarding demand forecasting. The image below illustrates how various parameters and mathematical models with the use of AI analyzes and forecasts demand.

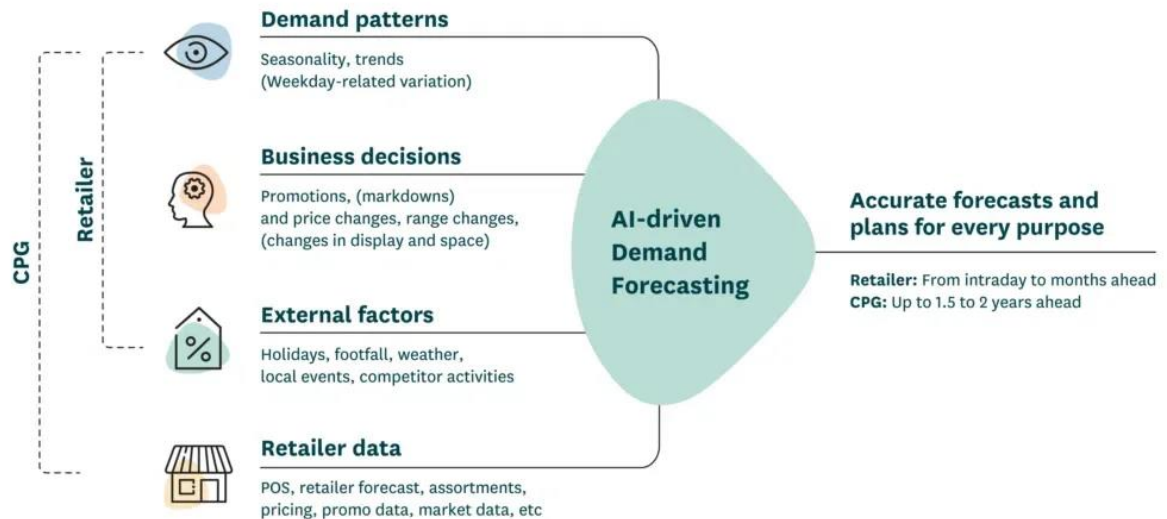


Image source: <https://www.relexsolutions.com/resources/demand-forecasting/>

5.2.3.2.2 Transportation Optimization

Logistics is essential for managing a company's goods from their origin to consumption, ensuring that the right product is delivered to the right place, at the right time, and in optimal condition. It significantly enhances overall supply chain performance. The image below illustrates factors critical regarding the accuracy of final delivery.

