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The impact of digital supply chain transformations and smart technologies on manufacturing productivity: A resource-based view

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Abstract

The study examines the role of digital supply chains and the associated smart technologies in enhancing productivity performance in the manufacturing industry. Thus, the research aimed to explore the effects of digital supply chain transformations, supply chain traceability, and supply chain transparency, as well as the impact of smart technologies on firm performance, with a focus on the mediating effects of supply chain visibility. The current research conceptual model incorporates the independent variables of digital supply chain transformation, supply chain visibility, supply chain transparency, AI, and smart technologies, with the dependent variables including productivity performance. The data were collected from respondents with knowledge of supply chain management, using a convenience sampling technique. Due to the limited information available regarding digital supply chain innovation in supply chain operations, the research examines the factors of supply chain visibility, supply chain transparency, and supply chain traceability and how these factors affect operational performance. To test hypotheses and achieve study goals, the Resource-Based View (RBV) theory was combined with quantitative research methods. The findings revealed that digital supply chain transformations and smart technologies are positively associated with relationship performance, underscoring the importance for manufacturing organizations to integrate smart technology into their supply chains to enhance operational performance.

Keywords: digital supply chain transformation, smart technologies, supply chain visibility, supply chain transparency, productivity performance.

1. Introduction

Digital supply chains, combined with smart technologies known for their centralized and transparent nature, have potential to transform supply chain management by sharing a secure and efficient process for sharing complex information. However, the specific effects of innovative technology on knowledge sharing for effective supply chain management practices, aiming to increase inventory management and organizational performance, have been highlighted (Muafi & Sulistio, 2022). The technology of Blockchain originates from the concept of cryptocurrencies, such as Bitcoin, and provides the idea of decentralization (Labanava et al., 2022). The

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methodology of supply chain management contributes to the success factors that impact an organization's performance and profitability, as seen in the pharmaceutical sector. The pharmaceutical industry has adopted a more complex system of networks that involves manufacturers, suppliers, distributors, and retailers. Dues to these complex distribution networks, supply chain management faces substantial challenges (Medhi, 2020).

Historically, literature has noted that blockchain technology provides innovative support in the field of supply chain management, enhancing transparency through traceability and improving overall efficiency within the supply chain. The fundamental core concept of blockchain technology plays a significant role in decentralization, facilitating digital distribution, maintaining accurate transaction records, and preventing fraud or document manipulation, as no single node controls the data in this process (Centobelli et al., 2022). To integrate the factors of transparency and traceability with blockchain technology, providing visibility into all process activities (Badhwar et al., 2023). Digital supply chains and smart technologies have emerged as promising approaches to increase operational efficiency, reduce costs, and improve customer satisfaction (Queiroz et al., 2022).

Previous literature has shown that the field of digital supply chain management has undergone a shift towards customer-centric approaches, where distribution inventory plays a pivotal role. Effective digital supply chain distribution strategies enable the efficient and smooth flow of goods and services from producers to end-users, thereby creating value for customers and driving organizational success. The seamless integration of digital supply chain management practices with distribution marketing can lead to enhanced customer experiences, improved product availability, and increased market competitiveness (Swierczek, 2022). By investigating digital supply chain management, technology, and knowledge sharing, this research contributes to the potential benefits and challenges associated with integrating innovative technologies in the field of supply chain management to increase organizational productivity (Cagri Gurbuz et al., 2023).

The operations of supply chain management, including logistics functions, purchasing, distribution, pricing, quality, availability, time savings, and variety, facilitate customers and effectively enhance the firm's productivity in terms of cost performance and quality performance (Omoruyi et al., 2022). In business environments, technological advancements play a vital role in all sectors and are becoming increasingly sophisticated. Maintaining inventory management records and retrieving data has become more efficient, thanks to the advancement of smart technology, which has increased organizational performance (Juan & Li, 2023).

Despite the growing interest in smart technology, there is a need to investigate its impact on digital supply chain management and firm productivity. While some studies have explored the benefits of technology in enhancing traceability, transparency, and security within supply chains, the contributions of innovative technologies in coordinating knowledge sharing and their subsequent impact on firm productivity remain underexplored (Lee, 2023). While the implementation of digital supply chain management systems has shown substantial benefits, the effective

sharing of knowledge across supply chain partners remains a critical challenge. Knowledge sharing plays a vital role in enabling collaboration, fostering innovation, and driving operational excellence within supply chain networks. The lack of effective knowledge-sharing mechanisms can hinder the achievement of desired firm outcomes (Peng, 2023). Digital supply chain management (DSCM) has emerged as a promising approach to increase operational efficiency, reduce costs, and improve customer satisfaction (Queiroz et al., 2022).

