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Conceptualizing Next-Gen Supply Chains: Embracing the Platform Paradigm

Mohammad Milad Ahmadi[1,*], Seyed Ahmad Shayannia[2]

This study explores the implementation of virtual platforms in supply chain management, emphasizing online production, procurement, and distribution without traditional factory infrastructures. A qualitative descriptive-survey approach, with inductive reasoning, was employed to analyze the perspectives of industry experts. The research identifies key dimensions for enhancing supply chain performance: Digital Integration, Stakeholder Coordination, Edge Computing, Data Analytics, and Agility Management. Through thematic analysis, 139 initial codes were extracted, which were then refined into 25 categories and further grouped into 5 main themes. The findings underscore the importance of flexibility and agility in responding to market disruptions. Key insights include the necessity of real-time data exchange, advanced analytics for demand forecasting, and the integration of edge computing for operational resilience. Practical recommendations focus on deploying simulation tools, developing logistics optimization algorithms, and ensuring robust cybersecurity protocols to safeguard sensitive data. This research contributes to the understanding of virtual platforms as transformative enablers in supply chain management, offering actionable solutions for enhancing efficiency, reducing costs, and boosting competitiveness.

Keywords: *Virtual Platform, Supply Chain Management, Factory-less Production, Digital Integration, Operational Agility.*

1. Introduction

In today's rapidly evolving environment, advances in information and communication technologies (ICT)—notably the Internet of Things (IoT), artificial intelligence (AI), blockchain, and cloud computing—have spurred transformative changes in production and distribution methods (Shah et al., [29]). These innovations have redefined conventional notions of time and space, challenged traditional industrial models and given rise to novel managerial paradigms. One such paradigm is the virtual platform in supply chain management, which employs digital infrastructures to seamlessly coordinate manufacturers, suppliers, and distributors without relying on physical factories (Dixit et al., [9]). This shift not only boosts operational efficiency and reduces costs but also enhances flexibility and enables rapid responses to market fluctuations (Khan et al., [19]).

The evolution of the supply chain is considered inevitable in today's competitive business landscape. With rapid market changes and escalating customer demands, organizations are compelled to adopt innovative and cost-effective solutions. The virtual platform acts as a digital framework that integrates various processes and enables real-time information sharing, thereby fostering improved transparency, reduced response times, and enhanced accuracy in production and distribution planning (Mageto, [22]). By facilitating seamless data exchange among supply chain actors, the virtual

[*] Corresponding Author.
[1] Department of Management, SR.C., Islamic Azad University, Tehran, Iran, Email: mo_ahmadi@iau.ac.ir.
[2] Department of Management, Fi.C., Islamic Azad University, Tehran, Iran, Email: sa.shayannia@iau.ac.ir.

platform minimizes dependency on physical infrastructures and creates new opportunities for innovation and growth (Fang et al., [13]).

Despite its many advantages, the adoption of digital platforms introduces significant challenges. Modern supply chains are characterized by decentralized operations, where suppliers, manufacturers, and distributors often function independently. This fragmentation can lead to misalignment between demand and supply, diminished transparency, and increased managerial costs (Lugaresi et al., [21]). Furthermore, transitioning to an online, factory-less production model requires substantial changes in organizational culture and widespread adoption of new technologies. Data security and privacy remain critical concerns in these digital environments, necessitating robust measures to protect sensitive information (Khan et al., [19]).

A major strength of the virtual platform lies in its capacity for instantaneous data sharing. Key information—including inventories, orders, demand forecasts, production schedules, and transportation logistics—can be exchanged in real time, thereby enhancing coordination among supply chain stakeholders (Tran and Kim, [34]). This real-time integration not only improves operational oversight through precise product tracking from production to final delivery but also significantly enhances quality control. By reducing reliance on physical infrastructures such as factories, machinery, and extensive human resources, virtual platforms drive cost savings while fostering a dynamic environment for innovation (Fang et al., [13]).

However, the effectiveness of a virtual platform is contingent upon the establishment of integrated data exchange standards and robust security protocols. Without standardized practices and mutual trust among business partners, the flow of information can be disrupted, undermining overall supply chain effectiveness (Hur and Yoon, [16]). To mitigate such risks, organizations must prioritize the development of comprehensive protocols and invest in advanced cybersecurity measures that safeguard data integrity and promote seamless communication.

Another critical component of digital transformation in supply chain management is the application of advanced analytical tools. Virtual platforms facilitate the collection and processing of vast volumes of real-time data, enabling the extraction of valuable insights that support demand forecasting, inventory optimization, and proactive issue resolution. Advanced analytics, powered by mathematical models and AI algorithms, provide decision-makers with precise, data-driven insights that enhance production planning and inventory control. By optimizing inventory levels and preventing both shortages and surpluses, these insights contribute significantly to overall supply chain efficiency (Tsunoda and Zennyo, [35]).

In addition to operational improvements, the virtual platform plays a crucial role in managing flexibility and agility. In today's volatile market conditions, the ability to respond rapidly to unexpected disruptions is essential. The platform's real-time capabilities allow organizations to swiftly detect and react to supply chain disturbances, such as identifying alternative suppliers when a disruption occurs and promptly adjusting production schedules. This agile response minimizes the negative impact of disruptions, reduces associated costs, and bolsters the overall resilience of the supply chain (Varelas, [36]).

The strategic benefits of virtual platforms extend beyond mere cost reduction and operational efficiency. By fostering an environment of transparency and coordination, digital platforms help organizations achieve a sustainable competitive advantage. Firms that integrate virtual platforms into their supply chain operations not only reduce production and distribution costs but also enhance service quality and responsiveness. This positions them favorably in global markets, where rapid adaptation to change is crucial (Jiao and Deng, [17]).

Delays in adopting virtual platforms can result in missed opportunities and a diminished competitive edge. Organizations that fail to develop integrated digital infrastructures risk facing escalating operational costs, reduced planning accuracy, and slower responses to market changes. Consequently, both managerial and technical aspects—such as investing in modern tools, comprehensive training, and establishing robust communication channels—must be addressed to maximize the benefits of digital transformation (Tiedemann, [33]).

In summary, the virtual platform represents a revolutionary paradigm shift in supply chain management. By seamlessly integrating digital technologies with real-time data exchange and advanced analytics, it enhances transparency, reduces operational delays, and significantly boosts responsiveness to market disruptions. The elimination of dependence on traditional physical infrastructures not only drives substantial cost savings but also fosters continuous innovation and agility. This integrated approach enables organizations to optimize decision-making, streamline production and distribution processes, and maintain a competitive edge in a rapidly changing global environment (Kim et al., [20]).

The primary objective of this research is to conceptualize and validate the virtual platform as an effective model for online production, procurement, and distribution. Employing a qualitative interpretive methodology, the study utilized thematic analysis to systematically extract and refine key codes from expert interviews, culminating in the construction of a comprehensive thematic network. This approach allowed for an in-depth exploration of the interplay between digital integration, advanced data management, and supply chain agility. The resulting framework not only offers practical solutions for addressing current challenges but also provides strategic insights that can guide organizations in their digital transformation efforts, ensuring sustainable improvements in supply chain performance.

2. Literature Review and Research Background

Rapid advances in information and communication technology—and the emergence of new technologies such as the Internet of Things, artificial intelligence, blockchain, and cloud computing—have created new grounds in the field of supply chain management. These technological innovations have not only challenged traditional supply chain concepts but also enabled significant performance improvements and cost reductions. In this section, by reviewing both theoretical literature and empirical research, a comprehensive framework is developed to understand the enhancement of production, procurement, and distribution processes through the adoption of new technologies (Birkel and Müller, [4]; Erkayman et al., [12]).

