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Supply Chain Digitalization and Performance: The Serial Mediation of Visibility and Resilience

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Abstract

This study aims to examine how supply chain digitalization enhances supply chain performance through the serial mediation of supply chain visibility and supply chain resilience. Grounded in the Resource-Based View and Dynamic Capabilities Theory, the research model was empirically tested using survey data collected from 379 managers of manufacturing firms operating in Vietnamese industrial parks. The data was analyzed through Partial Least Squares Structural Equation Modeling (PLS-SEM). The findings reveal that supply chain digitalization positively influences both visibility and performance. However, while visibility improves performance when examined independently, its direct effect becomes insignificant once resilience is incorporated, suggesting that visibility alone is insufficient to achieve superior performance without strong resilience capabilities. Moreover, the serial mediation path digitalization → visibility → resilience → performance was statistically significant, confirming the sequential mechanism through which digitalization improves performance outcomes. The study contributes to the literature by clarifying the complementary roles of visibility and resilience and highlighting resilience as the key capability linking digitalization to performance. From a managerial perspective, the results emphasize that investing in digital technologies should be accompanied by initiatives to strengthen resilience capabilities to maximize the benefits of digital transformation in supply chains.

Keywords:

Supply Chain Digitalization;
Supply Chain Visibility;
Supply Chain Resilience;
Supply Chain Performance;
PLS-SEM.

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1- Introduction

The growing complexity and unpredictability of global supply chains have compelled businesses to accelerate their digital transformation efforts. Supply chain digitalization is recognized as a key driver of transformation, enhancing supply chain adaptability and resilience to disruptions while improving operational efficiency [1, 2]. Supply chain digitalization involves integrating digital technologies like the Internet of Things, artificial intelligence, blockchain, big data analytics, enterprise resource planning, and cloud computing into supply chain operations [3-5]. This process is not just a technological upgrade but a fundamental shift in modern supply chain management strategy, aimed at optimizing processes, improving decision-making, and creating sustainable value [1, 6]. The application of digital technologies in supply chains has become a key strategy for enhancing adaptability and maintaining operational efficiency. Digital transformation not only enables businesses to automate processes and integrate real-time data but also enhances supply chain visibility and strengthens resilience, thereby improving overall supply chain performance.

Previous studies have extensively examined the effects of supply chain digitalization on supply chain performance, visibility, and resilience. Recent studies consistently emphasize the positive effects of supply chain digitalization on supply chain performance. Supply chain performance refers to how well the supply chain can meet the end-customer

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requirements in terms of cost, quality, responsiveness, and flexibility [7]. As a strategic enabler, supply chain digitalization improves product quality and operational efficiency by streamlining processes, enhancing coordination, and lowering costs [8, 9]. It also promotes sustainability by integrating technologies throughout procurement, production, and logistics, extending product life cycles and enhancing resource efficiency. [1, 10]. Moreover, supply chain digitalization enhances real-time information sharing, inventory management, and forecasting accuracy factors essential for responsiveness and overall performance [9, 11]. Empirical evidence from developing economies, including Vietnam and India, further supports the role of SCD in enhancing performance in highly responsive sectors such as textiles [12, 13]. Recent enterprise-level studies reinforce the idea that supply chain digitalization is a key capability for achieving better supply chain performance [14-17].

Digitalization also indirectly affects performance through mediating capabilities such as supply chain resilience, agility, and, especially, visibility. Digital tools enhance supply chain visibility by enabling real-time information sharing, transparency, and coordination among supply chain partners [1, 18, 19]. Improved visibility leads to higher operational efficiency, customer satisfaction, and market responsiveness. Recent studies confirm that SCV mediates the relationship between digitalization and performance. Overall, digitalizing the supply chain enhances performance by strengthening visibility, agility, and resilience [9, 12]. In addition, recent studies [20-23] have demonstrated that supply chain resilience serves as a key mediating capability between supply chain digitalization and supply chain performance. Therefore, two intermediate capabilities, supply chain visibility and supply chain resilience, play a pivotal role in translating the benefits of supply chain digitalization into improved supply chain performance by optimizing costs, enhancing quality, and increasing responsiveness to market fluctuations [12, 13, 21-23].

However, previous studies have primarily examined the individual mediating roles of visibility or resilience, without exploring how these two capabilities interact sequentially to translate the benefits of digitalization into specific performance outcomes. Moreover, empirical evidence from emerging economies, such as Vietnam, remains limited. To address this gap, the present study develops and tests a sequential mediation model that explains how supply chain digitalization enhances performance through visibility and resilience. Grounded in the Resource-Based View and Dynamic Capabilities Theory, the study integrates two complementary perspectives: the Resource-Based View explains why digital capabilities serve as strategic resources, while Dynamic Capabilities Theory elucidates how firms sense, seize, and reconfigure these resources to build resilience and improve performance. Using survey data from manufacturing enterprises in Vietnam, this research contributes to the literature on digital supply chains by clarifying the sequential mechanisms through which digital transformation creates value in emerging economies.

The remainder of the paper is structured as follows. Section 2 introduces the theoretical background and reviews the literature on supply chain digitalization, supply chain visibility, supply chain resilience, and supply chain performance. Section 3 outlines the research methodology. Section 4 reports the findings on the direct, indirect, and serial mediation effects among the study variables. Finally, Section 5 presents the conclusions, highlights the theoretical and managerial implications, acknowledges the study's limitations, and offers directions for future research.

2- Theoretical Background

2-1-Supply Chain Digitalization

Supply chain digitalization has emerged as a strategic imperative in the digital era, reflecting the systematic integration of digital technologies across the entire supply chain to enhance connectivity, information transparency and responsiveness [24, 25]. Traditionally, digitalization primarily involved the deployment of isolated tools such as barcodes, radio frequency identification (RFID), warehouse management systems (WMS), and enterprise resource planning (ERP) systems to optimize specific functions [26, 27]. In contrast, the contemporary perspective regards supply chain digitalization as a holistic and strategic organizational capability [22, 24, 28, 29], conceptualize supply chain digitalization as a multidimensional construct comprising: (i) product and service digitalization, (ii) operational process digitalization, and (iii) business model digitalization. This comprehensive framework reflects not only the extent of technology adoption but also the level of digital maturity within an enterprise.

