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Global Supply Chain Resilience in the Post-COVID Era

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A B S T R A C T

The COVID-19 pandemic starkly exposed the fragility of supply chain structures on a global scale and made the need to reconsider the concept of resilience in these networks one of the major concerns in operations management. The present study was conducted to examine the factors affecting global supply chain resilience in the post-COVID era using quantitative methods based on descriptive and inferential statistics. In terms of purpose, this study is classified as applied research, and in terms of data collection method, it is categorized as descriptive-survey research. The data collection instrument was a researcher-developed questionnaire based on a five-point Likert scale, which was distributed among a sample of 250 experienced managers and experts in the fields of supply chain management, logistics, and procurement who had been professionally active during and after the COVID-19 pandemic. The sample size was estimated using Cochran's formula, and simple random sampling was employed. The validity of the instrument was confirmed using content validity, while its reliability was established by calculating Cronbach's alpha coefficient, which was 0.87. Data analysis was conducted at both descriptive and inferential levels using Spearman's correlation test and multiple linear regression in SPSS. The findings indicated positive and significant relationships between supply chain flexibility, risk management, supplier diversification, and interorganizational collaboration and supply chain resilience. According to the regression analysis results, interorganizational collaboration and flexibility made the greatest contributions to explaining supply chain resilience. Overall, the findings demonstrate that achieving an optimal level of resilience in the post-COVID environment requires an integrated and dynamic approach centered on effective interaction, risk management, and strategic flexibility. These findings can serve as a useful reference for managerial policy formulation and decision-making in response to future crises.

Keywords: *supply chain resilience, global supply chain, COVID-19 pandemic, supply chain risk management, post-pandemic era.*

1. Introduction

The globalization of production, sourcing, and distribution has transformed supply chains into highly interconnected networks that span multiple countries, institutional environments, transportation systems, and tiers of suppliers. Although such global integration has generated substantial benefits in terms of cost efficiency, specialization, market access, and economies of scale, it has also increased the exposure of firms to disruptions originating far beyond their immediate organizational boundaries. Supply chain resilience has therefore become a central concern in operations management, particularly as organizations increasingly face disruptions that are multidimensional, geographically dispersed, and difficult to predict. Contemporary resilience thinking extends beyond the traditional emphasis on recovery from isolated disturbances and increasingly encompasses the capacities to anticipate, absorb, adapt to, respond to, and learn from disruptive events while maintaining acceptable levels of operational performance. This broader conceptualization reflects the evolution of supply chain resilience from a relatively reactive concept toward a dynamic organizational and interorganizational capability embedded in supply chain design, governance, and decision-making (Kania, 2026). The COVID-19 pandemic accelerated this intellectual and managerial transition by revealing that many globally optimized supply chains were efficient under stable conditions but insufficiently prepared for large-scale, prolonged, and simultaneous disruptions across supply, demand, logistics, labor, and information flows (Hung et al., 2026).

The COVID-19 pandemic represented an exceptional systemic shock to global supply chains because it simultaneously affected multiple dimensions of supply chain functioning. Lockdowns, border restrictions, manufacturing shutdowns, workforce shortages, port congestion, transport capacity constraints, and sudden changes in consumer demand produced cascading effects across industries and geographic regions. Unlike localized disruptions, the pandemic affected suppliers, producers, logistics providers, retailers, and customers at the same time, thereby reducing the effectiveness of conventional contingency mechanisms that relied on shifting operations from one location or supplier to another. A systematic analysis of COVID-19-related supply chain disruptions demonstrates that the pandemic generated not only immediate operational interruptions but also persistent consequences for sourcing strategies, inventory policies, supplier relationships, transportation decisions, and risk-management practices (Hung et al., 2026). Moreover, the pandemic demonstrated that structural complexity can magnify disruption exposure when interconnected supply networks contain multiple dependencies, long lead times, limited substitutability, and insufficient visibility across tiers. Evidence concerning the interaction between supply chain complexity and disruption complexity indicates that firms require coherent portfolios of resilience strategies rather than isolated responses, because the effectiveness of an individual strategy depends on the broader configuration of the supply chain and the nature of the disruption environment (Yildiz et al., 2025).