The theory of the resource-based view was based on the resources utilized to explain the theoretical research model, investigating the digital supply chain and innovative technologies for enhanced productivity, including quality and cost performance. The theory of the resource-based view holds significant importance in utilizing a company's resources and firm capabilities, thereby reducing difficulties and errors and increasing sustainable competitive advantage (Anwar et al., 2025). The current research addresses the significant research gap regarding digital supply chain innovation and Artificial Intelligence, focusing on supply chain visibility and transparency to enhance operational efficiency within the firm.

The dynamic theory of the resource-based view is a prominent philosophy used to clarify the associations between resources and their performance. As per the productivity of organizational resources that possess the attributes of being valuable, non-substitutable, rare and inimitable serve to attain a competitive edge has been extensively employed in prior information systems (IS) literature (Ahmed et al., 2022) to clarify how digital technology competencies can be leveraged to augment organizational skills and enhance supply chain capabilities and point out, digital technology is a tangible asset that is integrated into an organization’s strategic plan to expand its capacity (Frederico, 2021).

The current study contributes to the development of strategic long-term strategies and enhances firm performance from a managerial perspective (Parmar & Ahmed, 2013). Furthermore, this is also of significant importance for firms and organizations to develop long-term strategic decisions and implementation strategies that better meet customer needs and improve their revenues. In the manufacturing industry, numerous opportunities exist to leverage digital supply chains and smart technology to gain a competitive edge, capitalizing on the advantages of technology in the field and increasing market shares (Ahmed et al., 2017). According to the utilization of digitalization, there are results in enhanced supply chain capabilities, leading to a direct impact on business operations. The effects include operational costs, improvements in product quality, supply chain development, the introduction of new products, an increase in market share, and the fulfillment of customer demand. The concept of digitalization involves enhancing efficiency and enabling rapid responses from stakeholders (Juan & Li, 2023).

Digitalization refers to the generation of alternative solutions and improved mechanisms for organizations in response to unforeseen market conditions. According to the latest research in the field of information technology, researchers are increasingly regarding digital technology as an organizational resource to establish advanced capabilities such as responsiveness and adaptability in business

operations (Anwar et al., 2025). The integration of digitalization into performance facilitates collaboration through the timely distribution of information, thereby improving decision-making. The study suggests that integrating digitalization can enhance performance, ultimately leading to a positive impact on the organization and enabling it to gain competitive advantages (Marcucci et al., 2023). Thus, the supply chain and logistics are applicable in value, as evidenced by the period from 2013 to 2022, both within the enterprise and across the enterprise (accelerated by virtual innovation), resulting in sales growth and price discounts (Nagurney, 2021).

The creation of automation and digitalization has transformed the entire supply chain. The significant modern improvements in Information Technology (IT) and the creation of enterprises in the production area have numerous effects on the supply chain. In this paper, we will analyze the impact of practical supply chain dimensions of innovative technologies on supply chain performance (Swierczek, 2022). The functions of blockchain technology include provenance and authentication, which involve recording valuable information such as batch numbers, product quality tests, and certificates throughout the supply chain process. Through this approach, consumers can verify the authenticity of products by scanning the product's blockchain code. Through this technique, customer trust, satisfaction, and risk are increased, while organizational profitability is enhanced (Anjum & Dutta, 2022).

The competitive and dynamic field of digital supply chain management has thus been revolutionized by the rapid advancement of smart digital technologies, particularly in the context of firm performance. With the development of strategic and complex processes of global supply chains and the growing demand for efficient and effective distribution, organizations are seeking innovative solutions to enhance their supply chain processes because of the smart technology that has enhanced significant development in the field of supply chain management and the firm performance, which has the move to transform sharing of knowledge effective supply chain management practices and increase productivity (Basu, 2023). Thus, the current study investigates the role of the digital supply chain, smart technologies, supply chain visibility, supply chain transparency, and artificial intelligence on the performance of productivity in the manufacturing industry to gain a better knowledge of the firm performance with the help of developed conceptual research model, which is associated with the resource-based view theory (Lee et al., 2024). The conclusion is that the increasing adoption of digital supply chain management practices, coupled with the integration of smart technologies, has the potential to revolutionize firm performance (Anwar et al., 2025).

This study sheds light on the impact of digital supply chain management and smart technologies on knowledge sharing within supply chains, providing valuable insights for businesses seeking to optimize their firm’s productivity. From a future perspective, the current research could incorporate additional variables, including mediating and moderating factors, to enhance productivity and increase knowledge regarding digital supply chain management and supply chain sustainability.