2.1. Theoretical Foundations and Definitions

The supply chain is defined as the set of activities, processes, resources, and communications among suppliers, manufacturers, distributors, and customers. This system spans all stages—from procuring raw materials, production, warehousing, and transportation, to delivering the final product or service. The primary objectives of supply chain management are to improve efficiency, reduce costs, and increase product quality (Riquelme-Medina et al., [24]). Figure 1 provides a simplified representation of the supply chain in its entirety.

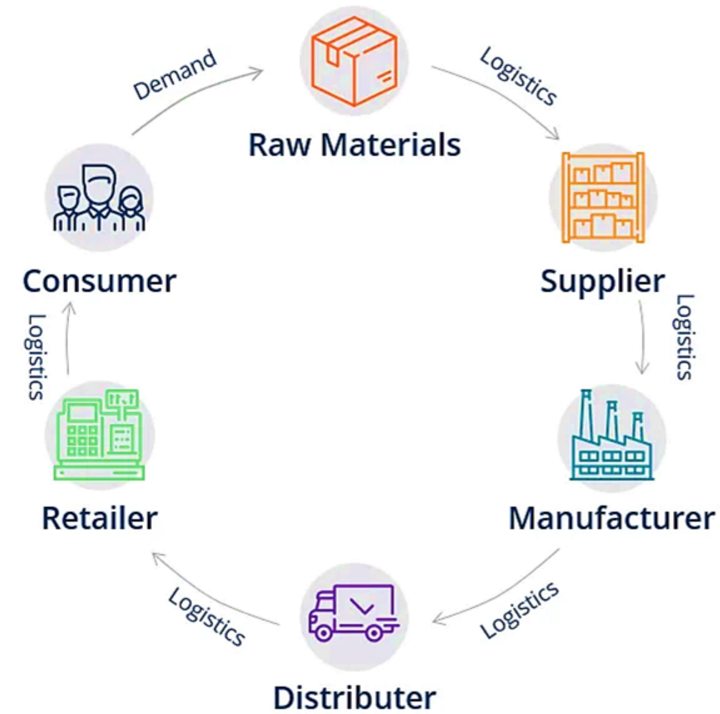

Figure 1. The Main Components that Form the Supply Chain (CFI, [39])

At its core, supply chain management involves coordinating and integrating various activities along the chain, thereby creating a dynamic ecosystem where knowledge and information are shared simultaneously among all members (Fridell, [14]). This conceptual foundation is critical for understanding how digital innovations can further enhance these processes.

2.2. Components of the Supply Chain and Technological Transformation

Fundamental to understanding the modern supply chain is the identification of its key components: suppliers, manufacturers, distributors, warehousing and logistics services, customers, processes, technologies, and communication systems. The coordinated interaction among these elements enhances overall system efficiency and reduces costs (Riquelme-Medina et al., [24]). With the advent of new technologies, several dimensions of the supply chain have been transformed. Digital systems for inventory management, demand forecasting, and production planning have increased transparency and improved decision-making. Modern information technologies facilitate real-time monitoring of supply chain processes, thereby enhancing communication among all actors (Bagus et al., [2]). This technological transformation not only optimizes traditional functions but also redefines them, making the supply chain more responsive and resilient.

2.3. Theoretical Approaches in Supply Chain Management

The literature presents various theoretical frameworks for analyzing and enhancing supply chain performance. Key approaches include:

- Evolutionary Theory: Emphasizes the continuous adaptation of the supply chain to environmental changes and the enhancement of competitive capabilities through innovation.
- Catch-up Theory: Focuses on close collaboration with suppliers and the use of shared knowledge to improve design and production processes (de Vass et al., [8]).

- Efficiency Theory: Concentrates on process optimization, cost reduction, and productivity improvements.
- Coordination Theory: Highlights the importance of synchronizing information, processes, and joint decision-making as a critical factor for improving supply chain performance (Dutta et al., [10]).
- Trust Theory: Stresses building trust and fostering long-term cooperation among supply chain members to enhance flexibility and mitigate risks (Bagus et al., [2]).

These approaches serve as the theoretical underpinnings for precise analysis and innovation, guiding both researchers and practitioners in developing strategies that respond effectively to evolving market demands.

2.4. Digital Innovations in the Supply Chain

The rise of digital technologies has ushered in transformative innovations in supply chain management. Key developments include:

- Digitalization: The use of information technologies to improve communication, monitor processes, and enhance operational efficiency. Tools such as AI, IoT, and data mining facilitate accurate demand forecasting, inventory optimization, and the reduction of human errors (Shah et al., [28]; Bamdadsofi et al., [3]).
- Virtual Platforms: As digital environments that enable the execution of programs and services without reliance on physical infrastructures, virtual platforms are pivotal in modern supply chains. They leverage virtualization technologies such as virtual machines and containers to integrate production, procurement, and distribution processes (Varelas, [36]; Jiao and Deng, [17]).
- Online and Factory-less Production: By utilizing automation, IoT, and AI, this approach enables customized and optimized production without the need for traditional factories. It leads to reduced costs, increased production speed, and improved product quality, allowing companies to respond swiftly to market changes (Wang et al., [37]; Jiao and Deng, [17]). Coyle and Nguyen [6] in their study presented a highly illustrative schematic model of what they refer to as factory-less goods producers (FGPs). In this model, international orders and the producers' factory-less capacities are effectively represented (Figure 2).

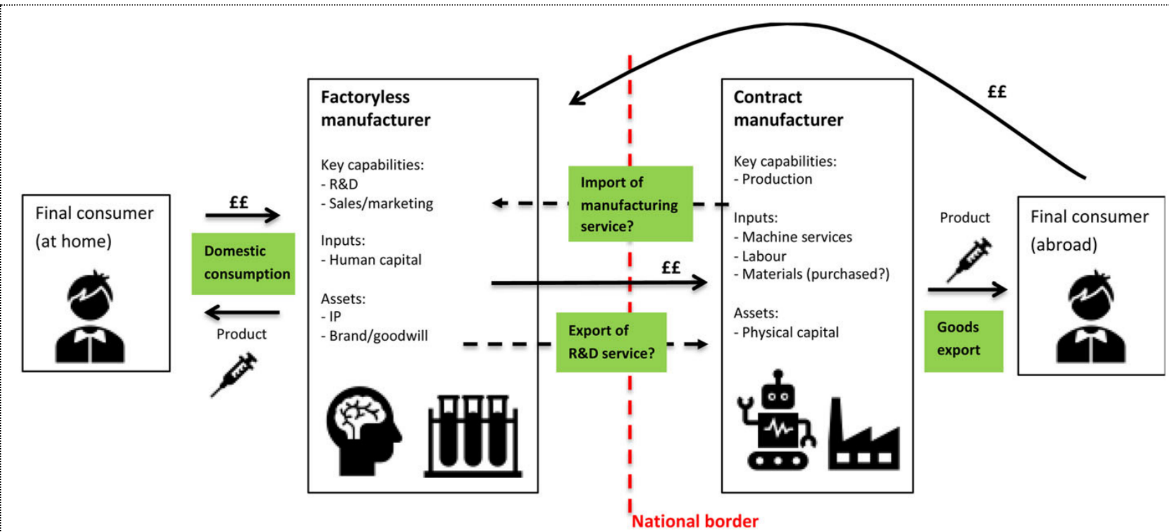

Figure 2. Schematic Representation of the Factory-Less Goods Production (Coyle and Nguyen, [6])

Collectively, these innovations pave the way for the development of dynamic, flexible, and efficient managerial systems that offer a competitive edge for organizations (Sadeghi et al., [25]).

