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Providing a Digital Supply Chain Model in the Online Food Retail Industry

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A B S T R A C T

This study was conducted with the aim of presenting a digital supply chain model in the online food retail industry. In terms of purpose, it is applied research, and in terms of data collection, it falls under mixed-method studies (qualitative–quantitative). The statistical population in the qualitative section consisted of professors, experts in the field of technology and supply chain, as well as senior managers of production and research and development in the online food retail industries. In the quantitative section, the population included all managers and employees of online supermarkets in Tehran. The sample size in the qualitative section was determined based on theoretical saturation (10 participants) using purposive sampling, while in the quantitative section, it was estimated at 380 participants based on structural equation modeling sampling requirements, using stratified random sampling. The data collection tool in the qualitative section was interviews, and in the quantitative section, a researcher-made questionnaire. The validity of the questionnaire was confirmed in terms of face and content validity by several experts; convergent validity was verified through the calculation of the Average Variance Extracted (AVE), and discriminant validity was confirmed using the square root of AVE. The reliability of the questionnaire was obtained through Cronbach's alpha at 0.898 for the entire instrument. SmartPLS 3 software was used for data analysis. The findings led to the identification of 27 components and 106 indicators. The variables of smart customer relationship management, intelligent communication in the supply chain, smart inventory and warehouse management, smart production control, and smart maintenance were identified as the main effective categories. Economic, social, technological, environmental, managerial, organizational, and industrial factors were identified as the effective causal conditions. Employee knowledge and skills, employee intelligence and awareness, and appropriate infrastructure were recognized as effective contextual conditions. Intra-organizational factors, laws and regulations, and inter-organizational factors were considered as effective intervening conditions. Financing, employee empowerment, and cultural development for creating a smart supply chain were determined as effective strategies. Finally, the outcomes included cost reduction, quality improvement, productivity increase, performance enhancement, flexibility, and customer satisfaction improvement.

Keywords: *Digital supply chain, Retail, Online food supermarket*

1. Introduction

The rapid digital transformation of industries worldwide has reshaped traditional business models, production systems, and supply chains. Among these, the retail food sector—particularly online food retailing—has been one of the most affected by emerging digital technologies. The shift toward digital supply chains has enabled organizations to achieve greater efficiency, flexibility, and resilience in the face of dynamic consumer demands, market volatility, and global disruptions such as the COVID-19 pandemic (Burgos & Ivanov, 2021). In this context, the digital supply chain is no longer a competitive advantage but rather a necessity for survival and growth. The increasing demand for speed, quality, and traceability, coupled with the complexity of global networks, highlights the urgency of adopting digitalized models in the food retail industry (Salimi Zavieh & Shams, 2023).

The concept of the digital supply chain extends beyond automation to include integration of digital technologies such as artificial intelligence, blockchain, cloud computing, the Internet of Things (IoT), and big data analytics. These technologies enable end-to-end visibility, real-time data sharing, predictive decision-making, and optimization of supply chain processes (Mohammadi, 2023). In the case of the food industry, which is characterized by perishable goods, complex logistics, and demand variability, the transition toward digital supply chains is both challenging and critical (Bagheri et al., 2021). Furthermore, consumers' growing expectations for speed, personalization, and sustainability reinforce the need for digital transformation in online food retail supply chains (Najjar & Yasin, 2021).

Scholars emphasize that digitalization is a multidimensional process requiring alignment of strategy, structure, people, processes, and technology (Haryanti et al., 2023). Digital maturity models have been developed to assess organizations' readiness and progress in adopting Industry 4.0 principles, and these provide a useful framework for evaluating the capacity of retail companies to implement digital supply chains effectively (Haryanti et al., 2023). Within this context, understanding the enablers and barriers of digital transformation is essential. Regional disparities, infrastructural constraints, and managerial attitudes play decisive roles in shaping the trajectory of adoption (Evdokimova et al., 2023).

The literature highlights several enablers that facilitate digital supply chain adoption. These include strong leadership commitment, robust financial capabilities, technological infrastructure, and integration of knowledge management practices (Gagliardi et al., 2023). Knowledge management, in particular, is identified as a critical factor that enhances organizational learning, innovation, and collaboration, thereby enabling digital supply chain integration (Gagliardi et al., 2023). Conversely, barriers such as regulatory gaps, cybersecurity concerns, resistance to change, and lack of digital literacy among employees hinder implementation (Rahimi et al., 2022). Thus, both micro-level organizational factors and macro-level environmental conditions need to be addressed for a successful transition.