The significance of the current study lies in its impact on scholars, policymakers, practitioners, and academics associated with the essential element of digital supply

chain and smart technologies (AlMulhim, 2021), particularly in terms of artificial intelligence and its impact on firm productivity in the manufacturing industry. The digital supply chain analysis and smart technologies. This study aims to investigate how the implementation of this approach within digital supply chain management and innovation technologies can influence the effectiveness of knowledge sharing in firm performance (Yontar, 2023).

The prior literature explains that the concept of artificial intelligence has a significant impact on firm productivity, and the competitive business environment has a greater impact on new generations and business applications (Wamba-Taguimdje et al., 2020). The technology of artificial intelligence has increased productivity in business, enhanced supply chain capabilities, and improved supply chain transparency (Sullivan & Wamba, 2024).

2. Literature review

Digital supply chain is a significant and critical approach in distribution management, providing substantial benefits to firm productivity by maintaining transaction data, sales data, inventory records, and customer data, as well as retrieving data for informed decision-making (AlMulhim, 2021). In prior literature, the significance of digital supply chain benefits has been highlighted through peer-to-peer networking and the use of centralized database functions. The study suggested that the digital supply chain offers several essential advantages and provides a good approach to achieving transparent working conditions, with tasks including data security, transparency in transaction approaches, and supply chain digital transformations, as well as the application of smart technologies in manufacturing industries (Juan & Li, 2023).

The innovation in the operational process of the supply chain is significant and the most crucial approach in distribution management, providing substantial importance to firm productivity in maintaining transaction data records, sales data records, inventory records, and customer data, which are based on permanent and retrievable data for decision-making (AlMulhim, 2021). In prior literature, the significance of digital supply chain benefits has been highlighted through peer-to-peer networking and the use of centralized database functions. The research suggested that the digital supply chain offers several vital advantages and provides a good approach to transparent working conditions, with tasks including data security, transparency in transaction approaches, and supply chain digital transformations, as well as the use of smart technologies in manufacturing industries (Juan & Li, 2023). Digital supply chains and smart technologies have emerged as promising approaches to increase operational efficiency, reduce costs, and improve customer satisfaction (Queiroz et al., 2022).

2.1 Digital supply chain and supply chain visibility

Prior literature has shown that the functionality of the digital supply chain is closely tied to supply chain visibility. In a competitive business environment, the significance

of the digital supply chain becomes complex due to the high adoption of innovative technologies and the need for new suppliers. With the advent of digital technologies, traditional supply chain management practices are undergoing a revolution, resulting in enhanced efficiency, transparency, and collaboration throughout the supply chain. One such technology that has gained considerable attention in recent years is the digital supply chain competitive environment (Ning & Yao, 2023). Therefore, this study examines the impacts of digital supply chain management on firm performance, with a specific focus on quality performance, thereby enhancing the significance of supply chain management productivity (Alkhatib & Momani, 2023).

Thus, digital supply chain management is a critical approach and process involving multiple links and the integration of various activities, including purchasing, procurement, production, inventory management, and distribution. Traditionally, supply chain management relied on manual, paper-based systems, which often resulted in inefficiencies, delays, and limited visibility throughout the supply chain. However, the digital revolution has paved the way for transformative changes in the way supply chains are managed (Basu, 2023)

2.2 Smart technologies and supply chain visibility

The study suggested that smart technology enables organizations to gain greater visibility into their supply chain, track products and assets more effectively, and make data-driven decisions to optimize their distribution marketing efforts (Ozmen & Bora, 2023). Digital supply chain management (DSCM) has emerged as a promising approach to increase operational efficiency, reduce costs, and improve customer satisfaction (Queiroz et al., 2022). The concept of innovative technologies and digital supply chain management, along with new technologies such as cloud computing, the Internet of Things (IoT), artificial intelligence (AI), and Blockchain, aims to enhance connectivity, automate processes, and enable real-time data sharing and analysis. These technologies enable organizations to gain greater visibility into their supply chains, track products and assets more effectively, and make data-driven decisions to optimize their distribution and marketing efforts (Ozmen & Bora, 2023).

Digital supply chain management (DSCM) has emerged as a promising approach to increase operational efficiency, reduce costs, and improve customer satisfaction (Queiroz et al., 2022). Past literature has shown that the field of marketing has undergone a shift towards customer-centric approaches, where distribution marketing plays a pivotal role. Effective distribution marketing strategies facilitate the smooth flow of goods and services from producers to end-users, thereby creating value for customers and driving organizational success. The seamless integration of digital supply chain management practices with distribution marketing can lead to enhanced customer experiences, improved product availability, and increased market competitiveness (Belhadi et al., 2021).

