

# Measuring the Broader Value Proposition of Digital Transformation in Supply Chains

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**Received** Feb 02, 2024, **Revised:** Feb 10, 2024, **Accepted:** Feb 20, 2024, **Published Online:** Feb 27, 2024

**Reviewers:** Anonymous Peer Review

**Citation:** Singh, P. K., 2024. Measuring the Broader Value Proposition of Digital Transformation in Supply Chains. *International Journal of Supply Chain Management*, 13(1), 16-24, <https://doi.org/10.59160/ijscm.v13i1.6222>

**Abstract** - The advent of digital transformation within supply chains heralds a new era of efficiency, innovation, and resilience. This paper explores the multifaceted impact of digital technologies—such as the Internet of Things (IoT), artificial intelligence (AI), blockchain, and cloud computing—on supply chain management. Through a comprehensive review of current literature, we identify the challenges and opportunities presented by digital transformation, emphasizing the importance of overcoming infrastructural constraints, skill gaps, and security concerns to harness the full potential of these technologies. Furthermore, we delve into the ethical considerations and social impacts, highlighting the imperative for sustainable and responsible practices in the digital age. The paper also forecasts future directions and emerging technologies, underscoring the need for supply chains to adapt to and capitalize on these advancements for sustainable growth and competitive advantage. Our analysis concludes that while digital transformation presents significant challenges, it also offers unparalleled opportunities for supply chains to become more agile, transparent, and customer-centric. The successful integration of digital technologies not only enhances operational efficiency but also drives innovation, fosters sustainability, and strengthens resilience against global disruptions. This paper contributes to the ongoing discourse on digital transformation in supply chains, providing insights for academics, practitioners, and policymakers on navigating the complexities of this digital revolution.

**Keywords:** *Digital Transformation, Supply Chain Management, Internet of Things (IoT), Artificial Intelligence (AI), Blockchain Technology, Cloud Computing, Operational Efficiency, Innovation, Sustainability, Ethical Considerations, Social Impact, Emerging Technologies, Competitive Advantage, Resilience, Future Directions.*

## 1. Introduction

The advent of digital transformation has redefined the operational and strategic paradigms of supply chains across the globe. In an era marked by rapid technological advancements and shifting market demands, the integration of digital technologies within supply chain processes has emerged as a critical factor for sustaining competitive advantage. Digital transformation in supply chains encompasses a wide array of technologies, including the Internet of Things (IoT), artificial intelligence (AI), blockchain, and cloud computing, each contributing to the enhancement of operational efficiency, transparency, and responsiveness [1-3].

While the pursuit of cost savings has traditionally been a primary driver behind the adoption of digital technologies in supply chains, this focus offers a limited perspective on the multifaceted value proposition of digital transformation. Beyond mere cost reduction, digital transformation holds the potential to significantly enhance customer satisfaction, foster innovation, improve supply chain visibility, and facilitate the transition towards more sustainable and resilient supply chain practices [4, 5].

However, the literature on digital transformation in supply chains has often emphasized technological adoption and operational efficiencies, with less attention paid to measuring the broader, strategic value contributions of these initiatives [6, 7]. This gap underscores the need for a comprehensive examination of how digital transformation transcends

cost savings to deliver a broader value proposition, encompassing enhanced agility, innovation, and stakeholder engagement within supply chain networks.

The objective of this paper is to explore and articulate the broader value proposition of digital transformation in supply chains, moving beyond the conventional focus on cost savings to uncover the multifaceted benefits that digital technologies confer to supply chain stakeholders. By integrating insights from existing literature and empirical examples, this study aims to provide a holistic understanding of the value generated by digital transformation efforts in the supply chain domain.

## 2. Literature Review

### 2.1 Transformative Potential of Digital Technologies

The digital transformation of supply chains represents a paradigm shift, driven by the integration of advanced technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), blockchain, and cloud computing. These technologies have been pivotal in enhancing operational efficiency, transparency, and resilience across global supply chains [1-4]. Gupya (2023) and Ning & Yao (2023) discuss the transformative potential of digital technologies in streamlining operations and improving visibility within the complex landscape of supply chain management [1,3].