The post-pandemic environment has consequently encouraged organizations to reconsider the long-standing trade-off between efficiency and resilience. Prior to COVID-19, many supply chains were designed according to principles such as lean operations, just-in-time inventory, supplier consolidation, global specialization, and extensive outsourcing. These practices were economically attractive because they reduced redundancy, working capital, and operational costs; however, they also created vulnerabilities when organizations faced synchronized disruptions and prolonged uncertainty. The pandemic showed that resilience cannot be treated as a standardized bundle of practices that can be uniformly applied across sectors. Instead, resilience strategies must be aligned with the specific risk exposure, operating model, product characteristics, network structure, and strategic priorities of individual organizations. The concept of bespoke supply chain resilience emphasizes precisely this distinction between theoretically desirable resilience capabilities and the practical requirements of different firms, suggesting that resilience must be contextually configured rather than implemented through universally prescribed solutions (Cohen et al., 2022). Consequently, post-COVID supply chain management increasingly requires a balanced perspective in which efficiency is supplemented by redundancy, flexibility, relational capabilities, risk awareness, and adaptive decision-making.

Within this context, flexibility has emerged as one of the most important capabilities underlying supply chain resilience. Supply chain flexibility refers to the capacity to adjust sourcing arrangements, production volumes, transportation routes, resource allocation, delivery patterns, and operational priorities when environmental conditions change. During large-scale disruptions, rigid networks may fail because they lack alternative resources or cannot rapidly

reconfigure existing processes. By contrast, flexible supply chains can adapt their structures and operating procedures to maintain continuity despite unexpected constraints. Recent robust optimization research highlights the critical role of flexibility in building resilient supply chains under uncertain conditions and shows that the resilience benefits of flexibility become particularly significant when it is combined with collaborative mechanisms across supply chain partners (Hosseini Shekarabi et al., 2025). This implies that flexibility should not be understood merely as excess production capacity or supplier switching capability; rather, it is a multidimensional adaptive competence that involves organizational routines, decision authority, network configuration, and access to alternative resources. In the post-COVID era, such flexibility is especially important because organizations continue to face volatile demand, transportation uncertainty, geopolitical instability, and changing regulatory conditions.

Closely related to flexibility is supply chain risk management, which provides the systematic processes through which organizations identify, assess, prioritize, monitor, and mitigate potential disruptions. The pandemic demonstrated that conventional risk-management systems often underestimated the possibility of low-frequency but high-impact events and were frequently insufficiently integrated with strategic supply chain decision-making. Contemporary research therefore increasingly treats resilience and risk management as complementary rather than separate domains. Resilience-oriented risk management requires organizations to move beyond static risk registers and develop capabilities for scenario analysis, continuous monitoring, early warning, rapid decision-making, and organizational learning. Research examining the evolution of resilience within supply chain risk management suggests that the pandemic significantly redirected scholarly attention toward systemic risks, interdependencies, adaptive capabilities, and the need for more dynamic approaches to uncertainty (Madzík et al., 2024). This shift is particularly relevant in the post-pandemic environment because disruptions are no longer understood as exceptional deviations from normal operations; instead, uncertainty and volatility have become persistent features of contemporary global supply networks.

Supplier diversification represents another major dimension of resilience because excessive dependency on a limited number of suppliers, regions, or transportation channels can create critical points of failure. The pandemic exposed the vulnerabilities associated with geographically concentrated supply bases, particularly when organizations depended on single-source arrangements for strategic materials, components, or services. Diversifying the supplier base can reduce dependency and improve the availability of alternatives when a specific supplier, country, or logistics corridor becomes unavailable. However, diversification also introduces additional coordination costs, quality-control requirements, contractual complexity, and managerial challenges. Accordingly, the value of supplier diversification should be assessed as part of an integrated resilience strategy rather than as an isolated sourcing practice. Network design studies increasingly incorporate resilience alongside responsiveness and sustainability, demonstrating the importance of configuring supply systems that can continue functioning under disruption while maintaining acceptable operational and environmental performance (Babagoli et al., 2025). Similarly, approaches to multistate resilient supply chain networks emphasize system reliability and the probability that a supply network can continue satisfying operational requirements despite variations in component performance and disruptive conditions (Lin & Lin, 2025). These perspectives suggest that resilience is partly embedded in the structural architecture of supply networks and that diversification can strengthen resilience when it increases genuine substitutability and reduces critical dependencies.