2.3 Supply chain visibility and firm performance

Prior research suggested that the approach to digital supply chain productivity is strongly dependent on innovative technology and smart inventory (Sohel & Bin Osman, 2018). The advancement of innovative technology enables retailers in retail superstores to manage inventory, customers, sales, backup, and transaction data more effectively, thereby reducing errors and increasing performance (Muafi & Sulistio, 2022). Thus, the evidence of the current study examines the impact of smart technologies, supply chain capabilities, and artificial intelligence capabilities on form performance. It also investigates how the firm adapts and changes its technological, innovative supply chain technology and artificial intelligence capabilities to enhance firm productivity.

In the current research, the concepts of smart technologies and digital supply chain management, along with new technologies such as cloud computing, the Internet of Things (IoT), and artificial intelligence (AI), as well as Blockchain, are explored to enhance connectivity, automate processes, and enable real-time data sharing and analysis. These technologies enable organizations to gain greater visibility into their supply chains, track products and assets more effectively, and make data-driven decisions to optimize their distribution and marketing efforts (Ozmen & Bora, 2023). Through the concept of supply chain visibility, the operational and functional aspects of the supply chain have gained more significance, enabling better monitoring of inventory and all processes and ensuring smooth operations, distribution, and logistics management. A past study suggested that the concept of visibility regarding the supply chain, along with the development of supplier coordination, efficiency, and effectiveness, is essential to ensure real-time visibility of all operations.

2.4 Supply chain transparency and supply chain visibility

The past study explained that, in the pharmaceutical industry, the functionality of the transparency of the supply chain has a greater and positive impact on the firm productivity, develops strong relations with the suppliers, inventory management, and the retail supply chain, and takes the better decisions making regarding the firm performance (Kamble et al., 2020). Through the approach of supply chain transparency, it is possible to minimize time wastage, reduce operational costs, and achieve consistent operations, thereby enhancing performance (Sodhi & Tang, 2019). With the integration of digital tools like Blockchain and IoT, transparency also ensures traceability, ethical sourcing, and sustainability, making it a strategic advantage in today's competitive environment (Tian, 2016).

2.5 Artificial intelligence and supply chain visibility

The study suggested that the concept and functionality of Artificial Intelligence (AI) have provided significant benefits, maintaining productivity levels, optimizing inventory, and enhancing operational accuracy while also improving firm

performance (Choi et al., 2018). Machine environments and innovative technologies are developing more productive methods for operational activities, enhancing firm performance. Most companies incorporate functions related to artificial intelligence to improve employee performance and overall firm performance (Lu et al., 2020; Wamba & Queiroz, 2020). Additionally, AI boosts supply chain visibility and flexibility, increasing overall agility and competitiveness (Dubey et al., 2021).

2.6 Research hypotheses

Based on the literature review, the following hypotheses are to be tested:

H1: Digital Supply Chain has a significant impact on the supply chain visibility.

H2: Smart Technology has a significant impact on the supply chain visibility.

H3: Artificial Intelligence has a significant impact on the supply chain visibility.

H4: Supply Chain transparency has a significant impact on supply chain visibility.

H5: The Supply Chain visibility has a significant impact on the Productivity Performance.

H6: The Supply Chain visibility mediates the relationship between the digital supply chain and the Productivity Performance.

H7: The Supply Chain visibility mediates the relationship between smart technology and the Productivity Performance.

H8: The Supply Chain visibility mediates the relationship between artificial intelligence and the Productivity Performance.

H9: The Supply Chain visibility mediates the relationship between supply chain transparency and Productivity Performance.

3. Methods

3.1 Research design

The proposed research methodology for the current study was a quantitative research design. The quantitative research design is employed to analyze quantitative data and test the research hypothesis. Therefore, the main advantage of the considered quantitative analysis is that this approach provides significant results, as quantifying the data can be easily validated in the research (Qadeer et al., 2014). The proposed research methodology for the current study was a quantitative research design. Because the quantitative research design is applied to test the research hypothesis through quantitative data analysis, the most significant advantage of this approach is that it provides reliable results, making it easy to validate the data in the research. The reliability analysis enables better decision-making and helps scholars and researchers generalize their results, making informed future decisions.