### 2.2 Innovation and Competitive Advantage

Emerging technologies not only facilitate operational improvements but also foster innovation and competitive advantage. Tana & Chai (2023) highlight the role of digital transformation in enabling service-oriented manufacturing industries to shift towards collaborative models, thereby enhancing their competitive positioning [2]. Similarly, Tsipoulanidis & Nanos (2022) emphasize the necessity for supply chains to leverage new business concepts and technologies to remain competitive in the marketplace [5].

### 2.3 Overcoming Digital Transformation Challenges

The journey towards digital transformation is fraught with challenges. Infrastructure constraints, skill gaps, and security concerns are significant barriers to the widespread adoption of digital solutions [6,7]. Doan et al. (2021) and Bejlegaard et al. (2021) discuss the critical need for addressing these challenges to fully realize the benefits of digital technologies in supply chains [6,7].

### 2.4 Ethical Considerations and Social Impact

Ethical considerations and the social impact of digital transformation have emerged as crucial dimensions, necessitating a balanced approach to digital adoption that prioritizes sustainability and ethical responsibility [8-10]. Sandul (2023) and Junge & Straube (2023) explore the ethical and social implications of digital transformation, emphasizing the importance of sustainable practices and the positive impact on environmental and social sustainability dimensions [8,9].

### 2.5 Future Directions and Emerging Technologies

Looking towards the future, emerging technologies are set to redefine supply chain management further. Wang & Pettit (2023), Ageron et al. (2020), and Cardiff University (2022) discuss the anticipated advancements in digital technologies, highlighting the role of these innovations in shaping next-generation supply chain capabilities [11,12,13]. Abideen et al. (2021) specifically address the technological transformation of the food supply chain, underscoring the need for resilience and sustainability in the face of global disruptions [14].

## 3. Research Methodology

This paper employs a systematic literature review methodology to explore the multifaceted impact of digital transformation on supply chains. The review process involved identifying, analyzing, and synthesizing scholarly articles and reports that discuss the integration of digital technologies in supply chain

management, challenges and opportunities of digital transformation, ethical considerations, social impacts, and future directions.

The selection of literature was guided by specific criteria, focusing on peer-reviewed journal articles, industry reports, and academic conference proceedings published within the last decade. Priority was given to studies that provided empirical evidence, case studies, or theoretical frameworks related to digital transformation in supply chains, encompassing technologies such as IoT, AI, blockchain, and cloud computing.

Key information was extracted from each selected document, including the authors' objectives, methodologies, key findings, and conclusions. This

data extraction facilitated a thematic analysis, where the literature was categorized based on recurring themes such as technological innovations, operational efficiencies, sustainability practices, and ethical and social considerations.

The findings from the literature review were synthesized to highlight the current state of digital transformation in supply chains, identify gaps in the existing research, and propose areas for future investigation. This synthesis aimed to provide a comprehensive overview of how digital technologies are reshaping supply chain management and the implications for businesses, society, and the environment.