Recent studies [9, 22, 30] have further emphasized that digitalization is not merely about technology adoption but about transforming how information flows across partners, enabling predictive decision-making, and enhancing network resilience. These works conceptualize supply chain digitalization as a construct encompassing three key aspects: (i) product and service digitalization, (ii) operational process digitalization, and (iii) business model digitalization. This comprehensive framework reflects not only the extent of technology adoption but also the level of digital maturity within an enterprise, which determines its ability to sense and respond to disruptions in real time.

2-2-Supply Chain Performance

Supply chain performance refers to the extent to which a supply chain achieves desired operational outcomes (such as cost efficiency, timeliness, and investment effectiveness) while simultaneously fulfilling customer requirements. These outcomes are attained through the integration of digital technologies, efficient resource utilization, and the maintenance of adaptive capacity in a dynamic business environment. Beamon [7] proposed a multidimensional

approach to supply chain performance, encompassing resource efficiency, output effectiveness, and flexibility. Building upon this foundation, Gunasekaran et al. [31] developed a comprehensive performance measurement framework across three management levels, strategic, tactical, and operational, allowing for a holistic assessment that includes both financial and non-financial aspects, such as coordination and decision-making efficiency. Recent research further highlights the importance of a supply chain's ability to sustain efficiency, respond to risks, and meet customer expectations in increasingly volatile environments [22, 32]. From this perspective, supply chain performance is not solely a reflection of operational efficiency but also serves as an indicator of the firm's level of technology integration, data-driven decision-making, and organizational resilience.

The relationship between supply chain digitalization and operational performance has attracted increasing attention from researchers. Numerous studies have demonstrated that supply chain digitalization directly enhances supply chain performance by improving efficiency, reducing costs, and enabling more effective decision-making processes [33, 34]. Recent empirical evidence further supports these findings, showing that supply chain digital transformation significantly influences performance across various contexts and organizational sizes [14-17, 35, 36]. However, an emerging body of research indicates that the impact of supply chain digitalization on supply chain performance is not purely direct but primarily mediated through intermediary mechanisms. Among these, supply chain visibility and supply chain resilience represent foundational dynamic capabilities that are strengthened through digitalization and, in turn, enhance operational efficiency, customer satisfaction, and market responsiveness [9, 12, 20-23]. Therefore, supply chain digitalization can be viewed as the basis for developing higher-order capabilities. In other words, digitalization creates value primarily by enhancing visibility and resilience, making it essential to clarify the mediating mechanisms linking supply chain digitalization to supply chain performance to understand better how digital transformation generates tangible value.

2-3- The Resource-Based View and Dynamic Capability Theory

The theoretical foundation of this study draws on two frameworks, the Resource-Based View and Dynamic Capability Theory, to explain how supply chain digitalization influences supply chain performance through two key mediators: supply chain visibility and resilience. According to the Resource-Based View [37], resources that are valuable, rare, difficult to imitate and non-substitutable (VRIN) can generate sustainable competitive advantage. Digital technology is considered a strategic resource that facilitates the development of distinctive organizational capabilities, such as supply chain visibility and resilience [1, 6, 38, 39]. However, the Resource-Based View alone does not explain how these resources are mobilized and transformed into performance outcomes in turbulent environments. To address this limitation, the Dynamic Capabilities Theory [40, 41] provides a complementary process-oriented perspective, emphasizing that firms must not only possess valuable resources but also develop the abilities to sense opportunities and risks (sensing), seize them (seizing), and reconfigure their resources (reconfiguring) to adapt to environmental changes. Within this framework, supply chain visibility functions as a sensing capability that enables firms to detect early signals of disruption through information transparency and data monitoring, whereas supply chain resilience represents the seizing and reconfiguring capabilities that allow organizations to respond to, adapt, and recover from shocks [22, 42, 43].

Integrating Resource-Based View and Dynamic Capabilities Theory provides a more holistic theoretical lens: Resource-Based View explains why digital technologies are valuable strategic resources, while Dynamic Capabilities Theory describes how firms can effectively leverage these resources through dynamic processes to achieve superior performance [30, 44]. Accordingly, this study suggests that supply chain digitalization enhances supply chain performance in two ways: directly and indirectly through a sequential mediation process involving visibility and resilience. In other words, digital resources only add value when they are effectively transformed into adaptive capabilities.

3- Hypotheses Development

3-1- Relationships Between Supply Chain Digitalization and Supply Chain Performance

In supply chains, digitalization enhances an organization's information-processing capacity by enabling real-time data collection, sharing, and analysis across various supply chain functions. This allows firms to minimize information delays, improve forecast accuracy, and better coordinate critical activities such as procurement, inventory management, and distribution, leading to better performance outcomes. Additionally, supply chain digitalization, as a strategic resource or capability, positively influences supply chain performance [37]. Empirical evidence supports this link. Saryatmo & Sukhotu [8] showed that digitalization boosts quality and productivity while cutting costs. Ageron et al. [11] and Queiroz et al. [1] highlighted digital tech's role in improving connectivity, reducing disruptions, and enhancing inventory management for supply chain performance. In Vietnam, Huang et al. [12] found that digitalization increases responsiveness and performance in textile firms. Talluri & Ananthamurthy [13] observed similar results in Indian manufacturing firms. Thus, this study proposes the following hypothesis:

Hypothesis H1: Supply chain digitalization has a direct and positive effect on supply chain performance

Digitalization within supply chains helps manage complexity through real-time data collection, analytics, and sharing [45, 46]. Supply chain visibility, including the accessibility, usefulness, and quality of information, supports both operational and strategic decisions [47]. It enables partners to access, share, and use high-quality, timely information related to customers, operations, and suppliers [48, 49]. Consequently, digitalization positively impacts supply chain visibility, as supported by empirical studies [9, 13, 50]. Al Tera et al. [9] emphasize that real-time data sharing improves visibility in dynamic environments. Therefore, this study proposes the following hypothesis:

Hypothesis H2: Supply chain digitalization has a positive effect on supply chain visibility

According to the Resource-Based View, supply chain visibility is a strategic informational resource. From the perspective of Dynamic Capabilities Theory, supply chain visibility is a dynamic capability that enables supply chains to detect risks and disruptions early, make rapid, accurate decisions, and thereby enhance their ability to reconfigure and adapt to disruptions. Empirical studies have also demonstrated the effects of supply chain visibility on supply chain resilience [51, 52]. Accordingly, both the theoretical perspective of dynamic capabilities and empirical evidence support a positive relationship between supply chain visibility and supply chain resilience. Based on this reasoning, the present study proposes the following hypothesis:

Hypothesis H3: Supply chain visibility has a positive effect on supply chain resilience

From the perspective of Resource-Based Theory, supply chain visibility is a strategic resource [37] that can provide a competitive advantage by improving inventory management, minimizing costs, and meeting customer requirements. This suggests that supply chain visibility directly affects supply chain performance. Empirical studies have demonstrated that supply chain visibility influences order accuracy, delivery time, and operational costs [9, 12, 50]. Therefore, supply chain visibility is expected to directly enhance supply chain performance by improving information quality, decision-making speed, and coordination efficiency across the supply chain. Based on this reasoning, the study proposes the following hypothesis:

Hypothesis H4: Supply chain visibility has a positive effect on supply chain performance

According to Dynamic Capabilities Theory, enhancing digital capabilities through supply chain digitalization enables firms to integrate, build, and reconfigure resources to effectively respond to changing environments, thereby strengthening supply chain resilience. From the perspective of the Resource-Based View, supply chain resilience is also considered a capability that helps maintain continuous operations and create sustainable competitive advantage in volatile market contexts. Thus, supply chain digitalization serves not only as a technological tool but also as a strategic mechanism that enhances supply chain resilience, translating digital capabilities into operational efficiency and improved performance. Similarly, Zhao et al. [22] highlighted that supply chain digitalization enhances firms' digital capabilities, enabling them to absorb information, respond rapidly, and recover from disruptions, thereby improving supply chain resilience. Based on this reasoning, the following hypothesis is proposed:

Hypothesis H5: Supply chain digitalization has a positive effect on supply chain resilience

Based on Resource-Based Theory, supply chain resilience is a strategic, rare, and sustainable organizational capability, developed through the unique integration of technology, processes, relationships, and disruption-response experiences. Dynamic Capabilities Theory also regards supply chain resilience as a higher-order dynamic capability, reflected in the ability to reconfigure resources and processes to adapt to environmental fluctuations and ensure operational outcomes. Empirical studies have shown that supply chain resilience reduces disruption time, enhances reliability and flexibility, and consequently improves supply chain performance [22, 42, 52, 53]. Therefore, supply chain resilience is expected to directly enhance supply chain performance by maintaining continuity and operational efficiency. Based on this reasoning, the study proposes the following hypothesis

Hypothesis H6: Supply chain resilience has a positive effect on supply chain performance

3-2-Single Mediating Effect of Supply Chain Visibility

According to the Dynamic Capabilities Theory, supply chain digitalization enhances data integration and real-time information transparency, thereby strengthening supply chain visibility. Enhanced supply chain visibility enables firms to detect disruptions early, coordinate effective responses, and consequently improve supply chain resilience. Thus, the effect of supply chain digitalization on supply chain resilience is expected to be mediated by supply chain visibility.

Hypothesis H7: Supply chain visibility mediates the effect of supply chain digitalization on supply chain resilience

Supply chain digitalization facilitates real-time data collection, analysis, and sharing, transforming data into insights such as supply chain visibility, which indicates how accessible and usable supplier, operational, and customer information is. The Resource-Based View argues that resources alone do not guarantee performance unless they are effectively deployed and integrated into routines [37, 54]. Thus, supply chain visibility connects digital resources to performance, supporting the benefits of digitalization. Recent studies support this connection. Al Tera et al. [9] found

that supply chain digitalization enhances visibility, improving traceability, transparency, and responsiveness. Huang et al. [12] showed that in Vietnam's textile industry, visibility helps turn digital investments into actual benefits by enabling flexible responses to disruptions. Based on this literature, the study proposes the following hypothesis:

Hypothesis H8: Supply chain visibility mediates the effect of supply chain digitalization on supply chain performance.

3-3-Single Mediating Effect of Supply Chain Resilience

According to Dynamic Capabilities Theory, supply chain digitalization enhances the ability to collect, process and share information across the supply chain, thereby strengthening supply chain resilience. Improved supply chain resilience enables firms to respond more flexibly to risks and disruptions, thereby improving supply chain performance. Empirical studies have shown that supply chain resilience mediates the relationship between supply chain digitalization and supply chain performance. Specifically, supply chain digitalization enhances firms' capabilities to anticipate, coordinate, and respond to risks, thereby improving supply chain resilience [20-23]. Enhanced supply chain resilience, in turn, optimizes performance across cost, quality, and flexibility. In summary, supply chain digitalization can improve resilience, which subsequently enhances supply chain performance [22]. Based on these arguments, the following hypothesis is proposed

Hypothesis H9: Supply chain resilience mediates the effect of supply chain digitalization on supply chain performance.

According to Dynamic Capabilities Theory, supply chain visibility reflects the ability to sense, enabling the supply chain to detect early signals of risks or disruptions. supply chain resilience, in turn, represents the capacity to seize and reconfigure, allowing firms to rapidly adjust operations and restructure the supply chain in response to environmental changes, thereby enhancing performance. Based on this theoretical foundation, supply chain visibility is expected to facilitate effective supply chain resilience, which in turn drives improved supply chain performance. In other words, supply chain resilience functions as a mediating variable in the relationship between supply chain visibility and supply chain performance [12, 52]. Accordingly, the following research hypothesis is proposed:

Hypothesis H10: Supply chain resilience mediates the effect of supply chain visibility on supply chain performance

3-4-Serial Mediating Effect of Supply Chain Visibility and Supply Chain Resilience in the Supply Chain Digitalization and Supply Chain Performance Relationship

According to the Dynamic Capabilities Theory, digital technologies are strategic resources that enable firms to identify and access data across the supply chain [41]. This capability enables supply chain visibility, reflecting the ability to collect, share, and use information in real time. Leveraging the comprehensive and transparent information provided by supply chain visibility, firms can enhance supply chain resilience by evaluating response options, making informed decisions, and rapidly restructuring the supply chain to adapt to changes. In this sense, supply chain resilience can be viewed as the subsequent outcome of supply chain visibility within the dynamic capabilities chain, as firms progress from identification to exploitation and adaptation. Ultimately, enhanced supply chain resilience enables firms to sustain and even improve supply chain performance by reducing recovery time, increasing flexibility, lowering costs, and improving supply reliability.

Thus, Dynamic Capabilities Theory elucidates the mechanism by which SCD influences supply chain performance through two successive intermediate capabilities: supply chain visibility and supply chain resilience. Based on this theoretical reasoning, the following research hypothesis is proposed:

Hypothesis H11: Supply chain visibility and supply chain resilience serially mediate the impact of supply chain digitalization on supply chain performance.