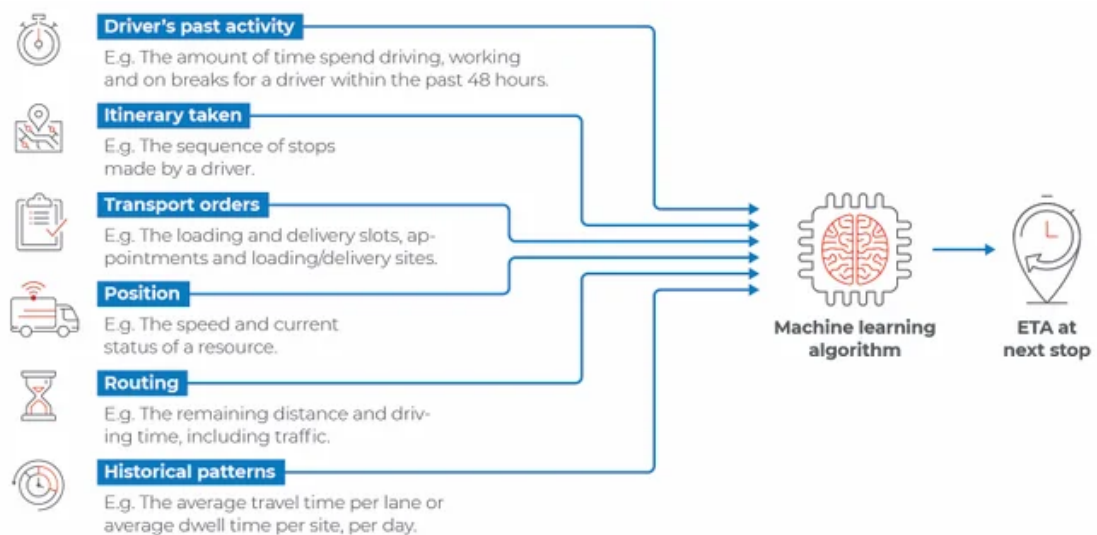


Image source : <https://www.relexsolutions.com/resources/demand-forecasting/>

5.2.3.2.3 Risk management in the supply chain

Predictive analytics models can uncover patterns and trends that enables anticipation and mitigate risks before they arise. By analyzing current and historical data we gain a deeper understanding of the supply chain, identify potential risks and take proactive measures to reduce exposure. Additionally, predictive analytics can help you pinpoint crucial supply chain metrics for tracking performance and identifying areas for improvement. For instance, by analyzing big data, you can detect trends in delivery times, inventory levels, and production output allowing for better-informed decisions and enhanced supply chain management.

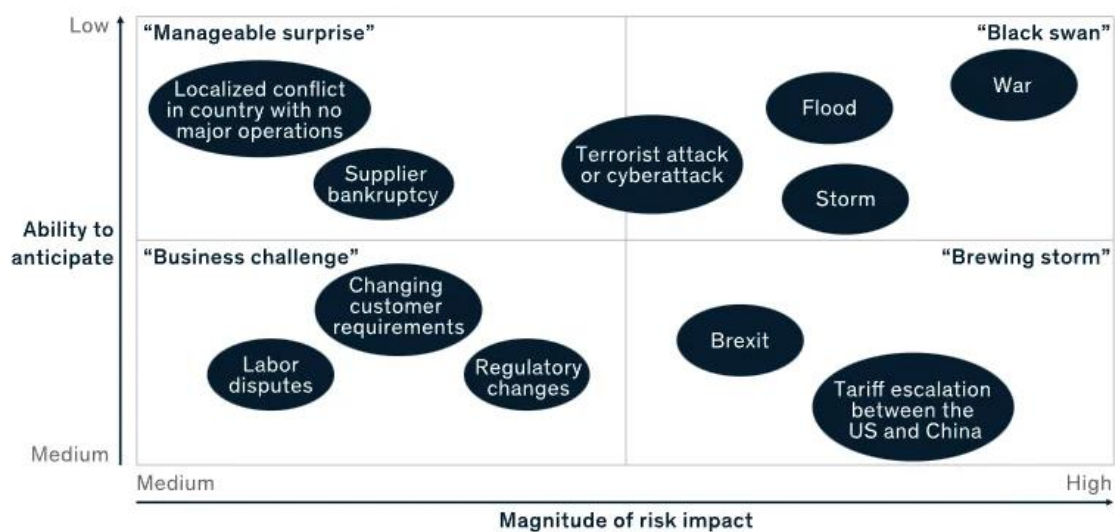


Image source: <https://www.mckinsey.com/capabilities/operations/our-insights/supply-chain-risk-management-is-back>

Source:

Neeraj Vavilala, (May 3, 2023). *"Predictive Analytics In Supply Chain"*

<https://dilytics.com/predictive-analytics-in-supply-chain/>

5.2.3.3 Prescriptive Analytics

Prescriptive analytics goes beyond prediction to recommend specific actions based on data analysis. This includes optimizing inventory levels, determining the best transportation routes and scheduling production activities to maximize efficiency.

Prescriptive analytics leverages data from various sources, such as big data, to recommend the best actions for specific scenarios using optimization techniques like mathematical models, machine learning, and artificial intelligence. It enhances predictive analytics by

taking predictions and providing actionable recommendations based on future events or trends. In supply chain networks, prescriptive analytics can optimize fuel consumption by identifying efficient transportation routes, assist in selecting the best suppliers by analyzing quality, lead time, and cost, optimize production schedules by identifying bottlenecks, and ensure optimal inventory levels by forecasting demand. Overall, prescriptive analytics enhances the impact of predictive analytics by guiding better decision-making based on data-driven insights.