#### 4. Discussion: The Role of Digital Technologies

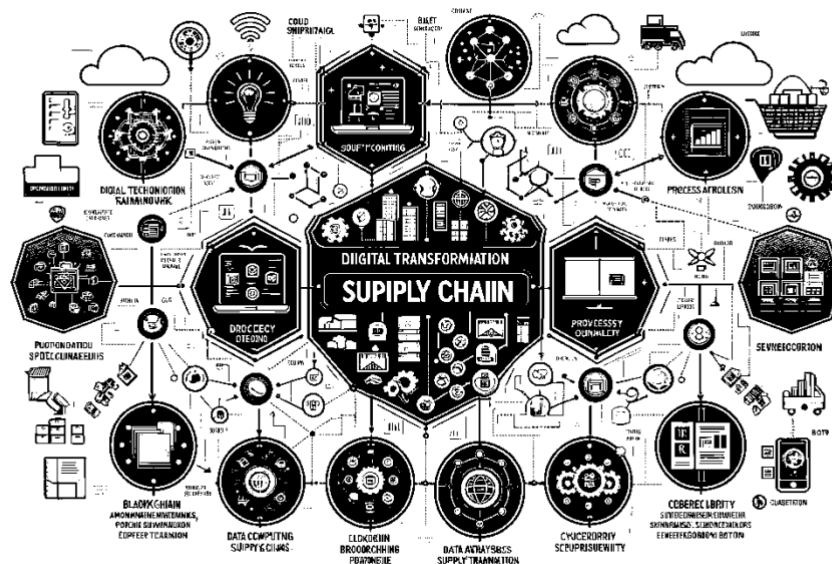


Figure 1. Supply Chain Digital Transformation Framework (source: Dall-E)

##### 4.1 Enhancing Supply Chain Resilience

In the face of global disruptions, ranging from pandemics to geopolitical tensions, the resilience of supply chains has never been more critical. Digital technologies stand at the forefront of enhancing this resilience, offering tools and capabilities that allow

supply chains to not only withstand shocks but also adapt and thrive in changing conditions. The integration of the Internet of Things (IoT), artificial intelligence (AI), blockchain, and cloud computing into supply chain operations exemplifies this transformative potential [1-3].

### **4.1.1 Enhancing Visibility and Transparency**

Visibility and transparency are foundational to resilient supply chains, enabling stakeholders to anticipate disruptions and respond proactively. IoT technologies facilitate real-time tracking of goods, providing up-to-the-minute data on their location and condition. This capability is crucial for managing perishable goods or sensitive pharmaceuticals, where deviations in temperature or delays can lead to significant losses. Blockchain technology further enhances transparency by creating immutable records of transactions and movements, building trust among participants through verifiable data [1,3]. For instance, blockchain's application in the food industry allows for the rapid identification and resolution of contamination sources, significantly reducing the impact on public health and business operations [4].

### **4.1.2 Facilitating Agile Decision-Making**

Agility in decision-making is another critical aspect of supply chain resilience, allowing organizations to pivot operations in response to emerging threats or opportunities. AI and machine learning algorithms analyze vast datasets to predict trends, identify risks, and suggest optimal responses. This predictive capability enables supply chains to move from reactive to proactive management, minimizing the impact of disruptions. For example, AI-driven demand forecasting can adjust production schedules and inventory levels to match fluctuating consumer demand, as seen in the rapid shifts experienced during the COVID-19 pandemic [2,5].

## **4.2. Driving Innovation and Competitive Advantage**

The digital transformation of supply chains transcends operational efficiencies, serving as a catalyst for innovation and the creation of competitive advantages. By harnessing digital technologies, companies can unlock new opportunities for growth, develop innovative business models, and enhance customer experiences, thereby differentiating themselves in a crowded marketplace.

### **4.2.1 New Business Models**

Digital technologies have paved the way for the emergence of new business models within supply chains. Platform-based ecosystems and as-a-service offerings exemplify how companies are leveraging digital connectivity to create value. These models facilitate collaboration among supply chain participants, enabling them to share data, insights, and resources more effectively. For instance, cloud computing allows for the scalable and flexible use of IT resources, supporting the as-a-service model that can be tailored to the specific needs of supply chain partners [4,5]. This adaptability not only improves operational efficiency but also enhances the ability to respond to market changes swiftly.

Blockchain technology, in particular, has been instrumental in developing trust-based models in supply chains. By providing a secure and immutable ledger for transactions, blockchain enables transparent and verifiable tracking of goods from origin to consumer, fostering trust among stakeholders. This capability is crucial for industries where authenticity and ethical sourcing are paramount, such as in the food and pharmaceutical sectors [1,3].