2.5. Review of Empirical Studies

Empirical research in supply chain management and digital innovation provides a rich understanding of both conceptual and practical issues. For instance, Taherkhani and Amouzad Khalili [31] employed the innovation diffusion and technology–organization–environment framework to identify 17 factors influencing blockchain adoption, offering valuable insights for executive policy formulation. Sayadi et al. [27] examined IoT applications using multi-criteria decision-making approaches, emphasizing the critical roles of monitoring perishable products, safeguarding employee health, and managing production lines. Additionally, Ehtesham Rasi et al. [11] used structural equation modeling to demonstrate how cloud computing positively impacts cost-effectiveness, delivery quality, system integration, and environmental flexibility in the construction industry.

Research by Hajipour and Rahbarjou [15] further highlights the integrative effects of IoT, blockchain, and AI on supply chain performance, while studies on online production reveal that automation and AI lead to customized manufacturing, cost reductions, and improved delivery times (Hur and Yoon, [16]). These studies, while comprehensive, also expose gaps—such as challenges in data security, integration barriers, and cultural resistance to technological change—which underscore the need for a more integrated framework.

2.6. Review of Empirical Studies

Although digital transformation in supply chain management has gained significant attention, notable gaps persist in understanding the integration of emerging technologies with traditional management models. Despite advancements in areas such as IoT, AI, blockchain, and cloud computing, there is a lack of comprehensive exploration into how these technologies can be cohesively integrated to optimize the entire supply chain process. Many studies have focused on the impact of individual technologies, but they have not addressed the operational, cultural, and security challenges associated with their integration into established supply chain management practices.

A second gap pertains to real-time data transfer and the assurance of information security within digital environments. Although digital platforms offer significant potential for enhancing supply chain performance through faster and more accurate decision-making, challenges related to data security and the seamless transfer of information across decentralized networks remain inadequately addressed. Furthermore, the cultural and organizational resistance to adopting new technologies often hinders the full potential of digital transformation, necessitating more research into effective change management strategies.

Finally, there is a clear need for an integrated framework that synthesizes multiple theoretical approaches—such as evolutionary theory, efficiency theory, coordination theory, and trust theory. This framework should offer a comprehensive solution to the challenges faced by organizations in leveraging digital technologies for supply chain optimization.

The present research addresses these gaps by proposing an innovative, integrated framework that leverages the benefits of virtual platforms and online production. By synthesizing diverse theoretical perspectives and empirical findings, this study introduces a holistic model that not only reduces costs and increases efficiency but also enhances coordination among supply chain members. Through expert interviews and thematic analysis, the research develops key themes such as Digital Integration, Stakeholder Coordination, Data Transparency, and Agility Management. These themes form the foundation of the proposed framework, which offers practical managerial solutions to the identified gaps and presents a roadmap for organizations seeking to implement digital platforms for improving supply chain performance.

This research makes a significant contribution by filling the gaps in the existing literature and offering actionable insights that can guide organizations through their digital transformation journeys. By synthesizing different theoretical perspectives and empirical findings, the study provides new directions for future research and practical solutions for enhancing supply chain agility, resilience, and competitiveness.

3. Research Methodology

In this study, the methodological framework is comprehensively presented to examine the phenomenon of conceptualizing the virtual platform in supply chain management—with a focus on online factory-less production, procurement, and distribution. The research adopts an applied, descriptive survey design with a qualitative approach and inductive reasoning. Its primary objective is to develop applied knowledge in the field of supply chain management and improve performance through the utilization of new technologies. Given the complexity of the phenomena under investigation, qualitative methods are essential for achieving a deep and comprehensive interpretation. An interpretivism philosophy underpins this research, which views reality as a subjective and social construct, interpreting individuals' experiences and conceptualizations within their cultural, social, and historical contexts (Creswell and Poth, [7]).

Data were collected using semi-structured interviews combined with library studies. In the interviews, the main research questions were initially determined, and through flexible adjustments during the sessions, a conversational space was created that facilitated the extraction of rich opinions and experiences from the participants (Sarmad et al., [26]). The sample was selected purposefully and non-randomly from a population of prominent supply chain management experts who met specific criteria, including holding a master's or doctoral degree and possessing at least five years of relevant experience. Data collection continued until saturation was reached, ensuring that no significant new insights emerged.

Data analysis was primarily conducted using thematic analysis, following the systematic approach outlined by Braun and Clarke [5]. The process began with the researcher becoming deeply familiar with the textual data through repeated readings (familiarization phase). Subsequently, initial codes were generated across the entire dataset by identifying and labeling significant features of the data relevant to the research questions (generating initial codes phase). This involved segmenting the data into meaningful semantic units.

Following initial coding, the analysis moved into the searching for themes phase, where codes were collated and grouped based on similarity and patterns to identify potential themes. This iterative process involved moving between the codes and the dataset. These potential themes were then systematically reviewed and refined by checking them against the coded extracts and the entire dataset (reviewing themes phase). This ensured themes were coherent, distinct, and accurately captured the essence of the data. During the defining and naming themes phase, the specifics of each theme were refined, and clear definitions and names were assigned, resulting in the final set of organizing and overarching themes. The use of a thematic network as a visual tool further aided in understanding and illustrating the interrelationships among the concepts extracted from the data (Ahmadi and Mohammadi, [1]). This systematic and rigorous analysis was informed by well-established methodologies (Braun and Clarke, [5]; Nowell et al., [23]).

To ensure the validity and reliability of the qualitative data, several strategies were employed. The accuracy and consistency of the findings were verified using data source triangulation, member checking, and providing detailed, rich descriptions. In addition, continuous discussions with academic colleagues and feedback from external reviewers helped to mitigate any potential biases (Creswell and Poth, [7]). The analysis also included an examination of demographic characteristics such as average age, work experience, and education, which confirmed that the participants were sufficiently expert in supply chain management and that the data effectively captured the depth of the subject matter.

Finally, the interpretation and conclusion drawn from the analyzed data have been presented as a coherent narrative (producing the report phase). Through qualitative analysis, the researcher identified patterns, themes, and key concepts, which were synthesized into a comprehensive theoretical framework. This framework not only offers practical solutions for enhancing supply chain performance via the utilization of virtual platforms and online production but also serves as a reference for the development of applied knowledge in this field. Overall, by employing semi-structured interviews and rigorous thematic analysis—and by incorporating established methodologies (Braun and Clarke, [5]; Nowell et al., [23])—this study adheres to scientific standards and presents a methodologically sound approach that can serve as a valuable reference for future research in supply chain management and digital technology utilization.

4. Findings

4.1. Open Coding (Generating Initial Codes)

In Table 1, a portion of the texts from Interviewee No. 1 is reported. To prevent the article from becoming excessively long, only this sample of the interview texts is presented.