3.2 Sample & sampling technique

The targeted population for this study comprises supply chain professionals and managers from various industries who possess experience and knowledge related to digital supply chain management and manufacturing. A convenience sampling technique was employed to select participants who met the inclusion criteria. The sample size of respondents was 260; however, researchers distributed 300 questionnaires, but they found 260 questionnaires completely and accurately filled out. Data for the current research had been collected through a structured questionnaire from respondents who have experience in manufacturing, hold a degree in supply chain management, and are experts or professionals in the field of supply chain management. The current research, based on the target population, directly or indirectly associated with the field of supply chain management, as well as production and manufacturing companies operating in Pakistan. The target population refers to the specific group of people from whom the data is collected (Hair et al., 2010)

3.3 Data collection procedure

The researchers approached the senior management of the manufacturing firms and obtained permission to collect the responses. Secondly, researchers ensured confidence with the respondents that this study would be used solely for academic purposes. The researchers administered the questionnaire personally to collect the data from selected manufacturing firms. The researchers obtained permission from the manager and other heads, building their trust that their opinions would be kept confidential so that they would provide information without hesitation. The researchers have distributed 300 questionnaires to the supply chain personnel in the manufacturing sector. The researchers found 260 questionnaires filled; thus, the response rate was 86.66%.

The most critical element in data collection is data entry, editing, and coding. The primary objective of the questionnaire is to identify and eliminate any irrelevant information. Another essential step is that coding is processed by computer software. The questionnaire's complete data is put into SmartPLS 4.0. The analysis of the reliability explained the internal consistency of the items in the research. Thus, the current study aims to calculate Cronbach's alpha, which assesses the reliability of the items within the constructs of the study. Therefore, all the values of Cronbach's alpha and composite reliability exceed 0.7, indicating that all the items in the constructs of the current research are reliable (Hair et al., 2017).

3.4 Estimation techniques

The partial least squares examine two models. The first model is referred to as the measurement model, also known as the outer model, and the other is the structured model, also known as the inner model. These models are analyzed through smart-PLS 4.0 (Ahmed et al., 2024; Perdana et al., 2023). Thus, through the study of the

measurement model results, the reliability, validity, composite reliability, convergent validity, discriminant validity, and the average variance extracted are examined, as well as the inner model, also known as the structural model, which explores the association between the variables. In the quantitative phase, to study bias through construct validity and identify errors in attitudinal measurement, construct validity is crucial. Based on the three essential forms of convergent validity, discriminant validity, and criterion validity (Sekaran & Bougie, 2009). Accessing the convergent validity based on the factor loading, average variance extracted, and composite reliability. The value of the AVE measures the variation of the items, and the range of the values of the average variance extracted is from 0 to 1, exceeding 0.5, which suggests convergent validity.

4. Results

4.1. Assessment of measurement model

Through the measurement model, the results indicate that the research model achieved internal consistency reliability. Table 1 demonstrates that Cronbach's alpha values for all factors range from 0.741 to 0.846. The composite reliability results indicate values of 0.84 and 0.741, which meet the threshold criteria. Thus, the current research model achieved internal consistency reliability, and all constructs demonstrated internal consistency among their items, indicating good reliability (Hair et al., 2016). The results of Table 1 and Figure 1 showed that the average variance extracted, which suggests that the convergent validity explained the research model variance examined, and indicated the threshold values, which should not <0.5, described the evidence of the convergent validity of the research model and the construct of the questionnaire. The results suggested that the current research model has good convergent reliability.

Table 1
Measurement model: construct reliability and validity

Measure	Cronbach's alpha	rho_A	Composite reliability	Average variance extracted
Artificial intelligence	0.741	0.835	0.829	0.533
Digital Supply Chain	0.789	0.803	0.862	0.610
Productivity performance	0.873	0.874	0.913	0.724
Supply chain transparency	0.843	0.849	0.888	0.613
Smart technology	0.864	0.878	0.902	0.650
Supply Chain Visibility	0.846	0.850	0.890	0.620

Source: designed by the authors.

Through discriminant validity, the uniqueness of the construct is explained in relation to others. Thus, the discriminant validity, as measured by the square root of AVE, is that each construct is higher than the correlation (Fornell & Larcker, 1981). Through past research, it has been suggested that discriminant validity, as explained, means that one variable is entirely distinct from the other variable. Thus, the simple test revealed that the square root of the average variance extracted is greater than the correlation between the two variables. Therefore, it is concluded that all the variables differ from one another, suggesting that the measurement instruments used in the current study possess discriminant validity. Heterotrait-monotrait ratio (Table 3) values less than 0.85 indicate discriminant validity (Mellor, 2022)

Table 2
Fornell-Larcker criterion – Discriminant validity

Measure	AI	DSC	PP	SCT	ST	SCV
Artificial intelligence	0.730					
Digital supply chain	0.584	0.781				
Productivity performance	0.060	-0.136	0.777			
Supply chain transparency	0.536	0.823	0.168	0.783		
Smart technology	0.685	0.739	0.110	0.689	0.806	
Supply chain visibility	0.665	0.701	0.120	0.678	0.731	0.788

Note: AI: Artificial intelligence; DSC: Digital Supply Chain; PP: Productivity performance; SCT: Supply chain transparency; ST: Smart technology; SCV: Supply chain visibility

Source: designed by the authors.