Industry 4.0 technologies have opened new opportunities to enhance supply chain agility, resilience, and sustainability (Dias et al., 2022). The IoT, for example, allows for real-time tracking of goods, predictive maintenance, and demand forecasting, which are particularly relevant for perishable goods in the food retail sector (Nozari et al., 2021). Similarly, blockchain technology has emerged as a transformative force, ensuring transparency, traceability, and trust across multi-tier supply chains (Kayikci et al., 2022). The adoption of blockchain in food supply chains not only reduces inefficiencies but also mitigates risks associated with fraud, contamination, and logistics disruptions (Kurdi et al., 2022).

From a systems perspective, digital supply chain management involves integrating diverse processes such as procurement, production, warehousing, and distribution into a cohesive and intelligent ecosystem (Shevtshenko et al., 2022). This integration improves responsiveness and quality of service, thereby aligning operations with customer expectations (Hassanpour et al., 2021). The role of digital twins and simulation models in predicting and managing disruptions has also been increasingly recognized (Burgos & Ivanov, 2021). These models enhance preparedness for shocks and ensure continuity in the face of crises.

In the context of food retailing, scholars argue that customer satisfaction and loyalty hinge on the ability of supply chains to provide reliable service, high product quality, and rapid delivery (Hassanpour et al., 2021). The uncertainties associated with perishability, fluctuating consumer demand, and external disruptions make this industry particularly reliant on advanced technologies (Rahamneh et al., 2023). By aligning lean manufacturing principles with digital technologies, organizations can minimize waste, improve efficiency, and achieve higher performance levels (Rahamneh et al., 2023).

Empirical studies indicate that the integration of digital supply chain management in the food industry significantly

enhances productivity, reduces costs, and increases flexibility (Mehdipour et al., 2022). Moreover, digital platforms provide companies with real-time market insights, enabling them to predict consumer preferences and adjust production strategies accordingly (Jantrani et al., 2022). This level of responsiveness is particularly crucial in competitive markets such as online food retail, where consumers demand rapid fulfillment and seamless shopping experiences (Yu, 2025).

The resilience of supply chains has also emerged as a prominent theme in recent research. Scholars note that digitalization contributes to resilience by enabling supply chain integration, enhancing visibility, and facilitating risk management (Jin & Wang, 2025; Yu, 2025). In particular, the digital economy provides new pathways for firms to withstand shocks and maintain continuity in their operations (Jin & Wang, 2025). This perspective aligns with global efforts to develop sustainable and circular supply chains, where environmental considerations are integrated into operational decision-making (Duan et al., 2025). Digital technologies support sustainability by optimizing resource use, reducing waste, and facilitating renewable energy adoption, thereby aligning business goals with broader societal and environmental objectives (El Bhilat & Hamidi, 2025).

Sustainability in digital retail supply chains is increasingly viewed not only as a competitive advantage but also as an ethical imperative (El Bhilat & Hamidi, 2025). The integration of circular economy principles into supply chain strategies highlights the role of digital technologies in enabling resource efficiency, recycling, and closed-loop processes (Duan et al., 2025). For example, data analytics can be used to optimize logistics routes, reduce carbon footprints, and ensure compliance with environmental regulations (Roknoddini et al., 2023).

The Iranian context provides a unique setting for exploring digital supply chain transformation. Several studies emphasize that local industries face challenges such as limited digital infrastructure, regulatory uncertainties, and resistance to organizational change (Hossein Khani et al., 2022). Despite these challenges, there is growing recognition among policymakers and managers of the necessity to embrace digitalization in order to remain competitive in global markets (Shahabi et al., 2022). The use of system dynamics approaches to simulate agile and smart supply chains has proven valuable in identifying pathways for integration and optimization (Hossein Khani et al., 2022).

Another stream of research underscores the importance of financial support, employee empowerment, and cultural adaptation in facilitating digital supply chain implementation (Salimi Zavieh & Shams, 2023). Without adequate financial resources and managerial support, even the most advanced technologies cannot deliver expected outcomes (Ahmad, 2025). Similarly, employee training and skill development are essential for enabling the workforce to adapt to digital tools and processes (Evdokimova et al., 2023). Creating a culture of innovation and trust in technology is also critical for overcoming resistance and fostering acceptance (Rahimi et al., 2022).

The digital supply chain is also linked to macroeconomic development. Studies reveal that digital transformation contributes to GDP growth by enhancing productivity, facilitating trade, and creating new business models (Jin & Wang, 2025). Moreover, the role of supply chain integration in mediating the relationship between digitalization and resilience has been empirically validated (Yu, 2025). These findings underscore the broader economic implications of digital supply chain adoption, beyond the boundaries of individual organizations.

In addition, scholars highlight that digital supply chain models are highly context-dependent, influenced by regulatory frameworks, market structures, and cultural dynamics (Najjar & Yasin, 2021). Therefore, adopting a one-size-fits-all approach is impractical. Instead, localized models tailored to specific industries and regions are required. For the food retail sector in Iran and similar emerging economies, this implies developing frameworks that account for infrastructural limitations, resource constraints, and cultural attitudes toward technology adoption (Roknoddini et al., 2023).