Table 1. Part of the Interview Texts of Interviewee No. 1

Summarized Interview Text No. 1
"I believe that developing digitalization indicators for the supply chain through the implementation of a virtual platform in supply chain management—with the aim of improving online production, procurement, and distribution—can lead to improvements in the performance and efficiency of the supply chain in various ways. By developing digital indicators related to data analysis, organizations can use the collected information to forecast trends, improve processes, and optimize decision-making. This results in enhanced production, procurement, and distribution of products. With the use of digital indicators associated with artificial intelligence and machine learning, improvements in demand forecasting, inventory optimization, pattern recognition, and process efficiency can be achieved. These tools help organizations to operate their activities automatically and with greater accuracy. By developing indicators related to online inventory tracking, organizations can experience improvements in inventory management, waste reduction, and shorter delivery times. By applying indicators related to blockchain technology, supply chain information becomes transparent and reliable, which increases trust among supply chain members and facilitates improvements in procurement and distribution. By developing indicators related to enhancing communications and coordination, organizations can improve their interactions and create greater alignment among supply chain members, thus helping improve production and distribution. In light of the above, the development of digitalization indicators for the supply chain through the implementation of a virtual platform in supply chain management can facilitate improvements in production, procurement, and distribution, and enable organizations to respond to market needs more agilely and efficiently. Increasing the speed of data processing through the implementation of a virtual platform in supply chain management can lead to significant improvements in production, procurement, and distribution. Higher data processing speed results in increased operational efficiency and productivity within the supply chain. This helps reduce waiting times, improve production planning, and optimize processes. Faster data processing allows data-driven decisions to be made more quickly and accurately, which in turn contributes to improved production, procurement, and distribution. With higher

Summarized Interview Text No. 1
data processing speed, one can experience better demand forecasting, inventory optimization, pattern recognition, and process efficiency, ultimately leading to improved procurement and distribution. Moreover, faster data processing enables the implementation of artificial intelligence and machine learning solutions to enhance forecasting, decision-making, and overall supply chain efficiency. With increased processing speed, it becomes possible to track and control improvements in the supply chain in the best possible manner. Therefore, increasing data processing speed through the implementation of a virtual platform in supply chain management can facilitate improvements in production, procurement, and distribution, allowing organizations to meet market needs with greater accuracy and speed. Additionally, the percentage of smart equipment connected to the virtual platform in supply chain management can have a significant impact on enhancing performance in production, procurement, and distribution. Connecting smart equipment to the virtual platform enables the collection and analysis of more data, which helps improve decision-making accuracy and planning. With access to more data from smart equipment, demand forecasting can be improved, leading to enhanced production and distribution. The connection of smart equipment increases automation in processes, ultimately resulting in improved efficiency and productivity. Access to data from smart equipment facilitates better internal communication as well as communication with suppliers and customers. However, the percentage of smart equipment connectivity to the virtual platform depends on the industry type, organization size, and the specific needs of the supply chain. If an organization possesses a large amount of smart equipment, higher connectivity of these devices can further contribute to improved performance and efficiency. Nonetheless, it is always necessary to precisely evaluate the needs and resources required for these connections to achieve the best results."

Table 2 reports the codes extracted from the interview, which are based on the text of the interviews conducted with the questioned expert No. 1 and the content codes derived from that text.

Table 2. Codes Extracted from Interview No. 1

Row	Research Objective	Initial Extracted Codes
1	Designing and implementing a virtual platform for production, procurement, and distribution in the supply chain	Developing digitalization indicators for supply chain performance
2		Data analysis to enhance decision-making via supply chain digitalization
3		Implementation of artificial intelligence (AI) and machine learning (ML) systems
4		Artificial intelligence for enhanced demand forecasting, inventory optimization, and pattern recognition
5		Supply chain digitalization enabling online inventory tracking and monitoring
6		Utilizing blockchain technology to enhance supply chain transparency
7		Supply chain digitalization for improved communication and coordination
8		The virtual platform for enhanced data processing speed
9		Higher data processing speed leading to increased efficiency and productivity
10		Higher data processing speed facilitating faster and more accurate decision-making

Row	Research Objective	Initial Extracted Codes
11		Higher data processing speed enabling improved forecasting and optimization
12		Implementation of artificial intelligence (AI) solutions leveraging higher data processing speed
13		Increased data processing speed for enhanced monitoring and control of improvements
14		Smart equipment connectivity rate to the virtual platform
15		Connection of smart equipment leading to increased data volume and accuracy
16		Access to increased data from smart equipment for enhanced demand forecasting accuracy
17		Smart equipment integration enabling increased automation in supply chain operations
18		Access to real-time data from smart equipment for improved communication
19		Smart equipment connectivity for enhanced tracking and control capabilities

Table 3 reports the codes extracted from the interview, which are based on the text of the interviews conducted with the questioned expert No. 2 and the content codes derived from that text.

Table 3. Codes Extracted from Interview No. 2

Row	Research Objective	Initial Extracted Codes
1	Designing and implementing a virtual platform for production, procurement, and distribution in the supply chain	Enhanced data protection through increased cybersecurity measures
2		Increased cybersecurity for attack prevention
3		Ensuring supplier and supply chain network security through cybersecurity measures
4		Cybersecurity development enabling improved access management
5		Enhanced cybersecurity for rapid attack detection and response
6		Implementing security standards with enhanced cybersecurity measures
7		Cloud computing for enhanced supply chain flexibility
8		Cloud computing for cost reduction in the supply chain
9		Cloud computing and virtual platform implementation for enhanced collaboration
10		Cloud computing enhancing data accessibility
11		Normalized cloud services for enhanced security
12		Cloud computing for simplified management
13		Access to transparent information for improved communication and collaboration
14		Access to transparent information enabling improved needs forecasting
15		Increased access to transparent information for reduced delays
16		Access to transparent supply chain performance and operations data for improved risk management

Table 4 reports the codes extracted from the interview, which are based on the text of the interviews conducted with the questioned expert No. 3 and the content codes derived from that text.

Table 4. Codes Extracted from Interview No. 3

Row	Research Objective	Initial Extracted Codes
1	Designing and implementing a virtual platform for production, procurement, and distribution in the supply chain	Facilitating supplier coordination and information transmission for virtual platform implementation
2		Enhanced transparency and data transmission among supply chain members
3		Virtual platform for active communication and information exchange
4		Development of supplier coordination indicators for improved monitoring and control
5		Establishing common standards and coordination criteria among suppliers
6		Improved supplier coordination for cost reduction
7		Virtual platform implementation for reduced order cycle time
8		Enhanced communication and coordination among suppliers and other supply chain members
9		Leveraging new technologies through the virtual platform
10		Establishing common standards for ordering, production, and distribution processes
11		Enhanced monitoring and control of processes and supplier performance
12		Facilitating communication among supply chain stakeholders
13		Enhanced transparency and accessibility of information for stakeholders
14		Virtual platform enabling faster and more efficient processes for stakeholders
15		Virtual platform for improved demand forecasting
16		Reducing errors and problems in the supply chain

Table 5 reports the codes extracted from the interview, which are based on the text of the interviews conducted with the questioned expert No. 4 and the content codes derived from that text.

Table 5. Codes Extracted from Interview No. 4

Row	Research Objective	Initial Extracted Codes
1	Designing and implementing a virtual platform for production, procurement, and distribution in the supply chain	Facilitating real-time data sharing across the supply chain
2		Real-time data sharing for enhanced decision-making
3		Real-time data sharing enabling time and cost reduction
4		Real-time data sharing for enhanced coordination
5		Real-time data sharing for improved forecasting accuracy
6		Accurate demand forecasting for enhanced planning
7		Precise demand forecasting for reduced excess inventory
8		Accurate demand forecasting leading to increased customer satisfaction
9		Precise demand forecasting for improved supply-demand balance

Row	Research Objective	Initial Extracted Codes
10		Accurate demand forecasting enabling increased supply chain flexibility
11		Timely and accurate data analysis for enhanced forecasting accuracy
12		Optimized data analysis for reduced delay times
13		Accurate and reliable data for enhanced decision-making
14		Precise data analysis leading to increased productivity
15		Precise data analysis for increased conformity to standards

Table 6 reports the codes extracted from the interview, which are based on the text of the interviews conducted with the questioned expert No. 5 and the content codes derived from that text.