Figure 1 displays the research model, which includes hypotheses about direct relationships, mediations and serial mediation effects.

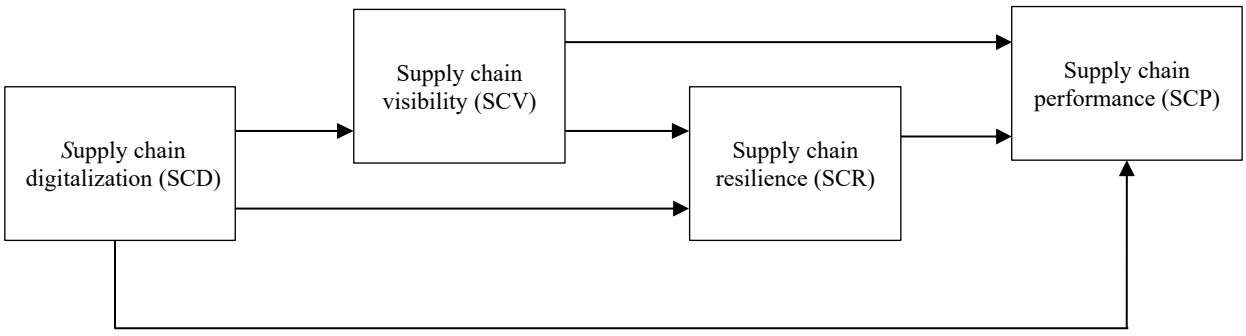

Figure 1. Proposed Research Model

4- Research Methodology

4-1- Measurement Scales of Variables

The authors designed a questionnaire using a five-point Likert scale: (1) = Strongly Disagree, (2) = Disagree, (3) = Neutral, (4) = Agree, and (5) = Strongly Agree. We selected this scale because Vietnamese respondents are more familiar with a ten-point scoring system (multiples of 5). However, the ten-point scale was found to be too complex and time-consuming for participants. Thus, a five-point scale was chosen as a more practical alternative to enhance response reliability and save time.

The items measuring Supply Chain Digitalization (three items) and Supply Chain Performance (four items) were adapted from Zhao et al. [22]. The items for Supply Chain Visibility (six items) were adapted from Agrawal et al. [55], and those for Supply Chain Resilience (five items) were adapted from Belhadi et al. [43]. All items were translated into Vietnamese and then back-translated into English to ensure both linguistic and conceptual equivalence.

The semi-final questionnaire was given to survey managers in Gia Lai industrial parks to assess their understanding and interpretation. Results showed they understood the questions, especially those related to variables in the research model. We then made minor corrections and finalized the questionnaires.

4-2- Data Collection and Sample Characteristics

Data collection will be carried out between late 2024 and mid-2025, spanning approximately eight months from December 2024 to July 2025. During this period, data will be obtained using a structured questionnaire, with oversight provided by members of the Economic Zone Management Board, Industrial Zone Management Board and local tax authorities across various provinces in Vietnam.

As this study focuses on manufacturing enterprises, the questionnaire was distributed online to firms located in industrial zones within provinces with the highest concentration of manufacturing activity. The unit of analysis is the enterprise, as the survey addresses market revenue, supplier input costs, supply chain visibility, and supply chain performance. Accordingly, respondents were selected from the middle or senior management level to ensure the data were accurate and relevant. Participants were informed of the study's objectives, and the questionnaire clearly stated that all business information would remain confidential and that the data collected would be used solely for research purposes.

This study employed convenience sampling. An online questionnaire, developed in Google Forms, was distributed to managers of enterprises located in industrial zones across Vietnam, with assistance from officials from the Economic Zone Management Board, the Industrial Zone Management Board, and local tax authorities. These officials forwarded the survey link to enterprise managers through their respective business management networks. This approach expedited data collection and ensured that respondents were relevant decision-makers, thereby enhancing the reliability and validity of the data. Over eight months, 379 valid responses were obtained.

Hair [56] recommends a minimum sample size of about 100-150 for SEM with five or fewer constructs. Since this study's model only includes four constructs, a sample size of 379 is sufficient for SEM analysis. Of these respondents, 15 identified as directors, 26 as vice directors, 244 as managers or deputy managers, and 94 in other management roles. All had at least three years of managerial experience, with 64.1% having over five years. About 42.7% of the firms employed fewer than 200 staff. Additionally, more than two-thirds of the firms reported annual revenues of VND 200-500 billion in 2024 (see Table 1).

Table 1. Profile of the respondents and sample firms

Characteristics	Frequency	Percent
Position		
Directors	15	4,0%
Vice Directors	26	6,9%
Managers or Deputy Managers of Departments	244	64,4%
Other Management Positions	94	24,8%
Years of Management Experience		
From 3 to 5 years	136	35,9%
More than 5 years	243	64,1%
Number of Employees		
1–200 employees	162	42,7%
201–500 employees	110	29,0%
401–600 employees	40	10,6%
601–800 employees	26	6,9%
801–1000 employees	14	3,7%
Over 1000 employees	27	7,1%

Annual Revenue in 2024		
VND 20 billion or less	8	2,1%
Over VND 20 billion to VND 200 billion	52	13,7%
Over VND 200 billion to VND 300 billion	136	35,9%
Over VND 300 billion to VND 500 billion	150	39,6%
Over VND 500 billion	33	8,7%

5- Research Result Analysis

5-1- Assessment of Nonresponse Bias and Common Method Bias

Before testing the measurement and structural models, the study assessed potential sources of bias that could affect the validity of the data, including nonresponse bias and common method bias

To assess nonresponse bias, the study employed a clustering approach based on the timing of data collection. Specifically, survey participants were divided into two groups: early respondents and late respondents. An independent-samples t-test was then conducted to compare the mean scores of the main research variables between the two groups. The results indicated no statistically significant differences ($p > 0.05$), suggesting that nonresponse bias was not a concern in this study.