Interorganizational collaboration is equally important because modern supply chain resilience cannot be achieved by individual firms acting independently. Global supply chains consist of networks of autonomous organizations whose performance depends on coordinated flows of materials, information, resources, and decisions. During disruption, the speed and quality of information exchange among suppliers, manufacturers, logistics providers, distributors, and customers can substantially influence the effectiveness of response strategies. Collaboration enables organizations to share forecasts, identify emerging constraints, jointly prioritize scarce resources, redesign delivery schedules, and coordinate corrective actions. Robust optimization research on resilience has demonstrated that collaboration can significantly strengthen supply chain performance under uncertainty and can complement flexibility by enabling coordinated adaptation across organizational boundaries (Hosseini Shekarabi et al., 2025). Trust is particularly important within such relationships because firms may be reluctant to share sensitive information or operational vulnerabilities in the absence of reliable governance mechanisms. Therefore, resilient

collaboration requires not only formal coordination structures but also relational capital, transparent communication, shared objectives, and mechanisms for joint problem solving.

The increasing role of digital technologies further changes how organizations build and maintain supply chain resilience. The pandemic accelerated the adoption of digital platforms, real-time tracking systems, advanced analytics, automation, cloud-based coordination tools, artificial intelligence, and other technologies designed to improve visibility and responsiveness. Technology can enhance resilience by supporting early detection of disruptions, increasing information transparency, accelerating communication, improving forecasting, and enabling alternative operating arrangements. A systematic review of technology-enabled resilience during the COVID-19 pandemic and disruptions associated with economic sanctions indicates that digital technologies can strengthen supply chain visibility, coordination, agility, and decision-making, although their effectiveness depends on organizational capabilities, infrastructure, and implementation conditions (Dura et al., 2025). Technology should therefore be viewed as an enabling mechanism rather than as a substitute for managerial capability. Digital visibility becomes strategically valuable when organizations possess the governance structures, analytical competencies, and collaborative relationships necessary to translate information into timely action.

The experience of COVID-19 also demonstrates that resilience must be understood within a broader environment of overlapping disruptions. Although the pandemic was a defining event, global supply chains continue to face geopolitical conflict, trade restrictions, economic sanctions, climate-related disturbances, energy volatility, and regulatory uncertainty. Geopolitical turbulence can alter sourcing patterns, transportation corridors, market access, and supplier availability, creating risks that are qualitatively different from routine operational uncertainty. Research on resilience under geopolitical turmoil emphasizes the necessity of incorporating geopolitical risk into sourcing, network design, contingency planning, and strategic decision-making (Iftikhar & Vlachos, 2025). This broader disruption landscape suggests that post-COVID resilience should not be conceptualized merely as preparedness for another pandemic. Rather, the pandemic should be understood as a critical learning event that exposed structural weaknesses and generated insights relevant to multiple forms of future disruption. Organizations capable of converting pandemic experiences into institutionalized practices may therefore be better positioned to manage subsequent shocks.

Sector-specific evidence further demonstrates that the importance of resilience varies according to the social and operational consequences of supply failure. In healthcare and pharmaceutical supply chains, disruptions can have direct implications for public health, making responsiveness, redundancy, and continuity particularly important. Dynamic analysis of vaccine supply chain resilience under disruptions associated with viral mutations and emerging pandemics shows that resilience must account for evolving demand, production constraints, uncertainty in disease dynamics, and changing supply conditions (Mousavizadeh et al., 2025). Such findings reinforce the importance of adaptive capacity and dynamic planning rather than reliance on static contingency arrangements. They also demonstrate that resilience is not simply a matter of maintaining pre-disruption performance; in some settings, organizations must continuously reconfigure their operations as disruption characteristics evolve over time.