Overall, the literature demonstrates that the digital supply chain in online food retailing is a multifaceted phenomenon shaped by technological, organizational, social, and environmental factors. While the potential benefits include cost reduction, quality improvement, customer satisfaction, and sustainability, significant challenges remain in terms of infrastructure, regulation, and cultural readiness (Burgos & Ivanov, 2021; Dias et al., 2022; Rahimi et al., 2022). Addressing these challenges requires a holistic approach that combines technological adoption with organizational transformation and stakeholder collaboration (Gagliardi et al., 2023).

Therefore, the present study seeks to contribute to this field by developing and validating a comprehensive digital supply chain model for the online food retail industry.

2. Methods and Materials

Considering that the present study seeks to provide a digital supply chain model in the online food retail industry using the grounded theory approach, the research method was, in terms of purpose, applied; in terms of type of data, mixed-method (qualitative–quantitative); and in terms of data collection method or nature of research, descriptive–correlational.

The statistical population included professors, experts in the field of technology and supply chain, and senior managers of production and research and development in the online food retail industry. In the quantitative section, the population included all managers and employees of online supermarkets in Tehran. The sample size in the qualitative section was determined by theoretical saturation (10 participants) through purposive sampling, and in the quantitative section, based on structural equation modeling requirements, it was estimated at 380 participants using stratified random sampling. The data collection tool was semi-structured interviews in the qualitative section and a researcher-made questionnaire in the quantitative section. Qualitative data analysis was performed using document analysis and semi-structured interviews through grounded theory. At this stage, 10 interviews were conducted on the subject of the digital supply chain in the online food retail industry, and the results obtained from the three stages of coding using MAXQDA software are presented below.

The coding process of the data (identifying concepts, categories, and their relationships, or the process of data analysis) was carried out during data collection as follows. First, the audio files of the recorded interviews were transcribed. For open coding, the interview transcripts were read several times, the main concepts were extracted, and the concepts were registered as codes. Then, similar codes were grouped into categories, resulting in the identification of 106 open codes at this stage. In axial coding, the categories were linked to their core categories to provide more accurate and comprehensive explanations of the phenomenon. Furthermore, in axial coding, the initial categories formed in open coding were compared, and those with similarities were placed around a common axis, resulting in the identification of 27 codes, as shown in Table 1. Finally, in selective coding, categories were integrated and refined; one category was chosen as the central category (the digital supply chain in the online food retail industry), and the intended model was designed around the central category. Overall, the model was divided into six categories: core phenomenon, causal factors, outcomes, strategies, contextual factors, and intervening factors.

To ensure the qualitative characteristics of the research, three criteria—credibility, confirmability, and reliability—were applied as follows. Regarding credibility and verification of findings, interview transcripts and the research report were sent to several participants (6 individuals) to provide feedback on the interview questions. Based on the participants' comments, the questions were reviewed and finalized. To ensure the reliability of findings, the processes and decisions related to the research were documented and clearly explained in the text. For confirmability of results, the findings were compared with previous research and explained by referring to theoretical discussions. In addition, to examine validity in this study, the research findings were presented to participants, the theoretical text was read by them, and their perspectives were incorporated. At the end, the study was reviewed by professors, and some modifications or changes to the final theory were suggested. Furthermore, to calculate interview reliability through inter-coder agreement, a PhD student in statistics was invited to participate as a research collaborator (coder). The necessary training and techniques for coding the interviews were transferred to this collaborator.

3. Findings and Results

In this study, the main source of data was the analysis of upstream documents and interviews. The initial interviews were exploratory and descriptive in nature, and gradually, after each interview, the coding of the obtained data was performed. Through the constant comparative method, theoretical codes emerged via open coding.

First Research Question: What are the indicators, components, and dimensions of the digital supply chain in the online food retail industry?

Based on the findings obtained from grounded theory, the digital supply chain in the online food retail industry consists of five components (smart customer relationship management, intelligent communication in the supply chain, smart inventory and warehouse management, smart production control, and smart maintenance).