Table 3
Heterotrait-monotrait ratio

Measure	AI	DSC	PP	SCT	ST	SCV
Artificial intelligence						
Digital Supply Chain	0.738					
Productivity performance	0.112	0.112				
Supply chain transparency	0.638	0.812	0.130			
Smart technology	0.811	0.073	0.086	0.791		
Supply Chain Visibility	0.779	0.840	0.107	0.789	0.824	

Source: designed by the authors.

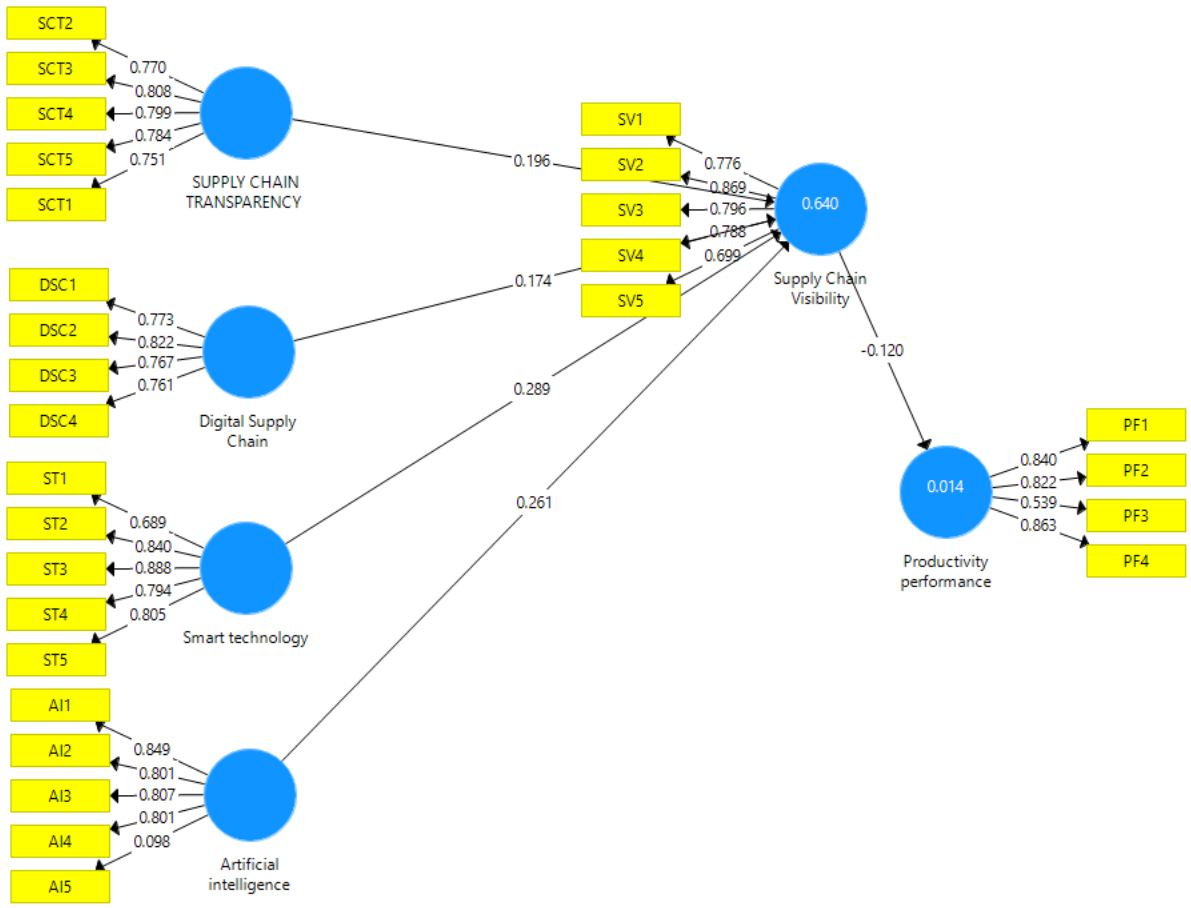

Fig. 1. Measurement model.
Source: designed by the authors.