Environmental sustainability has also become increasingly interconnected with resilience. Post-pandemic supply chain redesign cannot focus exclusively on continuity and risk reduction while ignoring decarbonization, circularity, and environmental performance. Research on decarbonized closed-loop supply chain resilience shows that COVID-19-related disruptions can influence both operational risk mitigation and sustainability objectives, requiring decision frameworks capable of simultaneously considering resilience, environmental impact, and network complexity (Amoozad Mahdiraji et al., 2024). This perspective is particularly important because some resilience strategies, such as maintaining larger inventories or using multiple transportation routes, may create environmental or economic trade-offs. Conversely, localized sourcing, circular supply systems, and closed-loop configurations may provide opportunities to jointly enhance resilience and sustainability under appropriate conditions. Hence, contemporary resilience research increasingly emphasizes integrated decision-making rather than optimization around a single performance objective.

The development of resilient supply chains consequently requires a combination of structural, relational, operational, and technological capabilities. Structural measures such as supplier diversification and alternative network configurations can reduce dependency, while operational flexibility enables organizations to adapt to changing

conditions. Risk-management practices provide systematic mechanisms for identifying and mitigating threats, whereas interorganizational collaboration facilitates coordinated responses across organizational boundaries. Technology enhances visibility and analytical capacity, but its contribution depends on the underlying maturity of organizational processes. The theoretical evolution of supply chain resilience reflects this multidimensional nature, increasingly characterizing resilience as an adaptive system capability rather than a single organizational outcome (Kania, 2026). Similarly, current network reliability approaches underscore that resilience depends on how individual components interact within the broader supply system rather than on the isolated performance of individual nodes (Lin & Lin, 2025). These developments suggest that empirical studies should examine multiple resilience antecedents simultaneously in order to determine their relative contributions to supply chain performance.

Despite the expanding literature on supply chain resilience, important empirical questions remain concerning the relative influence of different resilience-building factors in the post-COVID period. Much of the existing research has focused on conceptual frameworks, optimization models, industry-specific applications, technology-based approaches, or analyses of disruption mechanisms. For example, robust network design studies have emphasized the simultaneous achievement of sustainability, responsiveness, and resilience (Babagoli et al., 2025), while decision-making frameworks have examined the integration of decarbonization and resilience under pandemic-related uncertainty (Amoozad Mahdiraji et al., 2024). Other studies have focused on the role of complexity in determining the effectiveness of resilience strategy portfolios (Yildiz et al., 2025), the gap between theoretical resilience principles and firm-level implementation (Cohen et al., 2022), or the contribution of technology to resilience under pandemics and sanctions (Dura et al., 2025). While these streams provide substantial theoretical and analytical insight, additional survey-based empirical evidence is needed to assess how managers and supply chain professionals evaluate the practical importance of resilience determinants after experiencing the operational consequences of COVID-19.

This empirical requirement is particularly important because the post-COVID period provides an opportunity to investigate resilience after organizations have moved beyond the immediate emergency response stage. During the pandemic itself, many managerial decisions were reactive, temporary, and implemented under exceptional constraints. In the subsequent period, organizations have had greater opportunity to institutionalize lessons, revise sourcing strategies, strengthen risk-management systems, redesign collaboration mechanisms, and incorporate flexibility into operational planning. Systematic evidence on COVID-19 disruptions indicates that the consequences of the pandemic extend beyond the crisis period and continue to shape supply chain strategy and organizational practices (Hung et al., 2026). At the same time, evolving research directions in supply chain risk management suggest that resilience should be studied as a continuing capability within a persistently disruptive global environment rather than as a short-term response to a single crisis (Madzík et al., 2024). Evaluating the relationships among flexibility, risk management, supplier diversification, interorganizational collaboration, and overall supply chain resilience can therefore contribute to a clearer understanding of which capabilities have become most consequential in the emerging post-pandemic operating environment.

Accordingly, this study aims to examine the effects of supply chain flexibility, supply chain risk management, supplier diversification, and interorganizational collaboration on global supply chain resilience in the post-COVID era.