### **4.2.2 Competitive Advantage through Customer Experience**

Digital transformation also significantly impacts customer experience, offering personalized and efficient service that contributes to competitive advantage. AI and IoT technologies enable the collection and analysis of customer data, facilitating personalized offerings and predictive service models. For example, AI can analyze customer buying patterns to predict future purchases, allowing companies to tailor their inventory and marketing strategies accordingly [2].

Moreover, IoT devices can enhance post-sale customer engagement by enabling smart, connected products that offer ongoing services, updates, and interactions. This continuous engagement not only improves customer satisfaction but also opens new revenue streams for companies through value-added services [5].

### 4.3 Sustainability and Environmental Impact

The imperative for sustainability in supply chain operations has never been more pronounced, with digital transformation playing a pivotal role in enabling more environmentally friendly and sustainable practices. Through the strategic application of digital technologies, supply chains can achieve significant reductions in waste, energy consumption, and greenhouse gas emissions, contributing to the global sustainability agenda.

#### 4.3.1 Reducing Environmental Footprint

Digital technologies such as IoT and AI are at the forefront of driving operational efficiencies that directly impact sustainability. For instance, IoT devices can monitor and optimize energy use in real-time across supply chain operations, significantly reducing unnecessary consumption [6]. Similarly, AI algorithms can optimize routing and logistics, leading to decreased fuel consumption and lower carbon emissions. These technologies not only contribute to environmental sustainability but also offer cost savings and operational efficiencies, showcasing the dual benefits of digital transformation [7].

Blockchain technology further contributes to sustainability by enhancing traceability and accountability in supply chains. By providing a transparent record of the origin, movement, and handling of products, blockchain enables companies and consumers to make informed choices about the environmental and ethical implications of their purchases [1,3]. This level of transparency is crucial for promoting sustainable practices and reducing the environmental footprint of supply chain operations.

#### 4.3.2 Promoting Circular Economy

Digital transformation also facilitates the transition towards a circular economy, where the value of products, materials, and resources is maintained in the economy for as long as possible, and waste generation is minimized. Technologies such as AI and big data analytics play a critical role in this transition by

enabling the efficient design of products for reuse, remanufacturing, and recycling [2,4].

For example, AI can predict the lifecycle of products and components, identifying opportunities for refurbishment or recycling before they reach the end of their useful life. This predictive capability ensures that materials are kept in use at their highest utility and value, aligning with the principles of the circular economy [5]. Additionally, digital platforms can facilitate the sharing of information and resources among supply chain partners, promoting collaborative consumption and the efficient use of assets [8].

### 4.4 Overcoming Challenges in Digital Transformation

The journey towards digital transformation in supply chains is fraught with challenges that can hinder progress and impact the realization of its full potential. From infrastructure constraints to security concerns, supply chains must navigate a complex landscape to harness the benefits of digital technologies fully. However, by identifying and addressing these challenges head-on, organizations can unlock new opportunities for efficiency, resilience, and innovation.

#### 4.4.1 Infrastructure Constraints and the Digital Divide

A significant barrier to digital transformation is the lack of robust technological infrastructure, particularly in developing countries. Gupya (2023) highlights how infrastructure constraints and the digital divide pose critical challenges in India, affecting the widespread adoption of digital solutions across supply chains [8]. These issues are not unique to India; they are prevalent in various regions worldwide, necessitating a concerted effort to improve connectivity and access to digital technologies.

#### 4.4.2 Skill Gaps and the Need for Digital Literacy

The successful implementation of digital technologies in supply chains requires a workforce equipped with the necessary skills and knowledge. The lack of digital

literacy and skill gaps among supply chain stakeholders is a considerable challenge, as noted by Gupya (2023) [8]. Addressing this issue requires targeted training programs and educational initiatives to upskill employees and ensure they are capable of leveraging new technologies effectively.

#### **4.4.3 Security Challenges in IoT-Based Supply Chains**

The integration of IoT technologies into supply chains offers numerous benefits, from enhanced visibility to improved efficiency. However, it also introduces significant security challenges, as the increased connectivity exposes supply chains to new vulnerabilities. Nozari et al. (2022) emphasize that security challenges are among the most critical concerns for IoT-based digital supply chains, necessitating robust cybersecurity measures to protect data and infrastructure [9].