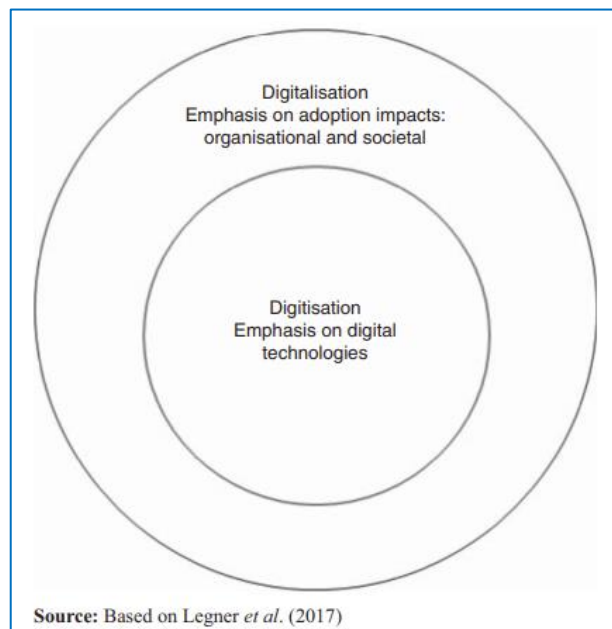
Source: "*Prescriptive analytics provides actionable recommendations based on data analysis, helping companies optimize their supply chain operations*" (Bertsimas & Kallus, 2019).

6 Analysis and Conclusions

6.1 *Synthesis of Findings from the Literature Review and Case Studies*

The review of the literature and case studies presented in this dissertation reveals several critical insights into the digital transformation of supply chains. The integration of key digital technologies—specifically mentioned in the study are the Internet of Things (IoT), artificial intelligence (AI) and machine learning and data analytics—has been shown to significantly enhance supply chain efficiency, responsiveness and decision-making capabilities.

The literature on digitalization remains limited, with some confusion between the terms digitization and digitalization. According to Legner et al. (2017), digitization involves converting analogue signals into a digital format, while digitalization encompasses the broader impact of these technologies on organizational and societal levels. Although this study uses the terms interchangeably, it focuses more on digitalization. Digitization is considered a



subset of digitalization, which has implications for capabilities in both aspects. Digitization relates closely to resource capabilities in adoption, development, and operations. In contrast, digitalization affects the entire supply chain and can enhance organizational competitiveness through the capabilities developed during digitization.

The concept of Digital Supply Chains (DSC) is still evolving (Kayikci, 2018). A DSC is defined as an intelligent technological system leveraging vast data resources and advanced cooperation and communication among digital hardware, software, and networks. This system supports and synchronizes interactions between organizations, making services more valuable, accessible, and affordable with consistent, agile, and effective outcomes

(Büyüközkan and Göçer, 2018). This definition highlights the need for organizations to integrate ICT resources with human resources. Digitalization is already transforming all types of supply networks (Korpela et al., 2017; Li et al., 2016; Srai et al., 2016). Recent studies emphasize the need for organizations to understand DSC in various contexts. For example, Scuotto et al. (2017) examined how ICTs can enhance buyer-supplier relationships in the service sector, fostering new partnerships and improving transactions. From an ICT perspective, Korpela et al. (2017) demonstrated how integrating blockchain technology into DSCs can enhance security and reduce transaction costs.

The initial step towards supply chain digitalization is assessing readiness, a multifaceted issue that requires considering multiple factors and perspectives (Parihar and Sinha, 2021; Ardito et al., 2019). When an organization embarks on this digital transformation, it must evaluate various parameters. Decision-makers in supply chain management need to understand the comprehensive set of factors essential for successfully embracing this significant change.

6.1.1 IoT Devices

The deployment of IoT devices in supply chains facilitates real-time tracking and monitoring, leading to improved inventory management, reduced losses and enhanced transparency. For instance, Amazon's use of IoT devices allows for precise tracking of goods, optimizing inventory levels and ensuring on time deliveries. Zara's adoption of RFID tags provided real-time data on inventory enabling rapid response to market demands and minimizing stockouts.

6.1.2 Artificial Intelligence and Machine Learning

AI and machine learning algorithms are pivotal in predictive analytics, demand forecasting, and decision support. These technologies enable companies to analyze vast amounts of data to identify patterns, predict future trends and make informed decisions. Amazon's AI-driven demand forecasting models, for example, help optimize inventory levels and reduce lead times while Zara's use of AI in production scheduling ensures that new designs are swiftly brought to market.