2. Methods and Materials

In terms of purpose, this study is applied research, and in terms of implementation method, it is classified as descriptive-survey research. The nature of the research topic, which focuses on examining global supply chain resilience in the post-COVID era and identifying its influencing factors, necessitates an analysis of the current situation and the collection of field-based evidence from practitioners and decision-makers in the supply chain domain. Since the objective of the study was to assess managers' and experts' attitudes, experiences, and practical evaluations concerning different dimensions of supply chain resilience, experimental or historical research methods were not considered appropriate. Therefore, a survey approach based on the perspectives of actual respondents in this field was adopted so that data could be collected from the lived experiences of individuals directly involved in supply chain challenges during and after the COVID-19 crisis.

The data collection instrument used in this study was a researcher-developed questionnaire designed on the basis of a systematic review of the theoretical literature and domestic

and international empirical studies, as well as preliminary interviews with five university professors and experts in supply chain management. The questionnaire consisted of five main sections: supply chain resilience, supply chain flexibility, supply chain risk management, supplier diversification, and collaboration and coordination among supply chain members. The questionnaire items were designed using a five-point Likert scale ranging from "strongly disagree" to "strongly agree" in order to facilitate quantitative and comparative data analysis.

The statistical population of the study consisted of all managers, experts, and employees working in the areas of supply chain management, logistics, procurement, and operations planning in manufacturing and service companies operating in domestic and international markets. Given that the research focused on post-COVID conditions, respondents were selected from individuals who had professional experience during the COVID-19 crisis and the period thereafter. To enhance the generalizability of the findings and reduce sampling bias, efforts were made to include respondents from different industries and various organizational levels. The sample size was estimated at 250 participants using Cochran's formula, with a 95% confidence level and an allowable error margin of 5% to 7%. Simple random sampling was employed so that all members of the statistical population would have an equal chance of being selected. In addition, demographic information, including age, gender, work experience, educational level, and industry type, was included in the questionnaire to enable supplementary analyses.

Content validity was used to assess the validity of the questionnaire. For this purpose, the initial version of the questionnaire was provided to several university professors and supply chain management specialists, and their suggested revisions concerning the clarity of the items, the relevance of the questions to the research objectives, and the adequate coverage of the constructs were incorporated. Subsequently, to assess the reliability of the measurement instrument, a pilot study was conducted with 30 members of the statistical population, and Cronbach's alpha coefficient for the entire questionnaire was calculated as 0.87, indicating satisfactory reliability and acceptable internal consistency of the research instrument. Table 2 presents the operational definitions of the variables and the questionnaire items.

Table 1

Operational Definitions of the Variables and Questionnaire Items

Construct	Operational Definition	Questionnaire Items
Supply Chain Resilience	The extent to which the organization's supply chain is capable of anticipating, coping with, adapting to, and recovering from disruptions caused by crises in the post-COVID era	1. Our organization's supply chain maintains its performance in the face of sudden disruptions. 2. Our organization rapidly returns to normal conditions after a crisis occurs. 3. Alternative processes are quickly activated during disruptions. 4. Our organization is capable of continuing operations even under resource shortages. 5. Experience gained from previous crises has improved the current preparedness of the supply chain. 6. Our organization uses disruptions as opportunities for learning and improvement.
Supply Chain Flexibility	The ability of the supply chain to modify production volume, sourcing routes, or operational methods in response to unforeseen conditions	7. Our organization is capable of changing sourcing routes in the event of a disruption. 8. Production or distribution volumes can be adjusted under crisis conditions. 9. Operational processes can be changed rapidly. 10. Raw materials or resources can be substituted in emergency situations. 11. Our organization can rapidly change production or distribution priorities. 12. The organization's operational structure provides sufficient flexibility for rapid response.
Supply Chain Risk Management	The extent to which systematic procedures are employed to identify, assess, and control supply chain risks	13. Supply chain risks are regularly identified in our organization. 14. Specific plans are in place to address potential disruptions. 15. Our organization evaluates crisis scenarios in advance. 16. Risk assessments are periodically incorporated into decision-making. 17. A designated team or responsible individual exists for supply chain risk management. 18. Experiences from previous disruptions are used in future planning.
Supplier Diversification	The extent to which the organization uses multiple supply sources to reduce dependency and enhance supply reliability	19. Our organization has more than one supplier for key materials or services. 20. If a supplier encounters a problem, an appropriate substitute is available. 21. Our dependence on any single supplier is low. 22. Our suppliers are geographically dispersed. 23. Our organization continuously evaluates new suppliers. 24. Suppliers can be changed rapidly in emergency situations.
Interorganizational Collaboration	The level of interaction, coordination, information exchange, and trust among supply chain members	25. Regular information exchange exists between our organization and its suppliers. 26. Important decisions are made in coordination with supply chain partners. 27. Our relationships with supply chain partners are based on mutual trust. 28. Collaboration among supply chain members increases during crises. 29. Demand and supply information is shared transparently. 30. Supply chain problems are resolved through joint interaction.