#### **4.4.4 Navigating the Digital Transformation Process**

Despite the high initial investment costs and concerns about the success of digital applications, there are successful examples of digital transformation in supply chains that can serve as guides for others. Özkanlısoy and Akkartal (2021) discuss the advantages of digital transformation applications and the challenges encountered during the process, offering insights into how companies can navigate their digital transformation journeys more effectively [10]. Learning from these experiences can help organizations anticipate potential obstacles and develop strategies to overcome them.

### **7.5 Strategies for Overcoming Challenges**

To address these challenges, supply chains should focus on developing comprehensive digital strategies that include investing in infrastructure, fostering partnerships with technology providers, prioritizing cybersecurity, and committing to ongoing employee education and training. Collaborating with government and industry bodies to improve digital literacy and infrastructure at a broader level can also help mitigate some of these challenges.

## **4.5. Ethical Considerations and Social Impact**

The digital transformation of supply chains, while offering numerous benefits in terms of efficiency and innovation, also brings to the forefront critical ethical considerations and social impacts. These encompass a broad spectrum of issues, including labor practices, human rights, environmental stewardship, and the digital divide, necessitating a balanced approach to digital adoption that prioritizes sustainability and ethical responsibility.

### **4.5.1 Navigating Ethical and Social Dimensions**

The globalization of supply chains has magnified the ethical and social implications of their operations, challenging businesses to adopt more sustainable and responsible practices. Sandul (2023) emphasizes the importance of addressing these ethical considerations, highlighting the risks and challenges associated with labor violations, environmental harm, and other unethical practices that can significantly damage reputations and financial standing [11]. The paper advocates for a comprehensive approach to sustainability that includes not just economic, but also social and environmental dimensions, underscoring the need for transparency and ethical responsibility in global supply chains.

### **4.5.2 Impact on Sustainability**

Digital transformation technologies (DTT) offer promising avenues for enhancing the sustainability of supply chains, particularly in terms of environmental and social dimensions. Junge and Straube's research (2023) indicates that the deployment of DTTs, such as IoT and AI, can lead to improvements in energy efficiency, reduction of transport distances, and optimization of logistics resources, thereby contributing positively to environmental sustainability and social welfare [12]. These technologies enable supply chains to minimize their ecological footprint while also addressing social concerns, such as labor practices and community impact.

### **4.5.3 Enhancing Organizational and Supply Chain Sustainability**

The integration of digitalization practices within supply chains has shown a positive correlation with both supply chain and organizational sustainability. Hejazi (2023) highlights how digitalization enhances supply chain efficiency and has a significant positive effect on long-term business viability [13]. By adopting digital methods, including the use of social media and other digital platforms, organizations can improve their sustainability practices, ensuring a more resilient and future-proof supply chain.

## **4.6 Future Directions and Emerging Technologies**

The landscape of supply chain management is on the cusp of a transformative shift, driven by rapid advancements in digital technologies. As organizations strive to adapt to an ever-evolving marketplace, the integration of emerging technologies is not just a competitive advantage but a necessity for survival and growth. This section explores the future directions of digital transformation in supply chains, highlighting the role of emerging technologies in shaping next-generation supply chain capabilities.

### **4.6.1 Building Future Supply Chains with Emerging Technologies**

The future supply chain is envisioned to be a highly automated, data-driven ecosystem that leverages digital technologies to enhance efficiency, transparency, and resilience. Wang and Pettit (2023) emphasize the critical attributes of future supply chains, including automation, real-time visibility, and customer-centricity, facilitated by the adoption of emerging technologies [14]. These advancements promise to revolutionize supply chain operations, enabling organizations to ride the waves of change rather than falling behind.