6.1.3 Data Analytics

Data analytics tools aggregate and interpret data from various sources providing insights that drive strategic decisions. The ability to take into account and analyze big data is crucial for maintaining a competitive edge. Also, we analyzed the various methods of data analytics in the relevant section.

"The adoption of digital technologies such as IoT, AI, and data analytics has revolutionized supply chain management by providing enhanced visibility, predictive capabilities, and data-driven decision-making. These technologies enable companies to optimize their operations, reduce costs and improve customer satisfaction." (Wamba et al., 2020)

6.2 Discussion of Trends, Challenges, and Best Practices

6.2.1 Trends

The digital transformation of supply chains is characterized by several key technology trends. These trends reflect a shift towards more integrated, intelligent and responsive supply chain operations.

6.2.2 Challenges

Despite the significant benefits the implementation of digital technologies in supply chains is not without challenges. Data privacy and security concerns are paramount as the increased flow of digital information creates potential vulnerabilities. Additionally, the integration of new technologies with legacy systems can be complex and costly. Organizational resistance to change and the need for continuous employee training are also significant hurdles. Although those challenges exist, also comprehensive methodology and best practices throughout the industry in combination with success stories all over the world, indicates that the broad implementation of digitalization is inevitable.

"Data privacy and security are critical concerns in the digitalization of supply chains. As companies adopt IoT devices and data analytics, they must implement robust security measures to protect sensitive information and mitigate risks." (Kshetri, 2018)

6.2.3 Best Practices

To successfully navigate these challenges, companies should adopt several best practices

1. **Develop a Clear Digital Strategy:** Establish a comprehensive digitalization plan that aligns with overall business objectives.
2. **Invest in Training and Development:** Provide continuous training to equip employees with the necessary skills to utilize new technologies effectively.
3. **Prioritize Data Security:** Implement robust cybersecurity measures to protect data integrity and privacy.
4. **Foster a Culture of Innovation:** Encourage a culture that embraces change and innovation, promoting continuous improvement and agility.

In the context of the study a comprehensive “digital check list” is provided as a method to approach with a synopsis of the necessary steps the task of implementing technology projects in the supply chain.

6.3 *Comparison of Findings with Existing Theories and Frameworks*

The findings of this study align with several existing theories and frameworks in supply chain management and digital transformation. The Technology Acceptance Model (TAM) by Davis (1989) highlights the importance of perceived usefulness and ease of use in technology adoption, which is evident in the successful implementation of digital technologies by companies like Amazon and Zara. The Diffusion of Innovations (DOI) theory by Rogers (2003) underscores the role of relative advantage, compatibility, and complexity in the adoption of new technologies, all of which are crucial factors in the digital transformation of supply chains.

6.4 *Implications for Theory and Practice*

6.4.1 Theoretical Implications

The study contributes to the existing body of knowledge by providing empirical evidence on the impact of digital technologies on supply chain performance. It validates and extends the applicability of established theories such as TAM and DOI in the context of supply chain digitalization.

6.4.2 Practical Implications

For practitioners, this study offers valuable insights into the best practices for implementing digital technologies in supply chains. Companies can leverage these findings to develop effective digital strategies, enhance operational efficiency and achieve competitive advantage. Emphasizing the importance of organizational readiness, continuous training and robust data security can help mitigate challenges and ensure successful digital transformation.

"Effective digital transformation in supply chains requires a holistic approach that includes strategic planning, organizational readiness, continuous training, and robust data security measures." (Bharadwaj et al., 2013)

A step-by-step guide for companies looking to implement digital technologies in their supply chains should include various steps or prerequisites such as:

-Assess Readiness: Evaluate the current state of supply chain operations and identify areas for improvement.

Detailed Analysis

- **Current Process Mapping:** Start by mapping out the current supply chain processes to understand the existing workflow. Tools such as flowcharts or process mapping software can be used to visualize these processes.
- **Performance Metrics:** Assess key performance metrics such as lead times, inventory turnover rates, order accuracy. Identify any bottlenecks or inefficiencies that are impacting current processes.
- **Technology Audit:** Conduct a comprehensive audit of the existing technology infrastructure. Evaluation of the current software systems, hardware and network capabilities. Identify any outdated or underutilized technologies.
- **Capability Assessment:** Evaluate the current capabilities of the workforce in terms of digital literacy and technical skills. This may involve surveys, interviews or skill assessments.
- **Readiness Scorecard:** Present a readiness scorecard that includes parameters from previous steps. The scorecard is used to quantify the readiness level and identify specific areas that require attention.