In the data analysis section, descriptive statistics, including the mean, standard deviation, frequency, and frequency percentage, were first used to provide an overall picture of the status of the research variables. Subsequently, Spearman's correlation test and multiple linear regression were employed to test the research hypotheses and examine the relationships among the variables, because the data were ordinal and normality of their distribution could not be fully assumed. All statistical analyses were conducted using SPSS version 26. The results of the analyses provided a basis for developing practical recommendations aimed at enhancing supply chain resilience in the post-COVID era.

3. Findings and Results

To better understand the current status of supply chain resilience in the post-COVID era and evaluate the factors influencing it, descriptive statistical analyses were conducted in the first step. These analyses included the calculation of indicators such as minimum and maximum scores, mean, and standard deviation for each of the main research variables. Descriptive analysis makes it possible to obtain an overall picture of the level of supply chain resilience and managers' and experts' perceptions regarding flexibility, risk management, supplier diversification, and interorganizational collaboration, thereby providing an appropriate basis for testing the research hypotheses.

Table 2

Descriptive Statistics of the Research Variables

Variable	Minimum	Maximum	Mean	Standard Deviation
Supply Chain Resilience	2.1	5.0	3.88	0.57
Supply Chain Flexibility	2.0	5.0	3.75	0.61
Supply Chain Risk Management	2.3	5.0	3.82	0.58
Supplier Diversification	1.9	5.0	3.46	0.64
Interorganizational Collaboration	2.2	5.0	3.91	0.55

The mean score for supply chain resilience (3.88 out of 5) indicates that, from the respondents' perspective, the level of supply chain resilience in the post-COVID era was assessed as relatively favorable. Similarly, the mean score for supply chain flexibility (3.75) suggests that organizations have demonstrated an acceptable ability to adapt to environmental changes and disruptions, although further improvement remains possible. The results for risk management (3.82) indicate a relatively appropriate level of attention to the identification and control of supply chain risks. In contrast, the mean score for supplier diversification (3.46) shows that dependence on a limited number of supply sources remains one of the major challenges facing supply chains. Finally, the relatively high mean score for interorganizational collaboration (3.91) highlights the important role of interaction and coordination among supply chain members in enhancing resilience in the post-COVID era.

To test the research hypotheses and examine the relationships among the research variables, Spearman's correlation test and multiple linear regression were employed. Given that the data were collected using a five-point Likert scale and the normality of the variable distributions was not fully confirmed, Spearman's test was selected as a nonparametric test suitable for ordinal data. In addition, simple linear regression was used to assess the extent of the effect of each independent variable on supply chain resilience. The significance level for all tests was set at 0.05, and the analyses were performed using SPSS.

Hypothesis 1 test: There is a significant relationship between supply chain flexibility and supply chain resilience.

Table 3

Results of Spearman's Correlation Test for Hypothesis 1

Variables	Spearman Correlation Coefficient	Significance Level (Sig.)
Supply Chain Flexibility ↔ Supply Chain Resilience	0.61	0.000

The results of Spearman's correlation test indicate a positive and significant relationship between supply chain flexibility and supply chain resilience (Sig. < 0.05). The correlation coefficient of 0.61 indicates a relatively strong relationship between the two variables. This result suggests that as the supply chain's ability to adapt to environmental

changes increases, its level of resilience also improves. Therefore, the first research hypothesis is supported.

Hypothesis 2 test: There is a significant relationship between supply chain risk management and supply chain resilience.