Table 1

Selective, Axial, and Open Coding Derived from the Research Findings

Axial Coding	Open Coding
Smart Customer Relationship Management	Dependence of production speed through equipment digitalization on customer demand
	Expressing current and future customer demand to the marketing unit of the production company for machine adaptation and digitalization
	Customer feedback regarding product quality
	Customer visits to the smart production unit
Smart Production Control	Greater collaboration and communication among departments, suppliers, and different customers through the possibility of horizontal process integration
	Shortening the production process using smart equipment to respond quickly to customers
	Statistical process control over processes and production equipment
	Machinery compatibility and flexibility in production
	Implementation of lean and smart engineering
Intelligent Communication in the Supply Chain	Capability for two-way communication in Industry 4.0 is important
	Proper responsiveness in the supply chain from all members is emphasized
	Performance of suppliers' communication must be carefully evaluated
	Ability to provide online responsiveness to resolve potential errors
	Meeting customer expectations throughout the chain, from suppliers to the final consumer
	Ease of use for system users
Smart Inventory and Warehouse Management	Determining safety stock to avoid shortages in the chain
	Location and capacity of storage sites
	Planning for waste reduction through smart systems
	Identifying losses in the production process
	Item localization
Smart Maintenance	Providing solutions for medium- to long-term system failures caused by IT security weaknesses
	Improvement in total production costs, including labor, repair, and rework
	Improvement in total resource costs used in the company, including inventory held

The results showed that after content analysis and expert interviews, the influencing components of the digital supply chain in the online food retail industry were categorized into economic, social, technological, environmental, managerial, organizational, and industrial factors.

Table 2

Selective, Axial, and Open Coding of Influencing Factors Derived from the Research Findings

Axial Coding	Open Coding
Managerial Factors	Managers' beliefs and attitudes
	Support and cooperation of industry policymakers
	Managers' perspectives on financial and supply issues
	Support and backing from senior managers
	Awareness of the benefits of Industry 4.0 and the digital supply chain
	Systems thinking among managers and supply chain system integration
Technological Factors	Advanced information technology infrastructure and facilities
	Existence of strong signals and broad bandwidth (high-speed internet)
	Product and data security of supply chain members
	Establishing suitable databases to record vast volumes of complex information
Organizational Factors	Regulatory, legal, and contractual mechanisms
	Employees' expertise and awareness of Industry 4.0
	Data integration at all stages of the product life cycle
	Confidentiality of information and lack of transparency in company strategies
	Alignment of organizational policies with technology; organizational policy support for digitalizing the supply chain
Environmental Factors	Reducing environmental impacts (greenhouse gas emissions, water consumption, noise emissions, reduction of environmental incidents)

	Reduction of total waste and scraps
	Fear of losing customers (from partnerships)
	Use of renewable energy and energy efficiency
Industrial Factors	Presence of specialists in the online retail industry
	Lack of stakeholder and customer understanding of the effectiveness of the digital supply chain
	Industry readiness for adopting supply chain digitalization
Economic Factors	Investment in implementing Industry 4.0 and infrastructure
	Budget and financial tools for training, research, and development
	Financial support for machinery breakdowns
	Ability to transparently track costs
	Reduction of organizational costs (logistics costs, inventory reduction, cycle time reduction, labor cost reduction)
Social Factors	Industry interaction and cooperation with local markets and communities
	Corporate social responsibility

The results showed that after content analysis and expert interviews, the outcomes influenced by the digital supply chain in the online food retail industry included cost reduction, quality improvement, productivity increase, performance enhancement, flexibility, and improved customer satisfaction.

Table 3

Selective, Axial, and Open Coding of Influenced Factors (Outcomes) Derived from Research Findings

Axial Coding	Open Coding
Production Flexibility	Production based on customer needs
	Adaptation to technological changes
	Flexibility in production
	Flexibility in responding to changes in demand
Quality Improvement	Maximum quality must exist in the production process
	Enabling data analysis and learning from it, decision-making, and performing actions that usually require human intelligence, transformed for machines. This can lead to improved efficiency, productivity, and quality
	Use of smart devices with advanced technology in smart factories results in higher productivity and improved quality
Cost Reduction	Minimum waste must exist in the production process
	Minimum rework must exist in the production process
	Minimum raw materials must be used in the production process
Customer Satisfaction Improvement	Product return rate decreases
	Customer satisfaction level increases
	Customer complaints regarding product quality and delivery time decrease
Productivity Increase	Production based on demand with smart forecasting
	Minimum material inventory level on the production line according to smart line balancing
	Reduced production stoppages through smart production planning
	Conformity with the production plan and reduction of potential mismatches in a smart manner
Performance Enhancement	Intelligence at the lean production level reduces risks and facilitates transactions
	Intelligence at the lean production level results in better resource allocation
	Intelligence at the lean production level increases gross domestic product (GDP) growth
	Achieving predetermined goals using Industry 4.0 intelligence in lean production processes
	Intelligence at the lean production level enables continuous monitoring and tracking of business trends

Based on the literature review, theoretical foundations, expert interviews, and analysis of the dimensions, components, and indicators, the mechanisms or strategies for implementing the digital supply chain model in the online food retail industry are presented in the following table.