-Select Appropriate Technologies: Research and choose digital technologies that align with the company's goals and requirements.

Detailed Analysis:

- **Define Objectives:** Clearly define the objectives of the digitalization initiative. Align these objectives with the company's overall strategic goals.
- **Technology Landscape Review:** Research the latest digital technologies available in the market that includes IoT devices, AI and machine learning applications, blockchain, data analytics tools etc.. It is necessary to understand functionalities, benefits, and limitations.
- **Vendor Assessment:** Evaluate potential technology vendors based on criteria such as reputation, customer reviews, support services, scalability and cost. Request demos and pilot projects.
- **Cost-Benefit Analysis:** Conduct a cost-benefit analysis to compare the potential return on investment (ROI) of different technologies. Consider both the initial implementation costs, Capital expenditures (**CapEx**) or Operating expenses (**OpEx**) and the long-term operational savings or revenue enhancements.
- **Customization and Integration:** Evaluate the ease of integration of new technologies within existing systems. Evaluate whether the technology can be customized to meet specific business needs.

-Pilot Testing: Conduct pilot tests to assess the feasibility and effectiveness of solutions.

Detailed Analysis

- **Pilot Objectives:** Define clear objectives and success criteria for the pilot tests..
- **Scope and Scale:** Determine the scope and scale of the pilot projects. Start with a small, manageable segment that could be for example a specific warehouse.
- **Implementation Plan:** Develop a detailed implementation plan that includes timelines, resource allocation and responsibilities.
- **Training and Support:** Provide comprehensive training for everyone involved in the pilot project..
- **Data Collection and Analysis:** Collect data throughout the pilot testing phase. Use tools to monitor performance metrics in real-time and identify any issues for improvement.

- **Feedback Loop:** Establish a feedback loop to gather input from employees. Use this feedback to make necessary adjustments of the implementation process.
- **Evaluation and Reporting:** At the end of the pilot phase, conduct a thorough evaluation of the results.

-Full-Scale Implementation: Roll out digital initiatives across the entire supply chain network, monitor progress and address any issues.

Detailed Analysis

- **Implementation Roadmap:** Develop a comprehensive roadmap for full-scale implementation that includes timelines, milestones, resource allocation.
- **Change Management:** Implement a change management strategy to ensure smooth adoption across the organization.
- **Scalable Infrastructure:** Ensure that the technology infrastructure is scalable and can handle the increased load as it is rolled out across the entire supply chain.
- **Continuous Training:** Provide ongoing training and support for employees.
- **Performance Monitoring:** Use analytics and monitoring tools to track performance metrics.
- **Continuous Improvement:** Implement a continuous improvement process to regularly review and refine the digital solutions.
- **Risk Management:** Develop a risk management and contingency plan to identify and mitigate potential risks.
- **Sustainability and Scalability:** Ensure that the digital solutions are sustainable in the long term and can be scaled as the company grows.

6.5 Critical Analysis of Factors Influencing Successful Digital Transformation

Successful digital transformation in supply chains is influenced by several critical factors

Technological Readiness: The availability and maturity of digital technologies are essential for successful implementation. Companies must assess their technological infrastructure and readiness for integration.

Leadership and Vision: Strong leadership and a clear vision are crucial for driving digital transformation initiatives. Leaders must champion the adoption of new technologies and ensure alignment with strategic goals.

Organizational Culture: A culture that values innovation, agility, and continuous improvement is vital for fostering digital transformation. Companies should cultivate an environment that encourages experimentation and embraces change.

Employee Engagement: Engaged employees who are well-trained and motivated to use new technologies are key to successful digitalization. Continuous training and development programs are essential for building digital competencies.

"Organizational culture and leadership play pivotal roles in the success of digital transformation initiatives. Companies with a culture that values innovation and strong leadership are more likely to achieve successful digitalization." (Westerman et al., 2014)

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