Table 6. Codes Extracted from Interview No. 5

Row	Research Objective	Initial Extracted Codes
1	Designing and implementing a virtual platform for production, procurement, and distribution in the supply chain	Focus on data quality metrics
2		Utilizing accurate and error-free data for analysis
3		Utilizing complete and comprehensive data sets
4		Ensuring data accessibility and usability for informed decision-making
5		Utilizing integrated and consistent data from diverse sources
6		Ensuring the use of reliable and verified data for analysis
7		Virtual platform and precise data analysis for enhanced forecasting accuracy
8		Data analysis and optimization algorithms for optimized inventory adjustment
9		Reducing virtual platform inventory for increased productivity
10		Decreasing excess virtual platform inventory for cost reduction
11		Reduced excess virtual platform inventory for faster distribution and procurement
12		Predictive analysis indicators for enhanced demand forecasting accuracy
13		Development of predictive analysis indicators for inventory optimization
14		Utilizing predictive analysis indicators for increased productivity
15		Improved inventory management and optimized inventories for cost reduction
16		Obtaining more accurate predictive analysis for faster distribution and procurement

Table 7 reports the codes extracted from the interview, which are based on the text of the interviews conducted with the questioned expert No. 6 and the content codes derived from that text.

Table 7. Codes Extracted from Interview No. 6

Row	Research Objective	Initial Extracted Codes
1	Designing and implementing a virtual platform for	Minimizing supply chain reaction time to disruptions
2		Ensuring access to accurate and timely information via the virtual platform

Row	Research Objective	Initial Extracted Codes
3	production, procurement, and distribution in the supply chain	Enhanced inventory visibility through the virtual platform and related technologies
4		Virtual platform implementation for enhanced coordination
5		Utilizing available data and information for proactive issue forecasting and prevention
6		Decreased reaction time to disruptions for minimized delays
7		Facilitating agile coordination and collaboration across the supply chain
8		Increased supply chain agility for reduced delivery time
9		Development of agility indicators for rapid response to market changes
10		Increased supply chain agility for improved reliability
11		Improved supply chain agility for cost reduction

Table 8 reports the codes extracted from the interview, which are based on the text of the interviews conducted with the questioned expert No. 7 and the content codes derived from that text.

Table 8. Codes Extracted from Interview No. 7

Row	Research Objective	Initial Extracted Codes
1	Designing and implementing a virtual platform for production, procurement, and distribution in the supply chain	Rapid fulfillment of urgent orders for increased delivery speed
2		Enabling rapid order fulfillment for minimized reaction time
3		Ability to quickly fulfill orders for enhanced flexibility
4		Rapid fulfillment of urgent orders for improved inventory management
5		Rapid order fulfillment leading to increased competitiveness
6		Increased production flexibility for enhanced reaction speed
7		Ability to quickly change production units for minimized order modification time
8		Optimized inventory to enable production flexibility
9		Enhanced production flexibility for improved product quality
10		Emphasizing cost considerations related to sudden changes
11		Addressing potential production inefficiencies associated with increased production flexibility

Table 9 reports the codes extracted from the interview, which are based on the text of the interviews conducted with the questioned expert No. 8 and the content codes derived from that text.

Table 9. Codes Extracted from Interview No. 8

Row	Research Objective	Initial Extracted Codes
1	Designing and implementing a virtual platform for production, procurement, and distribution in the supply chain	Application of scenario simulation techniques for analysis
2		Scenario simulation for enhanced planning
3		Scenario simulation for risk reduction
4		Scenario simulation leading to increased productivity
5		Scenario simulation for enhanced training and preparedness
6		Scenario simulation for enhanced decision-making
7		Intelligent optimization of logistics routes for efficiency
8		Intelligent logistics route optimization for reduced delivery time

Row	Research Objective	Initial Extracted Codes
9		Logistics route optimization for cost reduction
10		Utilizing smart technologies for logistics route optimization
11		Optimized logistics routes for enhanced inventory adjustment
12		Optimized logistics routes for improved organization of processes

Table 10 reports the codes extracted from the interview, which are based on the text of the interviews conducted with the questioned expert No. 9 and the content codes derived from that text.

Table 10. Codes Extracted from Interview No. 9

Row	Research Objective	Initial Extracted Codes
1	Designing and implementing a virtual platform for production, procurement, and distribution in the supply chain	Smart inventory management for accurate demand forecasting
2		Smart inventory management for optimized inventory adjustment
3		Smart inventory management for optimized workflow
4		Smart inventory management for improved risk management
5		Smart inventory management for enhanced customer service
6		Enhanced accuracy in predicting virtual platform disruptions
7		Preventing virtual platform disruptions through accurate prediction
8		Proactive disruption forecasting and prevention for enhanced communication
9		Accurate disruption prediction for enhanced response time
10		Proactive disruption management for cost reduction
11		Prediction of potential disruptions for enhanced security
12		Establishing infrastructure for the physical and cybersecurity of the virtual platform

Table 11 reports the codes extracted from the interview, which are based on the text of the interviews conducted with the questioned expert No. 10 and the content codes derived from that text.

Table 11. Codes Extracted from Interview No. 10

Row	Research Objective	Initial Extracted Codes
1	Designing and implementing a virtual platform for production, procurement, and distribution in the supply chain	Implementing process automation within the virtual platform
2		Process automation leading to increased productivity
3		Process automation for error reduction
4		Process automation for reduced time and costs
5		Process automation enabling enhanced flexibility
6		Process automation for increased transparency
7		Real-time quality control for prompt identification of issues
8		Real-time quality control for cost reduction
9		Enhancing product and service quality for improved customer satisfaction
10		Real-time quality control for enhanced credibility and trust
11		Real-time quality control for enhanced operational performance

4.2. Searching for Themes (Generating Categories)

Following the generation of 139 initial codes from the interview data, the analysis proceeded to the "searching for themes" phase. The initial codes were systematically reviewed, compared, and grouped in this stage based on shared concepts and recurring patterns. This process resulted in identifying 25 potential themes (or initial categories). These potential themes represent the key patterns emerging from the data by grouping related initial codes, and they form the basis for further refinement and definition. They are presented in Table 12.