The next step is to analyze the structural model. In the structural analysis, the relationships among the independent variables, mediating variables, moderating effects, and dependent variables are examined, and empirical testing is conducted regarding the hypothesized conceptual research model.

4.2. Path coefficient analysis

The research developed a hypothesis to examine digital transformation and AI, with the mediating effect of supply chain visibility on firm performance. Thus, the results in Table 4 and Figure 2 suggest that artificial intelligence is associated with supply chain visibility, and the significance of the digital supply chain is also associated with supply chain visibility. However, supply chain transparency is not supported by supply chain visibility. Smart technology has developed a positive relationship with supply chain visibility. It was further suggested that the supply visibility developed was significantly related to firm performance.

Table 4
Path coefficients analysis

Direct Relationship	Point Estimate	Bootstrap mean	Standard Deviation	T Statistics	P Values
Artificial intelligence -> Supply Chain Visibility	0.544	0.549	0.053	10.250	0.000
Digital Supply Chain -> Supply Chain Visibility	0.211	0.210	0.078	2.723	0.007
Supply chain transparency -> Supply Chain Visibility	-0.068	-0.060	0.072	0.949	0.343
Smart technology -> Supply Chain Visibility	0.260	0.249	0.081	3.202	0.001
Supply Chain Visibility -> Productivity performance	0.664	0.668	0.067	9.923	0.000

Source: designed by the authors.

Therefore, the findings suggested that the sig-value=0.000, which is less than 0.05, thus concluding that the research hypotheses in the current research have supported and concluded that artificial intelligence has a positive association with supply chain visibility, digital supply chain, the smart technology, but the the, the supply chain transparency not positive associated with the supply chain visibility, because the sig-value>0.05. Further, results suggested that supply chain visibility is significant and has a positive association with productivity performance,

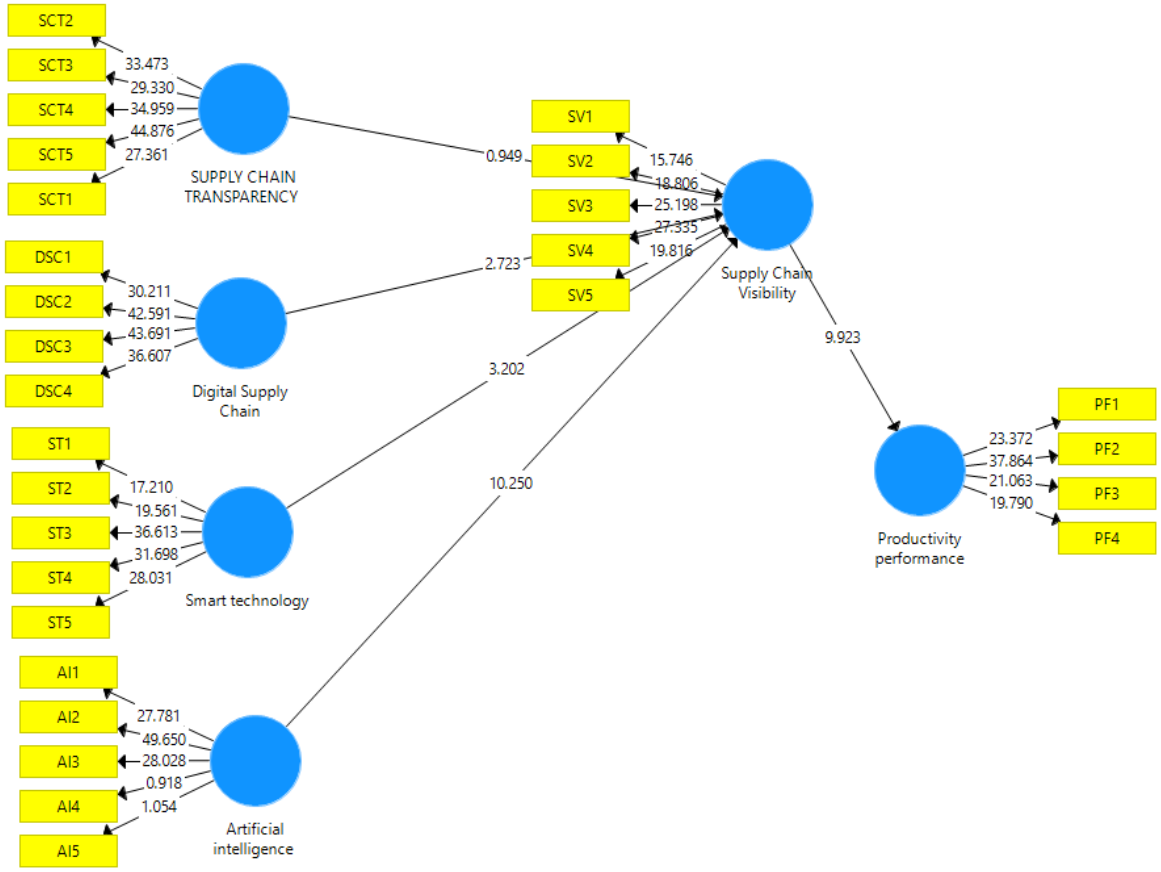

Fig. 2. Structural model.
Source: designed by the authors.