Since all data were collected using the same questionnaire at the same time from the same group of respondents, there was a potential risk of common-method bias, which could affect the reliability of the results. Common method bias is a well-documented concern in survey-based research [57]. To mitigate this risk, the study adhered to the principles of participant confidentiality and anonymity. All responses were kept confidential and not shared with third parties [58], which reassured participants and encouraged honest reporting, thereby reducing social desirability bias and enhancing data validity. To assess the presence of common method bias, Harman's single-factor test was conducted using unrotated principal component analysis. The first factor accounted for only 45.01% of the total variance, well below the 50% threshold, indicating that common method bias was not a major concern. In addition, the Variance Inflation Factor (VIF) was examined to detect potential multicollinearity among variables. All VIF values were below the threshold of 3.3 [59], further confirming that common method bias did not significantly affect the model. Together, these tests verified the objectivity and reliability of the research data.

5-2- Evaluation of the Measurement Models

After data collection, the authors reevaluated both the measurement and structural models using SmartPLS 4. The measurement scales used in this study were adapted from well-established sources that had been previously developed, tested, and validated. To verify the reliability and validity of these constructs within the present research context, confirmatory factor analysis (CFA) was performed [60-62]. The assessment of the measurement model involved evaluating construct reliability through Cronbach's Alpha and composite reliability, as well as construct validity, including both convergent and discriminant validity.

Table 2 presents the findings related to reliability and convergent validity. All indicators demonstrate outer loadings above 0.70, suggesting that each item significantly contributes to its corresponding construct. Composite reliability (CR) values range from 0.877 to 0.918, exceeding the recommended minimum of 0.70. Similarly, Cronbach's Alpha (CA) coefficients fall between 0.789 and 0.902, surpassing the acceptable threshold and indicating strong internal consistency [63].

Moreover, outer loadings are consistently above the 0.70 benchmark, varying from 0.756 to 0.882 (Joseph F Hair, Risher, Sarstedt, & Ringle, 2019). The Average Variance Extracted (AVE) values also meet the criterion of being greater than 0.50, ranging from 0.671 to 0.704 [63, 64]. These results collectively confirm that the measurement instruments employed exhibit robust convergent validity.

Subsequently, discriminant validity was further assessed using the Heterotrait–Monotrait (HTMT) ratio of correlations. As shown in Table 3, all HTMT values range between 0.402 and 0.885, remaining below the recommended cutoff of 0.90 [65, 66]. These findings provide additional evidence that the measurement scales employed in the research model demonstrate adequate discriminant validity.

Table 2. Construct Reliability and Validity

Variables	Items	Descriptions	Loadings	α	CR	AVE
Supply chain digitalization (SCD)	SCD1	Our company's supply chain has digitized products and services.	0.836	0.789	0.877	0.704
	SCD2	Our company's supply chain has digitized operational processes.	0.821			
	SCD3	Our company's supply chain has adopted a digital business model.	0.859			
Supply chain visibility (SCV)	SCV1	Our company's supply chain monitors the status of delivery processes to notify customers when needed.	0.834	0.902	0.924	0.671
	SCV2	Our company's supply chain provides timely information about deviations and their nature.	0.756			
	SCV3	Our company's supply chain provides inventory-level information for all locations.	0.856			
	SCV4	Our company's supply chain provides information on production capacity at all factories.	0.824			
	SCV5	Our company's supply chain provides information on the production and delivery times of goods.	0.827			
	SCV6	Our company's supply chain shares expected purchase quantities with suppliers.	0.814			
Supply chain resilience (SCR)	SCR1	Our company's supply chain is well prepared to withstand the constraints posed by supply chain disruptions.	0.843	0.888	0.918	0.691
	SCR2	Our company's supply chain can rapidly plan and execute contingency plans during disruptions	0.795			
	SCR3	Our company's supply chain can adequately respond to unexpected disruptions by quickly restoring its product flow.	0.827			
	SCR4	Our company's supply chain can swiftly return to its original state after being disrupted.	0.843			
	SCR5	Our company's supply chain can gain a superior state compared to its original state after being disrupted	0.848			
Supply chain performance (SCP)	SCP1	Our company's supply chain is more cost-efficient in operations.	0.810	0.836	0.891	0.672
	SCP2	Our company's supply chain generates higher returns on business investments.	0.773			
	SCP3	Our company's supply chain achieves faster delivery times.	0.882			
	SCP4	Our company's supply chain meets diverse customer requirements for products.	0.809			

Table 3. Discriminant Validity

	SCD	SCP	SCR	SCV
SCD				
SCP	0.865			
SCR	0.696	0.660		
SCV	0.370	0.424	0.751	

In summary, all observed indicators were statistically significant. The constructs showed strong reliability alongside satisfactory convergent and discriminant validity. Consequently, the collected data are deemed reliable and valid for testing the proposed research hypotheses.

5-3- Hypothesis Testing

The hypotheses were tested using Smart PLS 4, suitable for analyzing mediators and sequential mediation. Bootstrapping, a resampling technique that draws samples from the data to estimate population parameters and improve understanding, was employed. The results were derived from 5,000 bootstrap samples. The main findings are summarized in Table 4 and Figure 2. Multicollinearity was assessed using variance inflation factors (VIFs). All VIF values were below 3,3 [59] with the maximum at 2.879, well under the recommended threshold of 5 [63], indicating that multicollinearity was not an issue.

To test the research hypotheses, we specified two hierarchical models using partial least squares structural equation modeling (PLS-SEM). Model 1 examines the indirect effect of supply chain digitalization (SCD) on supply chain performance (SCP) through supply chain visibility (SCV). Model 2 builds upon Model 1 by incorporating supply chain resilience (SCR) as a serial mediator. The results are summarized in Table 4 and Figure 2, reporting path coefficients (β), t-values, adjusted R^2, and Q^2 statistics. All estimates were generated based on 5,000 bootstrap resamples to ensure robust inference.

Table 4. Hypothesis testing results

Hypothesis		Model 1 (with SCV as a mediating variable)		Model 2 (with SCV, SCR as a serial mediating variable)		
	Dependent variables	**SCV**	**SCP**	**SCV**	**SCR**	**SCP**
	Independent variables					
H1; H2; H5	SCD	0.314 (6.814)***	0.651 (16.810)***	0.313 (6.693)***	0.413 (12.000)***	0.570 (11.056)***
H3; H4	SCV	-	0.166 (3.947)***	-	0.544 (14.176)***	0.057 (0.973)^{ns}
H6	SCR	-	-	-	-	0.198 (2.986)***
H7; H8	Indirect effect: SCD → SCV	-	0.052 (3.563)***	-	0.170 (6.217)***	0.018 (0.953)^{ns}
H9	Indirect effect: SCD → SCR	-	-	-	-	0.082 (3.075)***
H10	Indirect effect: SCV → SCR	-	-	-	-	0.108 (2.877)***
H11	Indirect effect: SCD → SCV → SCR	-	-	-	-	0.034 (2.709)***
	Adjusted R-squared	0.096	0.517	0.096	0.605	0.530
	Q2	0.063	0.344	0.063	0.413	0.353

Note: ***, **, *, and ^{ns} indicate statistical significance at the 1%, 5%, 10%, and non-significant levels, respectively.