Table 12. Categories Extracted from Primary Codes

Row	Extracted Categories	Related Initial Codes
1	Development of Digitalization Indicators for Supply Chain Performance	• Developing digitalization indicators for supply chain performance • Data analysis to enhance decision-making via supply chain digitalization • Supply chain digitalization enabling online inventory tracking and monitoring • Supply chain digitalization for improved communication and coordination
2	Data Processing Speed Enhancement	• The virtual platform for enhanced data processing speed • Higher data processing speed leading to increased efficiency and productivity • Higher data processing speed facilitating faster and more accurate decision-making • Higher data processing speed enabling improved forecasting and optimization • Implementation of artificial intelligence (AI) solutions leveraging higher data processing speed • Increased data processing speed for enhanced monitoring and control of improvements
3	Percentage of Smart Equipment Connectivity to Virtual Platform	• Smart equipment connectivity rate to the virtual platform • Connection of smart equipment leading to increased data volume and accuracy • Smart equipment connectivity for enhanced tracking and control capabilities
4	Enhanced Cybersecurity Level	• Enhanced data protection through increased cybersecurity measures • Increased cybersecurity for attack prevention • Ensuring supplier and supply chain network security through cybersecurity measures • Cybersecurity development enabling improved access management • Enhanced cybersecurity for rapid attack detection and response • Implementing security standards with enhanced cybersecurity measures

Row	Extracted Categories	Related Initial Codes
		• Establishing infrastructure for the physical and cybersecurity of the virtual platform
5	Percentage of Cloud Computing Adoption in Supply Chain	• Cloud computing for enhanced supply chain flexibility • Cloud computing for cost reduction in the supply chain • Cloud computing and virtual platform implementation for enhanced collaboration • Cloud computing enhancing data accessibility • Normalized cloud services for enhanced security • Cloud computing for simplified management
6	Development of Information Transparency Indicators	• Utilizing blockchain technology to enhance supply chain transparency • Access to transparent information for improved communication and collaboration • Access to transparent information enabling improved needs forecasting • Increased access to transparent information for reduced delays • Access to transparent supply chain performance and operations data for improved risk management • Enhanced transparency and data transmission among supply chain members • Enhanced transparency and accessibility of information for stakeholders • Process automation for increased transparency
7	Development of Supplier Coordination Indicators	• Supply chain digitalization for improved communication and coordination • Facilitating supplier coordination and information transmission for virtual platform implementation • Development of supplier coordination indicators for improved monitoring and control • Establishing common standards and coordination criteria among suppliers • Improved supplier coordination for cost reduction • Enhanced communication and coordination among suppliers and other supply chain members • Real-time data sharing for enhanced coordination • Virtual platform implementation for enhanced coordination • Facilitating agile coordination and collaboration across the supply chain
8	Order Cycle Time Reduction	• Virtual platform implementation for reduced order cycle time • Establishing common standards for ordering, production, and distribution processes

Row	Extracted Categories	Related Initial Codes
		• Rapid fulfillment of urgent orders for increased delivery speed • Enabling rapid order fulfillment for minimized reaction time • Ability to quickly fulfill orders for enhanced flexibility • Rapid fulfillment of urgent orders for improved inventory management • Rapid order fulfillment leading to increased competitiveness • Ability to quickly change production units for minimized order modification time
9	Development of Stakeholder Satisfaction Indicators	• Facilitating communication among supply chain stakeholders • Enhanced transparency and accessibility of information for stakeholders • Virtual platform enabling faster and more efficient processes for stakeholders
10	Percentage of Real-Time Data Sharing Across Supply Chain	• Access to real-time data from smart equipment for improved communication • Facilitating real-time data sharing across the supply chain • Real-time data sharing for enhanced decision-making • Real-time data sharing enabling time and cost reduction • Real-time data sharing for enhanced coordination • Real-time data sharing for improved forecasting accuracy • Real-time quality control for prompt identification of issues • Real-time quality control for cost reduction • Real-time quality control for enhanced credibility and trust • Real-time quality control for enhanced operational performance
11	Enhanced Accuracy in Demand Forecasting	• Artificial intelligence for enhanced demand forecasting, inventory optimization, and pattern recognition • Access to increased data from smart equipment for enhanced demand forecasting accuracy • Virtual platform for improved demand forecasting • Accurate demand forecasting for enhanced planning • Precise demand forecasting for reduced excess inventory • Accurate demand forecasting leading to increased customer satisfaction

Row	Extracted Categories	Related Initial Codes
		• Precise demand forecasting for improved supply-demand balance • Accurate demand forecasting enabling increased supply chain flexibility • Predictive analysis indicators for enhanced demand forecasting accuracy • Smart inventory management for accurate demand forecasting
12	Reduction in Data Analysis Duration	• Data analysis to enhance decision-making via supply chain digitalization • Timely and accurate data analysis for enhanced forecasting accuracy • Optimized data analysis for reduced delay times • Precise data analysis leading to increased productivity • Precise data analysis for increased conformity to standards • Virtual platform and precise data analysis for enhanced forecasting accuracy • Data analysis and optimization algorithms for optimized inventory adjustment
13	Data Quality Indicators	• Connection of smart equipment leading to increased data volume and accuracy • Timely and accurate data analysis for enhanced forecasting accuracy • Accurate and reliable data for enhanced decision-making • Precise data analysis leading to increased productivity • Precise data analysis for increased conformity to standards • Focus on data quality metrics • Utilizing accurate and error-free data for analysis • Utilizing complete and comprehensive data sets • Utilizing integrated and consistent data from diverse sources • Ensuring the use of reliable and verified data for analysis • Virtual platform and precise data analysis for enhanced forecasting accuracy
14	Rate of Excess Inventory Reduction in Virtual Platform	• Supply chain digitalization enabling online inventory tracking and monitoring • Precise demand forecasting for reduced excess inventory • Reducing virtual platform inventory for increased productivity • Decreasing excess virtual platform inventory for cost reduction

Row	Extracted Categories	Related Initial Codes
		• Reduced excess virtual platform inventory for faster distribution and procurement • Improved inventory management and optimized inventories for cost reduction • Enhanced inventory visibility through the virtual platform and related technologies • Rapid fulfillment of urgent orders for improved inventory management • Optimized inventory to enable production flexibility • Optimized logistics routes for enhanced inventory adjustment
15	Development of Predictive Analysis Indicators	• Predictive analysis indicators for enhanced demand forecasting accuracy • Development of predictive analysis indicators for inventory optimization • Utilizing predictive analysis indicators for increased productivity • Obtaining more accurate predictive analysis for faster distribution and procurement
16	Reduction in Reaction Time to Supply Chain Disruptions	• Minimizing supply chain reaction time to disruptions • Decreased reaction time to disruptions for minimized delays • Enhanced accuracy in predicting virtual platform disruptions • Preventing virtual platform disruptions through accurate prediction • Proactive disruption management for cost reduction
17	Development of Supply Chain Agility Indicators	• Increased supply chain agility for reduced delivery time • Development of agility indicators for rapid response to market changes • Increased supply chain agility for improved reliability • Improved supply chain agility for cost reduction
18	Rate of Rapid Urgent Order Fulfillment	• Rapid fulfillment of urgent orders for increased delivery speed • Rapid fulfillment of urgent orders for improved inventory management • Rapid fulfillment of urgent orders for increased delivery speed • Rapid fulfillment of urgent orders for improved • Rapid fulfillment of urgent orders for improved
19	Implementation of Production Flexibility Procedures	• Cloud computing for enhanced supply chain flexibility • Accurate demand forecasting enabling increased supply chain flexibility

Row	Extracted Categories	Related Initial Codes
		• Ability to quickly fulfill orders for enhanced flexibility • Increased production flexibility for enhanced reaction speed • Optimized inventory to enable production flexibility • Enhanced production flexibility for improved product quality • Addressing potential production inefficiencies associated with increased production flexibility • Process automation enabling enhanced flexibility
20	Percentage of Scenario Simulation Application	• Application of scenario simulation techniques for analysis • Scenario simulation for enhanced planning • Scenario simulation for risk reduction • Scenario simulation leading to increased productivity • Scenario simulation for enhanced training and preparedness • Scenario simulation for enhanced decision-making
21	Intelligent Optimization of Logistics Routes	• Artificial intelligence for enhanced demand forecasting, inventory optimization, and pattern recognition • Higher data processing speed enabling improved forecasting and optimization • Data analysis and optimization algorithms for optimized inventory adjustment • Development of predictive analysis indicators for inventory optimization • Intelligent optimization of logistics routes for efficiency • Intelligent logistics route optimization for reduced delivery time • Logistics route optimization for cost reduction • Utilizing smart technologies for logistics route optimization
22	Intelligent Inventory Management	• Artificial intelligence for enhanced demand forecasting, inventory optimization, and pattern recognition • Smart inventory management for accurate demand forecasting • Smart inventory management for optimized inventory adjustment • Smart inventory management for optimized workflow • Smart inventory management for improved risk management • Smart inventory management for enhanced customer service