Table 4

Selective, Axial, and Open Coding of Implementation Mechanisms (Strategies), Contexts, and Barriers Derived from Research Findings

Selective Coding	Axial Coding	Open Coding
Strategy	Financing	Deviations must be observed in production processes, strategy implementation, budgets, and all organizational aspects, and their interrelations must be understood
		A lean company can always not only reduce the damages caused by its activities to society but also, due to its strong financial and managerial capabilities, play a significant role in meeting community needs
		The company's financial ability to equip production lines for implementing smart lean production processes is critical
	Employee Empowerment	Supporting employees' self-efficacy
		Enhancing employees' intrinsic motivation toward fulfilling tasks in implementing smart lean production plays a key role
		Creating a sense of competence and control over affairs among employees accelerates the implementation of lean production lines with smart equipment
	Cultural Development for Creating a Smart Supply Chain	Belief in and support from senior store management for innovation
		Fear of smart technology among store managers and employees
		Managers' level of trust in smart technology
		Perceived usefulness by the store
Contextual Factors	Employee Intelligence and Awareness	Possession of extensive information regarding external and internal environmental factors
		Ability of employees to generate new ideas
		Tendency toward learning and self-development
		Employee responsiveness to changing customer needs
	Employee Knowledge and Skills	Speed and accuracy in analyzing information obtained from sources
		Ability to respond in dynamic conditions and create value
		Acquiring essential skills for adapting to business process changes
		Responsiveness to special circumstances
	Appropriate Infrastructure	Existence of quality management, workforce management, production strategy, organizational features, and product design for a smart supply chain
		Companies now possess stronger knowledge for making more effective decisions regarding the supply chain, Industry 4.0, and its sustainability implications
		If the necessary infrastructure for implementing Industry 4.0 in lean and smart supply chains is absent, efficiency and effectiveness will not be achieved
Intervening Conditions	Laws and Regulations	Clear and specific regulations for legal support of smart contracts
		Transparent laws on financial and cyber crimes in the context of technology and digitalization
		Specific regulations on insurance and taxation of transactions in technological contexts
	Inter-Organizational Factors	Lack of proper awareness of technology among supply chain members
		Limited access of supply chain partners to information technology systems
		Lack of sufficient financial resources among supply chain partners for adopting technology
		Divergent approaches among supply chain partners regarding information sharing
	Intra-Organizational Factors	Confusion in integrating technology with existing retail software
		Absence of a designated department responsible for implementation
		Lack of acceptance of the necessity of adopting a digital supply chain in the industry
		Lack of commitment and willingness of senior managers to pursue improvements and fundamental changes (conservative approach)

Second Research Question: What model can be presented to explain the digital supply chain in the online food retail industry?

Using grounded theory, the final research model is presented as follows, where path analysis was conducted using PLS software:

Figure 1

Conceptual Research Model with Estimated Standardized Coefficients

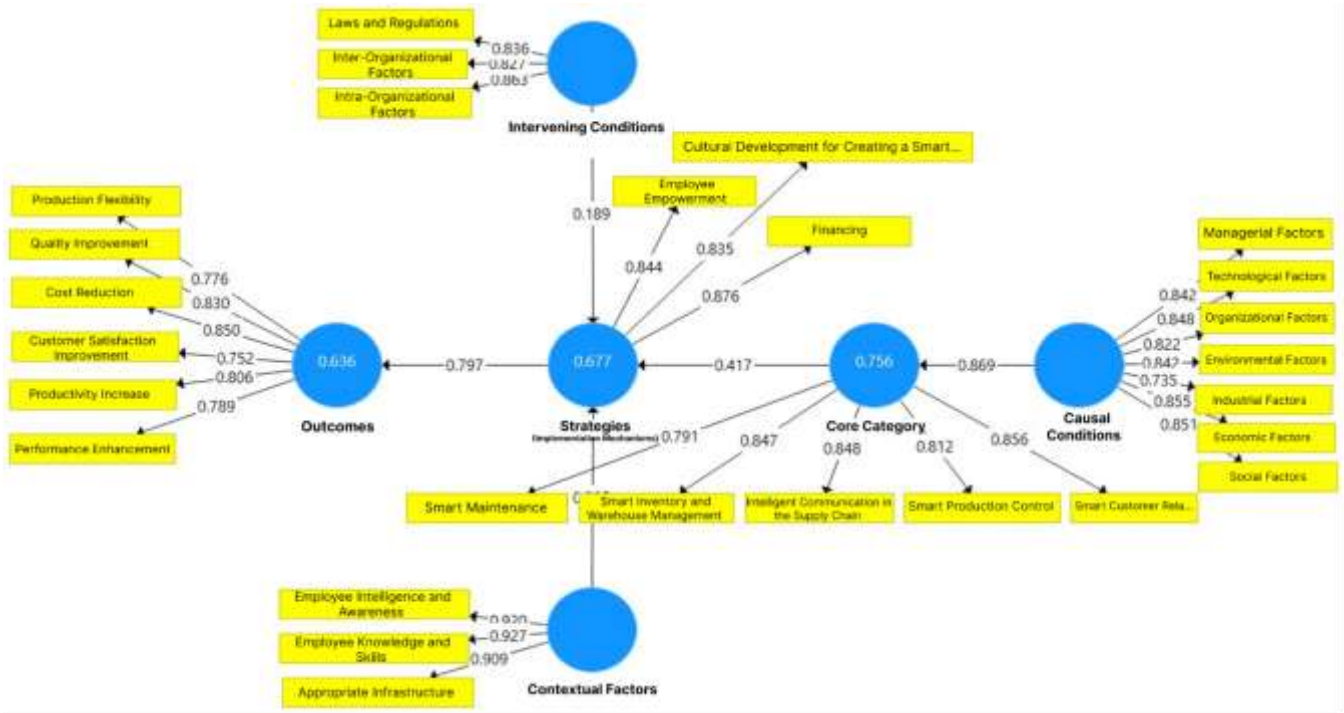
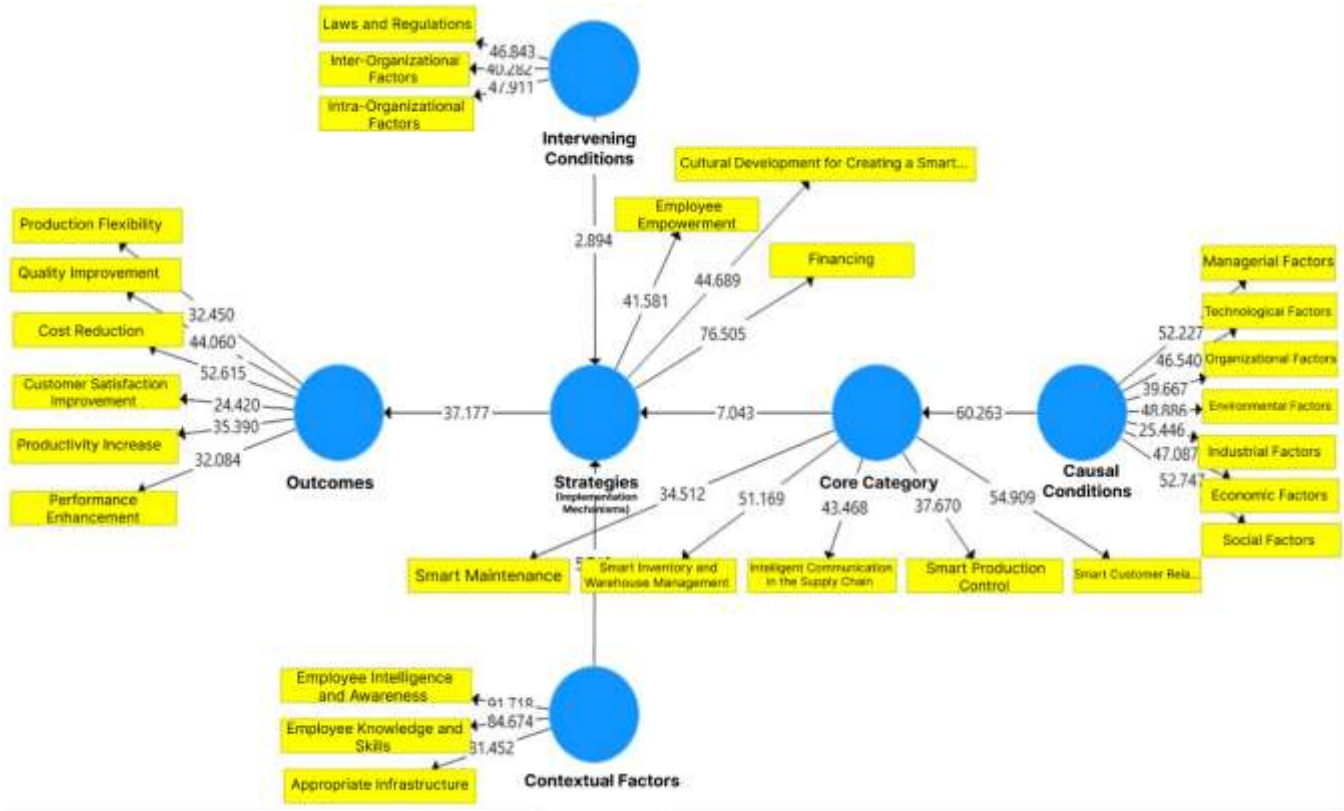


Figure 2

Conceptual Research Model with Coefficient Significance



Subsequently, using path analysis, the relationships between the process components of the digital supply chain in the online food retail industry are examined.