Table 4

Results of Spearman's Correlation Test for Hypothesis 2

Variables	Spearman Correlation Coefficient	Significance Level (Sig.)
Supply Chain Risk Management ↔ Supply Chain Resilience	0.57	0.000

Based on the obtained results, a positive and significant relationship is observed between risk management and supply chain resilience. The correlation coefficient of 0.57 indicates a moderate-to-strong relationship. This finding demonstrates that the identification, assessment, and control of risks play an important role in mitigating the effects of disruptions and enhancing supply chain resilience. Consequently, the second hypothesis is supported.

Hypothesis 3 test: There is a significant relationship between supplier diversification and supply chain resilience.

Table 5

Results of Spearman's Correlation Test for Hypothesis 3

Variables	Spearman Correlation Coefficient	Significance Level (Sig.)
Supplier Diversification ↔ Supply Chain Resilience	0.42	0.001

The results of Spearman's test indicate that supplier diversification has a positive and significant relationship with supply chain resilience. Although the correlation coefficient of 0.42 is lower than those observed for the other variables, it remains statistically significant at an acceptable level. This result indicates that reducing dependence on one or a limited number of specific suppliers can play a protective role when confronting crises. Therefore, the third hypothesis is also supported.

Hypothesis 4 test: There is a significant relationship between interorganizational collaboration and supply chain resilience.

Table 6

Results of Spearman's Correlation Test for Hypothesis 4

Variables	Spearman Correlation Coefficient	Significance Level (Sig.)
Interorganizational Collaboration ↔ Supply Chain Resilience	0.65	0.000

According to the test results, interorganizational collaboration exhibits the highest correlation with supply chain resilience. The correlation coefficient of 0.65 indicates a strong and statistically significant relationship. This finding demonstrates that information exchange, coordination, and trust among supply chain members play a key role in enhancing resilience in the post-COVID era. Therefore, the fourth research hypothesis is supported.

Table 7

Results of Multiple Linear Regression of the Research Variables on Supply Chain Resilience

Independent Variable	Standardized Beta Coefficient (β)	*t* Value	Significance Level
Supply Chain Flexibility	0.31	4.87	0.000
Supply Chain Risk Management	0.26	4.21	0.000
Supplier Diversification	0.15	2.64	0.009
Interorganizational Collaboration	0.35	5.02	0.000

Table 8

Model Fit Indices

Model Fit Index	Value
Coefficient of Determination (R^2)	0.62
Adjusted Coefficient of Determination (Adjusted R^2)	0.60
F Statistic	98.45
Model Significance Level	0.000
Durbin–Watson Statistic	1.89

The results of the multiple regression analysis indicate that the set of independent variables accounted for 62% of the variance in supply chain resilience, reflecting the satisfactory explanatory power of the model. The statistical significance of the *F* statistic also indicates that the regression model has an acceptable overall fit. When the effects of the other variables were simultaneously controlled, interorganizational collaboration (β = 0.35) had the strongest effect on resilience, followed by supply chain flexibility (β = 0.31). Risk management also demonstrated a positive and statistically significant effect, whereas supplier diversification, despite its smaller effect size, continued to play a statistically significant role in the model. These findings indicate that the simultaneous combination of relational and structural factors plays a decisive role in strengthening supply chain resilience in the post-COVID era.

4. Discussion and Conclusion

The findings of the present study demonstrate that supply chain flexibility, supply chain risk management, supplier diversification, and interorganizational collaboration are all positively and significantly associated with supply chain resilience in the post-COVID era. The descriptive findings further showed that respondents evaluated the overall level of supply chain resilience relatively favorably, with a mean score of 3.88 out of 5. Among the explanatory variables, interorganizational collaboration recorded the highest mean score, followed by supply chain risk management and supply chain flexibility, whereas supplier diversification received the lowest mean score. At the inferential level, interorganizational collaboration exhibited the strongest bivariate relationship with supply chain resilience, with a Spearman correlation coefficient of 0.65, followed by supply chain flexibility with a coefficient of 0.61, supply chain risk management with a coefficient of 0.57, and supplier diversification with a coefficient of 0.42. The multiple regression analysis reinforced these relationships by showing that the independent variables jointly explained 62% of the variance in supply chain resilience. In the multivariate model, interorganizational collaboration had the strongest standardized effect on resilience (β = 0.35), followed by supply chain flexibility (β = 0.31), supply chain risk management (β = 0.26), and supplier diversification (β = 0.15). These findings indicate that supply chain resilience in the post-pandemic environment is not attributable to a single structural or operational capability, but instead emerges from the combined influence of relational, adaptive, risk-oriented, and sourcing-related capacities.