Row	Extracted Categories	Related Initial Codes
		• Data analysis and optimization algorithms for optimized inventory adjustment • Development of predictive analysis indicators for inventory optimization
23	Enhanced Accuracy in Disruption Prediction	• Proactive disruption forecasting and prevention for enhanced communication • Accurate disruption prediction for enhanced response time • Prediction of potential disruptions for enhanced security
24	Implementation of Process Automation	• Smart equipment integration enabling increased automation in supply chain operations • Implementing process automation within the virtual platform • Process automation leading to increased productivity • Process automation for error reduction • Process automation for reduced time and costs • Process automation enabling enhanced flexibility • Process automation for increased transparency
25	Implementation of Real-time Quality Control	• Real-time quality control for prompt identification of issues • Real-time quality control for cost reduction • Real-time quality control for enhanced credibility and trust • Real-time quality control for enhanced operational performance

4.3. Reviewing (Defining and Naming) Themes

Following the initial identification of 25 potential themes, a crucial phase of review and refinement was conducted as outlined by Braun and Clarke [5]. This involved systematically evaluating the potential themes against the coded data and the entire dataset for coherence, distinctiveness, and relevance. Overlapping or insufficiently supported themes were merged or discarded through an iterative analytical process. This refinement stage consolidated the initial findings, resulting in the development of the five robust, core themes (Table 13) that form the final thematic structure for this study.

Table 13. Main Themes Extracted from Potential Themes (Categories)

Row	Extracted Main Themes	Related Potential Themes (Categories)
1	Digital Integration	Development of Digitalization Indicators for Supply Chain Performance
2		Data Processing Speed Enhancement
3		Percentage of Smart Equipment Connectivity to Virtual Platform
4		Enhanced Cybersecurity Level
5		Development of Information Transparency Indicators
6		Development of Supplier Coordination Indicators

Row	Extracted Main Themes	Related Potential Themes (Categories)
7	Integration and Coordination Among Stakeholders	Order Cycle Time Reduction
8		Development of Stakeholder Satisfaction Indicators
9		Percentage of Real-Time Data Sharing Across Supply Chain
10	Advanced Data Management and Analytics	Enhanced Accuracy in Demand Forecasting
11		Reduction in Data Analysis Duration
12		Data Quality Indicators
13		Rate of Excess Inventory Reduction in Virtual Platform
14		Development of Predictive Analysis Indicators
15	Resilience and Agility Management	Reduction in Reaction Time to Supply Chain Disruptions
16		Development of Supply Chain Agility Indicators
17		Rate of Rapid Urgent Order Fulfillment
18		Implementation of Production Flexibility Procedures
19		Percentage of Scenario Simulation Application
20	Leveraging Edge Computing and Artificial Intelligence	Percentage of Cloud Computing Adoption in Supply Chain
21		Intelligent Optimization of Logistics Routes
22		Intelligent Inventory Management
23		Enhanced Accuracy in Disruption Prediction
24		Implementation of Process Automation
25		Implementation of Real-time Quality Control

4.4. The Final Report (Thematic Network)

In this research, 139 initial codes were extracted from the transcripts of semi-structured interviews. From these 139 codes, 25 categories or potential themes were derived. Finally, through a review of these categories, 5 main themes were defined and named, which describe the design and implementation of a digital platform in the supply chain. The visual representation of these themes is notable in the form of Figure 3, which constitutes the thematic network.

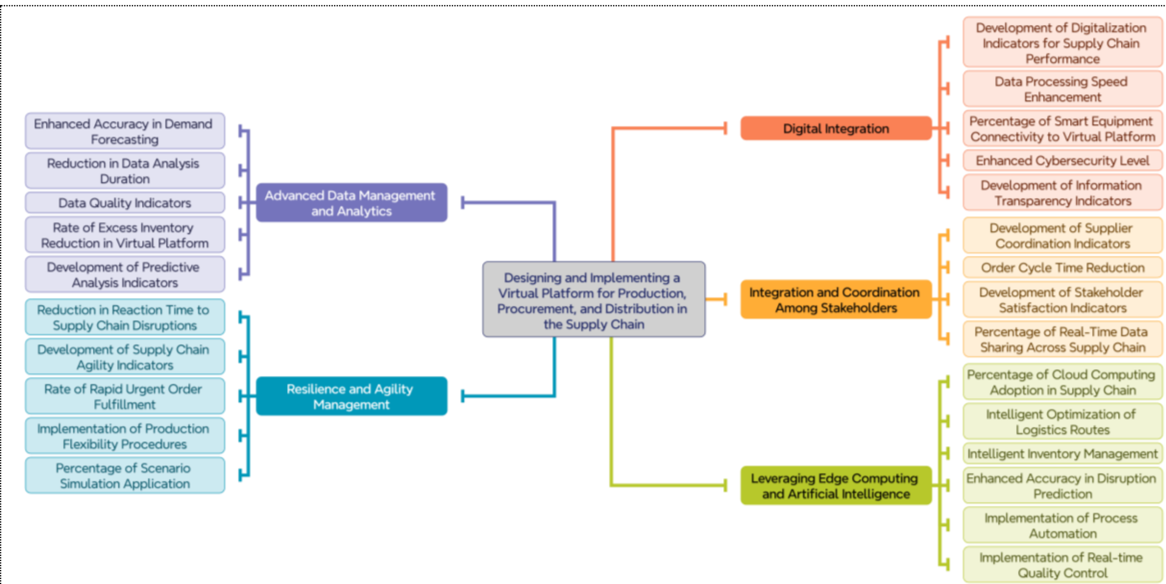

Figure 3. Thematic Network of Themes Extracted

Table 13 and Figure 3 present an integrated framework derived from a comprehensive thematic analysis, which aims to conceptualize platform-based production and its design and implementation within the supply chain. This framework is organized into five main themes, each encompassing several specific categories that collectively illustrate the multifaceted nature of digital and operational transformation within modern supply chains:

- Digital Integration is the foundational theme, capturing the evolution and measurement of digital transformation in supply chain performance. This theme is operationalized through indicators such as the development of digitalization metrics, enhancements in data processing speeds, the connectivity percentage of smart equipment to virtual platforms, and improved cybersecurity measures. These categories underscore the critical role of digital infrastructure in enabling efficient and secure supply chain operations.
- Integration and Coordination Among Stakeholders reflects the collaborative dimension of supply chain management. The categories under this theme include the development of indicators for information transparency and supplier coordination, reducing order cycle times, enhancing stakeholder satisfaction, and increasing real-time data sharing. Together, these elements emphasize the importance of cohesive stakeholder interactions and clear communication channels for achieving robust supply chain performance.
- Advanced Data Management and Analytics highlight the significance of data-driven decision-making processes. This theme is represented through categories that measure the accuracy of demand forecasting, the efficiency of data analysis procedures, the quality of data management practices, the reduction rate of excess inventory within virtual platforms, and the development of predictive analytics indicators. Collectively, these elements suggest that advanced analytics are pivotal for refining operational strategies and ensuring supply chain resilience.
- Resilience and Agility Management is centered on the ability of the supply chain to adapt swiftly to disruptions. The categories associated with this theme include the reduction in reaction time to disruptions, the development of agility indicators, the rapid fulfilment of urgent orders, the implementation of production flexibility procedures, and the application rate of scenario simulations. These categories provide a comprehensive overview of how resilience and agility can be systematically measured and enhanced to mitigate risks and improve overall responsiveness.
- Leveraging Edge Computing and Artificial Intelligence illustrates the role of emerging technologies in optimizing supply chain processes. Indicators in this category include the adoption percentage of cloud computing, the intelligent optimization of logistics routes, the intelligent management of inventory, enhanced accuracy in disruption prediction, the implementation of process automation, and real-time quality control measures. This theme reflects the cutting-edge integration of technology and analytics, driving innovation and efficiency within the supply chain.