Table 5

Path Analysis of the Main Research Model

Paths	Standard Coefficients	t-values	P-Value	Outcomes
Causal Conditions → Core Category	0.869	60.263	0.0003	Significant
Core Category → Strategies	0.417	7.043	0.0000	Significant
Contextual Conditions → Strategies	0.612	5.024	0.0000	Significant
Intervening Conditions → Strategies	0.189	2.894	0.0001	Significant
Strategies → Outcomes	0.797	37.177	0.0000	Significant

4. Discussion and Conclusion

The results of this study showed that the digital supply chain in the online food retail industry can be conceptualized through multiple interrelated dimensions including core components, causal conditions, contextual and intervening factors, strategies, and outcomes. The identification of five key components—smart customer relationship management, intelligent communication within the supply chain, smart inventory and warehouse management, smart production control, and smart maintenance—highlights the multifaceted nature of digital supply chain management. These findings confirm that technological integration alone is insufficient unless it is combined with organizational processes, employee readiness, and supportive managerial and environmental conditions. The results point toward a holistic understanding of digital supply chains in which customer interaction, operational intelligence, and system adaptability converge to generate efficiency, resilience, and customer satisfaction (Salimi Zavieh & Shams, 2023).

The emphasis on smart customer relationship management reflects the growing recognition that customer centricity is a defining feature of digital supply chains. Digital tools allow for capturing, analyzing, and responding to customer feedback in real time, which is vital in the food retail sector where consumer demands are both perishable and volatile. Previous studies confirm that companies leveraging digital technologies achieve greater responsiveness, customization, and loyalty (Ahmad, 2025). This finding is consistent with research indicating that digital transformation enhances supply chain integration and resilience by allowing companies to predict demand patterns and align production accordingly (Yu, 2025). Moreover, digital customer engagement ensures quality feedback loops that inform production, marketing, and service strategies, thus reinforcing competitiveness (Jin & Wang, 2025).

Intelligent communication within the supply chain was another critical component identified in this study, underlining the importance of connectivity and transparency. This finding is supported by research emphasizing that Industry 4.0 technologies, particularly IoT and blockchain, establish bi-directional communication channels that enhance traceability and responsiveness (Dias et al., 2022; Kayikci et al., 2022). The ability to evaluate suppliers' communication performance, address errors in real time, and maintain continuous dialogue across supply chain nodes resonates with studies showing that blockchain-based systems can significantly improve trust and reduce inefficiencies (Kurdi et al., 2022). In the food retail context, where safety, timeliness, and quality are paramount, such communication capacities are indispensable.

The study also highlighted the significance of smart production control and smart maintenance as levers for efficiency and adaptability. Findings showed that statistical process control, flexible machine adaptability, and the integration of lean principles within smart systems increase agility in responding to demand fluctuations. This aligns with evidence that lean manufacturing systems, when combined with digital tools, reduce waste, improve quality, and enhance responsiveness (Rahamneh et al., 2023). Similarly, predictive maintenance enabled by digital technologies reduces downtime, extends equipment life, and minimizes costs, which is particularly critical in perishable food supply chains where delays directly translate into losses. These results confirm arguments in the literature that the fusion of lean and digital practices represents one of the most effective pathways to sustainable competitiveness (Mehdipour et al., 2022).

Smart inventory and warehouse management also emerged as essential, with emphasis on safety stock determination, waste reduction, and efficient localization of items. These findings echo earlier studies highlighting the role of digital warehousing systems and IoT-enabled tracking in reducing uncertainty, increasing reliability, and improving operational flow (Nozari et al., 2021). By ensuring accurate inventory levels and minimizing losses, companies not only lower costs but also achieve higher levels of flexibility and customer satisfaction (Bagheri et al., 2021). The integration of intelligent warehouse systems thus directly supports outcomes such as cost reduction, performance improvement, and productivity gains, which were identified as central in this study.

The study further revealed the importance of contextual and causal conditions in shaping digital supply chain implementation. Managerial vision, organizational readiness, technological infrastructure, and employee skills were shown to determine the extent to which digital tools can be successfully adopted. This finding is consistent with research stressing that digital maturity is a multidimensional construct requiring alignment of people, processes, and technology (Haryanti et al., 2023). Leadership commitment and strategic alignment are particularly crucial, as managers' awareness of Industry 4.0 opportunities strongly influences adoption (Evdokimova et al., 2023). The recognition of knowledge management as a critical enabler reinforces previous findings that organizational learning and data-driven culture are indispensable for digital transformation (Gagliardi et al., 2023).

Economic and social factors were also confirmed as pivotal. Investment capacity, financial resources for research and training, and budget allocations were shown to be necessary preconditions for digitalization (Roknoddini et al., 2023). This aligns with empirical evidence that limited financial support undermines transformation, especially in industries like food retail where margins are often narrow (Ahmad, 2025). Social responsibility, community engagement, and safety considerations also emerged as influential, echoing studies emphasizing the societal and ethical dimensions of digital transformation (Burgos & Ivanov, 2021; Najjar & Yasin, 2021).