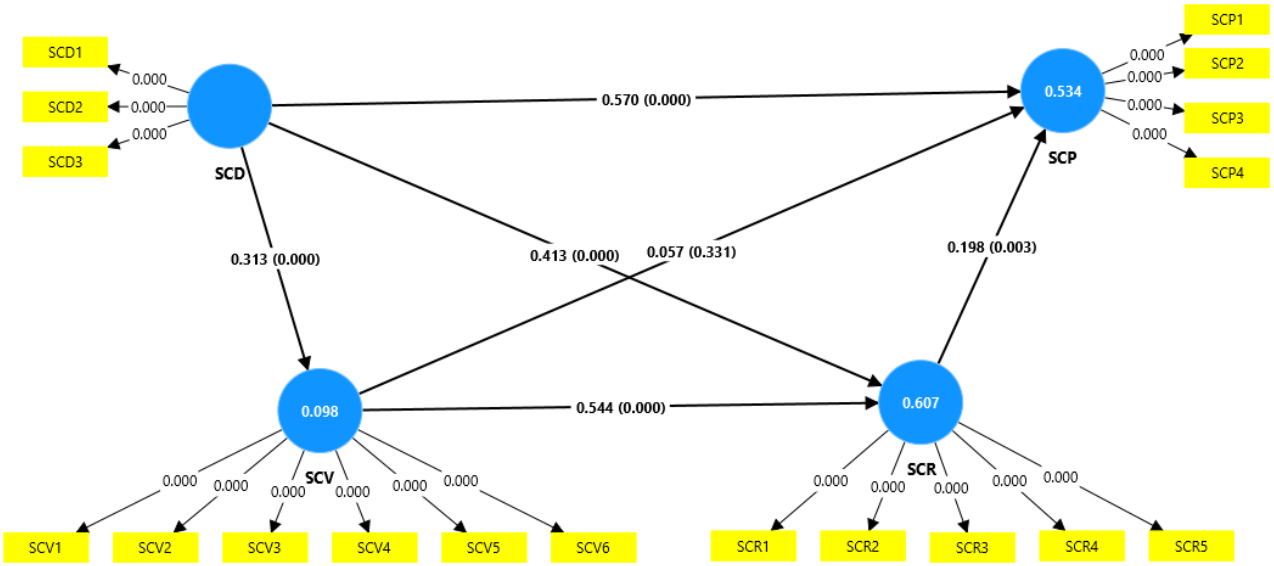

Figure 2. The Structural Model (Model 2)

The results from Models 1 and 2 indicate that SCD exerts a direct, statistically significant effect on both SCV and SCP. Specifically, SCD has a positive impact on SCV (Model 1: $\beta = 0.314$, $t = 6.814$, $p < 0.001$; Model 2: $\beta = 0.313$, $t = 6.693$, $p < 0.001$) and demonstrates a signicant and direct effect on SCP (Model 1: $\beta = 0.651$, $t = 16.810$, $p < 0.001$; Model 2: $\beta = 0.570$, $t = 11.056$, $p < 0.001$). Therefore, hypotheses H1 and H2 are supported. These findings strengthen the Resource-Based View argument that digitalization constitutes a strategic resource that enhances supply chain efficiency and overall performance.

In Model 1, SCV has a positive, statistically significant effect on SCP ($\beta = 0.166$, $t = 3.947$, $p < 0.001$), indicating that greater visibility enhances performance. Accordingly, hypothesis H4 is supported. However, when SCR is incorporated in Model 2, the direct effect of SCV on SCP becomes statistically insignificant ($\beta = 0.057$, $t = 0.973$, $p = 0.331$), meaning that H4 is not supported in this extended model. This finding suggests that the performance benefits of SCV are primarily transmitted indirectly through SCR. Additionally, the results reveal that SCV has a strong positive effect on SCR ($\beta = 0.544$, $t = 14.176$, $p < 0.001$) and SCR, in turn, significantly improves SCP ($\beta = 0.198$, $t = 2.986$, $p = 0.003$). Finally, SCD exerts a significant positive influence on SCR ($\beta = 0.413$, $t = 12.000$, $p < 0.001$). Collectively, these results support hypotheses H3, H5, and H6.

The mediation analysis indicates that SCV partially mediates the relationship between SCD and SCP in Model 1 ($\beta = 0.052$, $t = 3.563$, $p < 0.01$), thereby supporting hypothesis H8. However, when SCR is included in Model 2, the

indirect effect of SCD on SCP through SCV becomes statistically insignificant ($\beta = 0.018$, $t = 0.953$, $p = 0.341$), suggesting that H8 is not supported in the extended model. This finding underscores that SCV contributes to performance improvement primarily when it operates in conjunction with SCR, highlighting the complementary roles of visibility and resilience in enhancing supply chain outcomes.

Notably, SCV has a positive and statistically significant effect on SCR ($\beta = 0.544$, $t = 14.176$, $p < 0.01$), and the indirect effect of SCD on SCR via SCV is also significant ($\beta = 0.034$, $t = 2.709$, $p < 0.01$), supporting the hypothesis that SCV mediates the development of resilience. More importantly, the sequential pathway from SCV to SCR and subsequently to SCP is confirmed ($\beta = 0.108$, $t = 2.877$, $p < 0.01$). These results suggest that SCV does not directly enhance performance but primarily enables resilience, which, in turn, drives performance improvements. Collectively, these findings underscore the pivotal role of SCR as the key mediating mechanism that converts digitalization and information transparency into tangible performance outcomes.

Finally, the results of the serial mediation analysis reveal that the path SCD → SCV → SCR → SCP is statistically significant ($\beta = 0.034$, $t = 2.709$, $p = 0.007$), thereby supporting hypothesis H11 and providing empirical evidence for the dynamic capabilities framework. This finding suggests that SCV enables firms to detect risks and opportunities (sensing). At the same time, SCR equips them to mobilize resources and reconfigure supply chain structures (seizing and reconfiguring) in response to environmental changes, ultimately enhancing operational efficiency. Overall, these results not only elucidate the underlying mechanism through which supply chain digitalization influences performance but also highlight the pivotal role of SCR in converting information transparency into tangible performance outcomes.