The results in Table 5 and Figure 2 suggest that the development of supply chain visibility mediates the effect of digital supply chain factors, including smart technology, artificial intelligence, and supply chain transparency, on production and performance.

Table 5
Results of mediating effects

Mediating Relationships	Standard Deviation	T Statistics	P Values	Decisions
Artificial intelligence -> Supply Chain Visibility -> Productivity performance	0.049	7.437	0.000	Accepted
Digital Supply Chain -> Supply Chain Visibility -> Productivity Performance	0.054	2.587	0.010	Accepted
Supply chain transparency -> Supply Chain Visibility -> Productivity performance	0.047	0.957	0.339	Rejected
Smart technology -> Supply Chain Visibility -> Productivity performance	0.057	3.012	0.003	Accepted

Source: designed by the authors.

Table 6 explains the variations in the dependent variables, such as productivity performance and supply chain visibility, that result from the independent variables. The findings of Table 6 establish that the productivity performance has an impact of 0.010, and supply chain visibility has an impact of 0.634 on the dependent variable. Thus, it is concluded that R-square statistics show that supply chain visibility has a significant influence on the dependent variable.

Table 6
R Square statistics

Variables	R Square	R Square Adjusted
Productivity performance	0.014	0.010
Supply Chain Visibility	0.640	0.634

Source: designed by the authors.

It is crucial for experts, managers, and policymakers to analyze the factors of the manufacturing process in terms of productivity performance and quality performance (Qadeer et al., 2014). Furthermore, this is also of significant importance for firms and organizations to develop long-term strategic decisions and implementation strategies that better meet customer needs and increase organizational revenues (Anwar et al., 2025). In the manufacturing industry, numerous opportunities exist to adopt innovative approaches to the digital supply chain and smart technology, leveraging these advantages to gain a competitive edge and increase market share. Thus, it is important for the manager's perspective to analyze the factors of digital supply chain management in the product distribution, product availability, inventory management, and the operations of innovation of the factors of the functionality of

the supply chain and the innovations approaches and the methods to increase the firm's productivity in the process of manufacturing.

5. Conclusions

The literature encompasses significant knowledge regarding the innovation approach to supply chain management, smart technology, and the application of artificial intelligence to enhance supply chain visibility and transparency. The current research has contributed to the literature on digital supply chain management, supply chain transparency, AI, supply chain visibility, and smart technology, thereby enhancing the functionality of firm performance. It provides a platform for scholars and researchers to explore the gaps in the study experience and knowledge, ultimately leading to more informed decision-making in the manufacturing industry. Furthermore, the current study aims to enhance our understanding of digital supply chain transformation, as the theoretical contribution incorporates supply chain transparency, AI, supply chain visibility, and firm performance. Thus, the research has explored the concept of the applications of the digital supply chain in the field of supply chain and includes the competitive advantages of the mediating effects of the supply chain visibility for the approach of supply chain essential components or benefits such as AI, transparency, efficiency, and the security to increase organizational productivity, regarding the manufacturing industry, in the pharmaceutical industry.

The study makes various significant managerial contributions. The current research provides a deeper understanding of the research framework of the digital supply chain, offering four key benefits: transparency, supply chain visibility, AI, and efficiency, which collectively increase organizational productivity and benefit managers. The competitive advantages of transforming the digital supply chain are significant. The managers take the competitive advantages of the digital supply chain with the help of different advantages such as the materials flow track, products, and process in the supply chain, could better understand the enhance the network of the supply chain and information, strong system security, developed trust, reduce risk and improve good responsiveness in the complex supply chain. The results of the study are essential for large multinational companies and managers to make better strategic decisions.

The limitations of the current research, specifically regarding data collection in the city of Karachi, relate to the respondents in the digital supply chain and the use of smart technologies to increase firm productivity. In future studies, additional factors, such as those related to digital supply chain management, should be included. Future studies should also explore the concept of digital supply chain management and smart technologies, including AI, to address challenges that improve firm productivity in terms of cost, quality, and productivity.

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