The role of contextual conditions such as employee intelligence, knowledge, and awareness confirms earlier studies that emphasize digital literacy and skill development as essential for Industry 4.0 adoption (Jantrani et al., 2022; Shahabi et al., 2022). Employees must be able to analyze data, respond to dynamic environments, and generate innovative ideas. Without such capabilities, organizations cannot fully capitalize on digital technologies (Evdokimova et al., 2023). Infrastructure readiness was also highlighted, consistent with studies that show companies lacking broadband, databases, and IT systems suffer inefficiencies and fail to meet sustainability goals (Dias et al., 2022; El Bhilat & Hamidi, 2025).

Intervening conditions in this study included legal and regulatory frameworks, inter-organizational differences, and intra-organizational barriers. These findings corroborate research identifying regulatory uncertainty, cybersecurity risks, and contractual issues as obstacles to digital supply chain adoption (Rahimi et al., 2022). The lack of awareness and access among supply chain partners, divergent approaches to data sharing, and inadequate financial resources further hinder integration (Najjar & Yasin, 2021). Internally, managerial resistance and the absence of designated implementation units mirror findings that cultural inertia and lack of leadership commitment remain persistent barriers (Shahabi et al., 2022).

The strategies derived from this research—financing, employee empowerment, and cultural development—directly address these barriers. Strong financial capacity supports the acquisition of advanced technologies and infrastructure (Ahmad, 2025). Empowering employees enhances self-efficacy, motivation, and adaptability, facilitating smoother transitions (Evdokimova et al., 2023). Cultural development, particularly managerial support for innovation and employee trust in technology, resonates with research emphasizing the central role of organizational culture in driving digital transformation (Salimi Zavieh & Shams, 2023).

The outcomes identified—cost reduction, quality improvement, productivity gains, enhanced performance, flexibility, and customer satisfaction—corroborate a large body of prior evidence. Digitalization has been shown to reduce logistics and labor costs, minimize errors, and increase product quality (Hassanpour et al., 2021). Studies also emphasize that digital supply chains contribute to resilience and sustainability, enabling organizations to align economic efficiency with environmental objectives (Duan et al., 2025; El Bhilat & Hamidi, 2025). These results confirm that the adoption of digital supply chains in food retail is not only an operational imperative but also a strategic pathway toward long-term competitiveness and societal value creation (Yu, 2025).

This study therefore contributes by integrating diverse strands of literature into a comprehensive framework that

reflects both enablers and barriers, as well as strategies and outcomes. It advances theoretical understanding by validating the role of grounded theory in identifying interconnections among multiple dimensions and contributes practical insights into the mechanisms that organizations must prioritize. By contextualizing findings in the online food retail sector, it also enriches empirical knowledge in an area that remains underexplored compared to manufacturing or automotive industries (Jantrani et al., 2022; Jin & Wang, 2025).

The limitations of this study must be acknowledged. Although interviews with experts provided valuable qualitative data, the small sample size may not fully capture the variety of perspectives across regions or organizational types. The quantitative data, while statistically sufficient, were limited to Tehran-based online supermarkets, which restricts generalizability to other markets. Moreover, the cross-sectional design prevents analysis of long-term changes or the dynamic evolution of digital supply chain adoption. Finally, although advanced statistical modeling was applied, causal inferences are limited due to the non-experimental design.

Future research should therefore expand the empirical scope to include comparative cross-industry and cross-country analyses, particularly in emerging markets where infrastructural and regulatory conditions vary. Longitudinal research is recommended to capture the dynamic processes of digital transformation and its long-term effects on sustainability and resilience. Further studies could also examine the role of emerging technologies such as artificial intelligence, digital twins, and machine learning in enhancing predictive and optimization capacities. Another fruitful avenue would be investigating consumer perspectives on digital supply chain practices to better align organizational strategies with customer expectations. Finally, incorporating sustainability indicators and circular economy frameworks could provide deeper insights into how digital supply chains contribute to broader environmental and social goals.

For practitioners, several implications can be drawn. Managers should prioritize investments in digital infrastructure, ensuring robust IT systems and effective data management capabilities. Training and empowering employees are critical to foster adaptability and innovation, enabling the workforce to embrace digital tools. Senior leadership must actively champion cultural change, building trust in digital technologies and creating an organizational environment conducive to innovation. Collaboration with supply chain partners should be enhanced through shared systems and standardized platforms to improve integration and responsiveness. Above all, organizations must adopt a holistic strategy that balances financial, technological, organizational, and environmental considerations to maximize the benefits of digital supply chain adoption.

Authors' Contributions

Authors contributed equally to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

In this research, ethical standards including obtaining informed consent, ensuring privacy and confidentiality were considered.

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