### **4.6.2 Challenges and Research Opportunities in Digital Supply Chain Management**

The journey towards digital supply chain transformation is fraught with challenges that necessitate innovative solutions and research. Ageron, Bentahar, and Gunasekaran (2020) discuss the emerging theorization on digital supply chains, focusing on the integration of technologies such as big data, cloud computing, and the Internet of Things (IoT) [15]. They highlight the need for exploring new strategic, organizational, and human dimensions of digital supply chain management, underlining the importance of addressing these challenges to harness the full potential of digital transformation.

### **4.6.3 Sustainable Growth through Digital Transformation**

Economic systems are becoming increasingly susceptible to complications and uncertainties and supply chains are no exception [16]. The imperative for sustainability in supply chain operations has never been more pronounced. Emerging digital technologies offer promising avenues for achieving operational effectiveness while fostering sustainable growth. A comprehensive exploration by Cardiff University (2022) reveals how digital transformation technologies can underpin transformation in supply chains, emphasizing the moderate positive impact on environmental and social sustainability dimensions [17]. This research underscores the potential of digital paradigms and tools in creating innovative products and services that deliver sustainable supply chain outcomes.

### **4.6.4 Technological Inclusion for Resilient Food Supply Chains**

The food supply chain, in particular, stands to benefit significantly from technological inclusion, especially in the wake of disruptions such as the COVID-19 pandemic. Abideen et al. (2021) systematize literature on the transformation of the food supply chain through technology, proposing a future research direction that emphasizes the need for more integration between

specialized tools like IoT for enhanced resilience and viability [18]. Their findings highlight the critical role of digital technologies in reforming the food chain, addressing challenges related to quality, safety, and sustainability.

## 5 Conclusion

The journey of digital transformation within supply chains is a testament to the dynamic interplay between technology and organizational strategy, underscored by a commitment to sustainability and ethical responsibility. As this paper has explored, digital transformation transcends mere operational efficiency, embedding itself as a cornerstone of innovation, competitive advantage, and resilience in the face of global disruptions.

The integration of digital technologies such as IoT, AI, blockchain, and cloud computing has revolutionized supply chain management, offering unprecedented visibility, agility, and connectivity. These technologies have not only streamlined operations but also opened avenues for creating value in novel ways, as evidenced by the emergence of new business models and the enhancement of customer experiences [2,3,5]. However, the path to digital transformation is fraught with challenges, including infrastructure constraints, skill gaps, and security concerns, necessitating a strategic and nuanced approach to adoption [8,9,10]. Setting goals and benchmarking the entire supply chain is the most effective way to keep it running smoothly [19].

Ethical considerations and the social impact of digital transformation have emerged as critical dimensions, [1] Gupya, O. (2023). Digital Transformation in Supply Chain India: Challenges and Opportunities. Psychology and Education. <https://dx.doi.org/10.48047/pne.2018.55.1.52>

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emphasizing the need for supply chains to navigate these issues with diligence and foresight. The discussions highlighted the importance of adopting sustainable practices and ensuring that technological advancements contribute positively to environmental stewardship and social welfare [11,12,13]. The future directions of digital transformation, underscored by the potential of emerging technologies, point towards a landscape where supply chains are not only more efficient and resilient but also more sustainable and ethically responsible [14,15,16,17].

In conclusion, digital transformation in supply chains represents a complex yet rewarding endeavor. It demands a holistic perspective that balances technological innovation with strategic, ethical, and social considerations. As supply chains continue to evolve in this digital era, the ability to adapt, innovate, and uphold sustainability and ethical standards will distinguish the leaders in the global marketplace. The future of supply chains lies in leveraging digital technologies not just for operational excellence but as enablers of sustainable growth and societal well-being.

The discussions and analyses presented in this paper underscore the imperative for ongoing research, collaboration, and dialogue among academics, practitioners, and policymakers. Together, these stakeholders can navigate the challenges and harness the opportunities presented by digital transformation, shaping a future where supply chains are resilient, sustainable, and aligned with the broader goals of society.

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