6- Discussion and Implication

The results confirm that supply chain digitalization exerts a substantial and statistically significant direct effect on supply chain performance, aligning with prior research [5, 67, 68] that underscores the role of digital technologies as strategic resources for enhancing operational efficiency. This study contributes additional empirical evidence from the context of Vietnamese manufacturing enterprises. In this emerging market, digital transformation is still in an active implementation phase, thereby reinforcing the resource-based view proposition that supply chain digitalization represents a VRIN resource capable of generating sustainable competitive advantage.

In addition, the study reveals that supply chain visibility exerts a positive and statistically significant effect on supply chain performance when examined in isolation (Model 1), corroborating previous findings that supply chain visibility enhances coordination and mitigates operational [9, 12, 50, 52]. However, when supply chain resilience is incorporated into the model (Model 2), the direct relationship between supply chain visibility and supply chain performance becomes statistically insignificant, whereas the sequential pathway SCD → SCV → SCR → SCP attains significance. This suggests a dynamic mechanism in which visibility alone is insufficient to improve performance unless adaptive and recovery capabilities accompany it. This finding also diverges from studies such as Al Tera et al. [9], which reported a direct link between visibility and performance. The divergence may stem from contextual differences: in emerging economies, digital infrastructure and data-sharing mechanisms remain less mature, meaning that the benefits of visibility materialize only when complemented by resilience. This interpretation aligns with the Dynamic Capabilities Theory proposed by Teece (2007, 2014) [40, 41], which argues that firms must develop sensing, seizing, and reconfiguring capabilities to transform static resources into adaptive competitive advantages.

Importantly, the significant serial mediation path SCD → SCV → SCR → SCP provides strong empirical support for the dynamic capabilities framework. The results reveal that supply chain visibility functions as a sensing capability, enabling firms to detect disruptions and opportunities in real time, while supply chain resilience embodies the ability to seize and reconfigure, allowing organizations to adapt, respond, and recover swiftly. Hence, the performance benefits of digitalization do not arise directly from technological deployment but from the transformation of information transparency into adaptive capabilities. This integration of the Resource-Based View and Dynamic Capabilities Theory perspectives advances theoretical understanding by illustrating how digital resources create value through dynamic capability processes.

From a managerial standpoint, the findings suggest that firms, especially in emerging markets such as Vietnam, should perceive digital transformation as a capability-building journey rather than a mere technology adoption process. Managers should not only invest in visibility-enhancing technologies such as IoT platforms, ERP systems, and analytics tools but also focus on developing organizational resilience through risk management policies, supplier diversification, and crisis response planning. Such efforts enable firms to convert information visibility into timely, strategic, and adaptive decisions, ensuring operational continuity amid environmental turbulence.

Finally, this study advances the literature by elucidating the sequential mechanism linking supply chain visibility and supply chain resilience in the relationship between supply chain digitalization and supply chain performance. This area has received limited attention in prior research. The results highlight that supply chain resilience serves as the pivotal mediating link, explaining why firms that heavily invest in digitalization may still fail to realize the expected

performance gains: without resilience, the potential of visibility remains underexploited. Thus, the study offers both theoretical and practical implications by demonstrating that the true value of digitalization lies not in technology itself, but in the firm's ability to transform digital visibility into resilient operational performance.

7- Conclusion

This study provides robust empirical evidence on the pivotal roles of supply chain digitalization, visibility, and resilience in enhancing supply chain performance among Vietnamese manufacturing firms. Drawing upon the Resource-Based View and Dynamic Capabilities Theory, the findings confirm that supply chain digitalization serves as a strategic and valuable resource that improves performance both directly and indirectly. More importantly, the results unveil a novel mechanism in which the direct effect of supply chain visibility on supply chain performance becomes insignificant once supply chain resilience is incorporated, indicating that visibility alone does not guarantee better outcomes unless supported by resilience capabilities. These highlights supply chain resilience as the critical mediating mechanism that transforms digital transparency into adaptive and measurable performance gains. By empirically validating this sequential mediation pathway, the study advances the integration of the Resource-Based View and Dynamic Capabilities Theory. It enriches the theoretical understanding of how digitalization translates into tangible competitive advantage in emerging markets.

From a managerial perspective, the findings emphasize that digital transformation should be closely integrated with resilience development rather than focusing solely on technological investments. Managers should establish reliable forecasting systems, diversify supplier networks, and design flexible contingency plans to ensure adaptability and rapid recovery in the event of disruptions. Furthermore, digitalization practices such as AI-driven analytics, blockchain-based traceability, and IoT-enabled supply chain monitoring can substantially enhance visibility and resilience, thereby improving overall supply chain performance. These initiatives are particularly crucial for firms seeking to strengthen supply chain stability amid an increasingly uncertain global environment. Despite its contributions, this study has several limitations. The survey sample was restricted to manufacturing enterprises in Vietnam, potentially limiting the generalizability of the findings. Future research could extend the model to logistics and service sectors to explore whether similar mechanisms apply in non-manufacturing contexts. Moderator variables such as digital maturity and organizational culture, which may influence the mediating relationships among digitalization, resilience, and performance, should also be examined. Moreover, incorporating objective performance indicators (e.g., delivery time, operational costs) alongside self-reported data would enhance the robustness of the results. Finally, future studies could integrate environmental and social sustainability as outcome variables of digitalization and resilience, thereby providing a more comprehensive understanding of sustainable supply chain performance in the digital era.

8- Declarations

8-1- Author Contributions

Conceptualization, T.T.T.N. and N.M.N.; methodology, T.T.T.T., N.M.N., and D.A.D.; software, T.T.T.N.; validation, T.T.T.T., N.M.N., and D.A.D.; formal analysis, T.T.T.T. and N.M.N.; investigation, T.T.T.T.; N.M.N. and D.A.D.; data curation, N.M.N. and D.A.D; writing—original draft preparation, T.T.T.N.; writing—review and editing, T.T.T.T., N.M.N., and D.A.D.; funding acquisition, T.T.T.N. All authors have read and agreed to the published version of the manuscript.

8-2- Data Availability Statement

The data presented in this study are available on request from the corresponding author.

8-3- Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

8-4- Institutional Review Board Statement

Not applicable.