In summary, the presented model articulates a detailed and systematic depiction of how digital transformation, stakeholder integration, advanced data analytics, resilience, and technological innovation converge to redefine supply chain management. The integration of these themes and categories offers a robust structure for evaluating both the strategic and operational dimensions of platform-based production in the supply chain.

5. Conclusion

5.1. Discussion and Suggestions

The findings of this study clearly indicate that creating an integrated and intelligent supply chain system—one that focuses on key dimensions such as digital integration, stakeholder coordination, advanced data analytics, and flexibility management—can substantially improve overall performance and enhance the competitive position of organizations.

To begin with, the study underscores the critical role of digital integration in unifying the diverse systems, processes, and technologies that form the supply chain. Such integration facilitates real-time information exchange, which in turn reduces operational delays, improves forecasting accuracy, and increases transparency in strategic decision-making. For instance, modern technologies that coordinate data related to warehouse inventories, customer orders, and transportation have markedly improved response speeds and reduced operational costs (Tan et al., [32]; Sharabati and Jreisat, [30]). This evidences that digital integration forms the backbone of an efficient, responsive supply chain system.

Equally important is the establishment of effective coordination among supply chain stakeholders. Continuous communication across suppliers, manufacturers, distributors, and customers minimizes potential conflicts and strengthens trust among the involved parties. Enhanced collaboration not only reduces rework and streamlines process flows but also facilitates easier access to integrated information, thereby significantly cutting both costs and delivery times (Xia et al., [38]; Jiao and Deng, [17]). In this context, the virtual platform, by providing a unified data source, proves essential in establishing the necessary environment for optimal inter-organizational interactions and operational improvements.

Another major aspect of the results pertains to data management and advanced analytics. The virtual platform's ability to collect and process an enormous volume of real-time data enables the extraction of valuable insights regarding demand trends, customer behaviors, and potential operational issues. Advanced analytical techniques—employing mathematical models and artificial intelligence algorithms—facilitate data-driven decision-making. The application of precise forecasting models not only optimizes inventory levels but also prevents the occurrence of unnecessary shortages or surpluses, thereby enhancing the overall efficiency of the supply chain (Xia et al., [38]; Jodlbauer et al., [18]).

Flexibility and agility in response to sudden market changes and environmental conditions form another critical dimension. The virtual platform provides up-to-date information and analytical tools that allow organizations to respond promptly when disruptions occur. For example, in the event of a supplier disruption, the platform enables the rapid identification of alternative suppliers and the swift adjustment of production plans. This rapid response mitigates delay costs and contributes to greater stability and reliability across the supply chain (Khan et al., [19]).

Furthermore, the integration of emerging technologies such as edge computing and artificial intelligence plays a pivotal role in modernizing supply chain processes. Edge computing reduces latency by processing data near the source of production, thereby enhancing system efficiency. Simultaneously, artificial intelligence, through its ability to identify hidden data patterns, contributes to optimized inventory management and improved logistics routing. For instance, machine learning algorithms can fine-tune production schedules to balance supply and demand effectively while minimizing logistics costs (Tsunoda and Zennyo, [35]; Varelas, [36]).

The results further reveal that several sub-dimensions—including data processing speed, the percentage of smart equipment connectivity, cybersecurity level, percentage of cloud computing usage, information transparency indicators, data quality, rate of excess inventory reduction, reduction in reaction time to disruptions, and supply chain agility indicators—play crucial roles in enhancing supply chain performance. A detailed examination of 139 sub-categories extracted from the interviews has illuminated these dimensions, clearly depicting the strengths and weaknesses in the currently implemented systems. These findings are consistent with those reported in previous studies (e.g., Fang et al., [13]; Kim et al., [20]) and, for the first time, provide a comprehensive report on aspects such as the percentage of scenario simulation usage and smart logistics route optimization, topics that have previously received limited attention.

Based on these comprehensive findings, the study presents a series of practical recommendations for enhancing supply chain performance. Key among these is the adoption of simulation software (such as AnyLogic or FlexSim) to evaluate the potential impacts of disruptions, the design of transportation route optimization algorithms driven by real-time data, and the implementation of real-time data processing systems (e.g., Apache Kafka or AWS Kinesis). In addition, the installation and strategic interconnection of smart equipment at critical points in the supply chain, the migration of supply chain infrastructures to cloud computing environments, the deployment of artificial intelligence algorithms for precise demand forecasting, and the development of rapid response protocols for disruptions are strongly recommended. Collectively, these strategies can yield significant reductions in operational costs, enhance response speeds, and improve overall decision-making accuracy.

Looking ahead, the research suggests that the derived models should be tested across various organizations—including both governmental and private sectors—to fully assess their generalizability across different operational environments. Moreover, employing methods such as the Analytic Hierarchy Process (AHP) and Interpretive Structural Modeling (ISM) for indicator prioritization could significantly clarify the key factors influencing the successful implementation of virtual platforms. Future research should also consider the impact of cultural and geographical differences on technology adoption to offer practical, region-specific recommendations (Jiao and Deng, [17]).

5.2. Managerial Insights

The analyses indicate that implementing a virtual platform in supply chain management—through the integration of digital technologies, stakeholder coordination, advanced analytics, and agile operational strategies—can profoundly transform supply chain performance. This approach not only improves production quality, reduces costs, and shortens delivery times but also establishes a competitive advantage in an increasingly challenging market environment.

For managers, the study highlights several actionable insights:

- Investment in digital integration is essential to ensure seamless communication across all supply chain nodes and to enable real-time visibility into operations.
- Enhanced coordination mechanisms among suppliers, manufacturers, distributors, and customers are critical to minimize conflicts, streamline processes, and build trust-based relationships.
- Data-driven decision-making using advanced analytics and artificial intelligence should be prioritized to optimize inventory, anticipate demand fluctuations, and detect potential operational bottlenecks.
- Agility and flexibility protocols must be embedded within supply chain operations to rapidly respond to disruptions and unforeseen market changes.
- Adoption of emerging technologies such as edge computing, scenario simulation software, and AI-driven logistics optimization can significantly reduce latency, operational costs, and resource wastage.
- Strategic cloud migration and smart equipment deployment are recommended for organizations aiming to modernize infrastructure while maintaining scalability and operational resilience.

Collectively, these managerial practices can enable organizations to not only achieve efficiency and cost reduction but also to foster a resilient, responsive, and competitive supply chain ecosystem. The findings serve as a practical guide for policy formulation, strategic planning, and technology adoption within industrial and commercial organizations, supporting the digital transformation journey in the supply chain domain.

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