8-5- Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

8-6- Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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Appendix I: Questionnaire

Survey Questionnaire

Dear Sir/Madam,

We are conducting a research study on "The impact of supply chain digitalization on supply chain performance in Vietnamese enterprises." We would greatly appreciate your support by completing this questionnaire. All questions are non-sensitive and simple (please respond by marking X in boxes from 1 to 5). We assure you that all collected information will be used solely for scientific purposes. The research results will be presented in aggregate form only, and the data will be processed anonymously and kept strictly confidential.

PART 1: RESPONDENT INFORMATION

1. **What is your full name*?*.....**
2. **What is your email address*?* .....**
3. **What is your current position in the company?**
   - ☐ CEO/General Director
   - ☐ Deputy CEO/Deputy General Director
   - ☐ Head/Deputy Head of Department or Division
   - ☐ Other management position in the company
   - ☐ Staff/Employee
4. **How many years have you been working in this company*?*.....**

PART 2: COMPANY INFORMATION

1. **What is the name of your company*?*.....**
2. **In which industrial zone is your company located*?* .....**
3. **This industrial zone belongs to:**
   - ☐ Northern Vietnam
   - ☐ Central Vietnam
   - ☐ Southern Vietnam
4. **What is your company's main line of business? (Select one industry with the highest revenue):**
   - ☐ C10. Manufacture and processing of food products
   - ☐ C11. Manufacture of beverages
   - ☐ C12. Manufacture of tobacco products
   - ☐ C13. Textile manufacturing
   - ☐ C14. Manufacture of apparel
   - ☐ C15. Manufacture of leather and related products
   - ☐ C16. Wood processing and manufacture of wood, bamboo, rattan products (except furniture); manufacture of products from straw, rush, and plaiting materials
   - ☐ C17. Manufacture of paper and paper products
   - ☐ C18. Printing and reproduction of recorded media
   - ☐ C19. Manufacture of coke and refined petroleum products
   - ☐ C20. Manufacture of chemicals and chemical products
   - ☐ C21. Manufacture of pharmaceuticals, medicinal chemical, and botanical products
   - ☐ C22. Manufacture of rubber and plastic products
   - ☐ C23. Manufacture of other non-metallic mineral products
   - ☐ C24. Manufacture of basic metals

☐ C25. Manufacture of fabricated metal products (except machinery and equipment)
☐ C26. Manufacture of electronic products, computers, and optical products
☐ C27. Manufacture of electrical equipment
☐ C28. Manufacture of machinery and equipment n.e.c.
☐ C29. Manufacture of motor vehicles and other motorized transport
☐ C30. Manufacture of other transport equipment
☐ C31. Manufacture of furniture
☐ C32. Other manufacturing industries
☐ C33. Repair, maintenance, and installation of machinery and equipment
☐ Other: .....

5. What is the total asset value (capital) of your company?

☐ ≤ 20 billion VND
☐ 21 – 50 billion VND
☐ 51 – 100 billion VND
☐ 101 – 200 billion VND
☐ 201 – 500 billion VND
☐ 501 – 1.000 billion VND
☐ > 1.000 billion VND

6. What is the total number of employees currently working in your company?

☐ 1 – 200 employees
☐ 201 – 400 employees
☐ 401 – 600 employees
☐ 601 – 800 employees
☐ 801 – 1,000 employees
☐ Over 1,000 employees

7. Please indicate your company's revenue range in 2024:

☐ 20 billion VND or less
☐ Over 20 billion to 200 billion VND
☐ Over 200 billion to 300 billion VND
☐ Over 500 billion to 500 billion VND
☐ Over 500 billion VND

PART 3: MAIN CONTENT

1. Do you agree with the following statements about the digitalization level of your company's supply chain? (Use a 5-point Likert scale: (1) = Strongly Disagree; (2) = Disagree; (3) = Neutral; (4) = Agree; (5) = Strongly Agree)					
Our company's supply chain has digitized products and services.	1	2	3	4	5
Our company's supply chain has digitized operational processes.	1	2	3	4	5
Our company's supply chain has adopted a digital business model.	1	2	3	4	5
2. Do you agree with the following statements about the supply chain visibility of your company? (Use a 5-point Likert scale: (1) = Strongly Disagree; (2) = Disagree; (3) = Neutral; (4) = Agree; (5) = Strongly Agree)					
Our company's supply chain monitors the status of delivery processes to notify customers when needed.	1	2	3	4	5
Our company's supply chain provides timely information about deviations and their nature.	1	2	3	4	5
Our company's supply chain provides inventory-level information for all locations.	1	2	3	4	5
Our company's supply chain provides information on production capacity at all factories.	1	2	3	4	5
Our company's supply chain provides information on the production and delivery times of goods.	1	2	3	4	5
Our company's supply chain shares expected purchase quantities with suppliers.	1	2	3	4	5

3. Do you agree with the following statements about the supply chain resilience of **your company?** (Use a 5-point Likert scale: (1) = Strongly Disagree; (2) = Disagree; (3) = Neutral; (4) = Agree; (5) = Strongly Agree)					
Our company's supply chain is well prepared to face the constraints of supply chain disruptions.	1	2	3	4	5
Our company's supply chain can rapidly plan and execute contingency plans during disruptions	1	2	3	4	5
Our company's supply chain can adequately respond to unexpected disruptions by quickly restoring its product fow.	1	2	3	4	5
Our company's supply chain can swiftly return to its original state after being disrupted.	1	2	3	4	5
Our company's supply chain can gain a superior state compared to its original state after being disrupted	1	2	3	4	5
4. Do you agree with the following statements about your company's supply chain performance? (Use a 5-point Likert scale: (1) = Strongly Disagree; (2) = Disagree; (3) = Neutral; (4) = Agree; (5) = Strongly Agree)					
Our company's supply chain is more cost-efficient in operations.	1	2	3	4	5
Our company's supply chain generates higher returns on business investments.	1	2	3	4	5
Our company's supply chain achieves faster delivery times.	1	2	3	4	5
Our company's supply chain meets diverse customer requirements for products.	1	2	3	4	5

PART 4: OPTIONS

1. Would you like to receive a summary report of this survey's results?

☐ Yes

☐ No

2. If "Yes," how would you like to receive it?

☐ Email

☐ Postal mail

☐ In person

3. Please provide your contact information (confidential):

Company name:.....

Full name: .....

Email:.....

Mailing address: .....

Phone number: .....

Thank you very much for your kind cooperation!