The significant positive relationship between supply chain flexibility and resilience supports the view that the ability to rapidly modify sourcing arrangements, operational processes, production volumes, distribution priorities, and resource allocation represents a fundamental capability for coping with disruption. The correlation coefficient of 0.61 and standardized regression coefficient of 0.31 indicate that flexibility is one of the most influential determinants of resilience in the examined model. This finding is consistent with research emphasizing that resilient supply chains must be able to reconfigure their operations when established processes or supply routes become unavailable. Hosseini Shekarabi et al. showed that flexibility plays a central role in strengthening resilience under uncertain supply conditions and that its value becomes especially important when organizations are exposed to multiple forms of disruption simultaneously (Hosseini Shekarabi et al., 2025). The present result can therefore be interpreted as evidence that organizations with a greater capacity to change production schedules, substitute resources, redirect supply flows, and modify operational priorities are more capable of maintaining continuity and recovering from disruption. Such flexibility is especially relevant in the post-COVID environment, where uncertainty remains associated with geopolitical tensions, logistics bottlenecks, labor constraints, and changing demand patterns.

The importance of flexibility is also compatible with the broader theoretical evolution of supply chain resilience. Contemporary resilience frameworks increasingly

conceptualize resilience as a dynamic capability involving anticipation, adaptation, recovery, and learning rather than merely the restoration of pre-disruption operations (Kania, 2026). From this perspective, flexibility enables a supply chain to shift from passive resistance toward active adaptation. The results of the present study indicate that organizations that possess greater operational and sourcing adaptability are better able to absorb shocks and adjust to changing environmental conditions. This interpretation is further supported by Yildiz et al., who emphasized that complex disruptions require portfolios of response strategies and that the effectiveness of resilience mechanisms depends on their ability to address multiple forms of disruption simultaneously (Yildiz et al., 2025). Therefore, flexibility appears to function as a bridging capability that allows organizations to operationalize alternative strategies when disruption complexity makes routine procedures ineffective.

The second hypothesis was also supported, demonstrating a positive and significant relationship between supply chain risk management and supply chain resilience. The Spearman correlation coefficient of 0.57 indicated a moderate-to-strong association, while the regression coefficient of $\beta = 0.26$ confirmed that risk management maintained a significant effect after the simultaneous inclusion of the other predictors. This result suggests that organizations that systematically identify, assess, monitor, and mitigate supply chain risks are better positioned to maintain operational continuity under adverse conditions. The finding aligns closely with the literature that has increasingly integrated resilience with supply chain risk management. Madzík et al. argued that the disruptive environment generated during and after the pandemic shifted research attention toward more dynamic forms of risk management, particularly those addressing systemic uncertainty, interdependencies, and adaptive responses (Madzík et al., 2024). The findings of the present study support this orientation by showing that risk-management capability remains a meaningful determinant of resilience even when relational and structural variables are controlled.

The observed role of risk management may be explained by the fact that resilient organizations do not merely respond to disruptions after they occur, but actively prepare for them through structured monitoring, scenario development, contingency planning, and learning from previous events. The COVID-19 pandemic revealed the inadequacy of risk-management approaches that focused primarily on routine or localized disruptions. Hung et al. showed that pandemic-related disruptions affected multiple supply chain functions simultaneously and created long-lasting consequences for sourcing, logistics, inventory, and operational decision-making (Hung et al., 2026). Under such circumstances, effective risk management must extend beyond traditional risk registers and encompass broader scenario-based preparation and rapid decision-making mechanisms. The present study therefore suggests that post-COVID resilience is strengthened when organizations institutionalize risk awareness and integrate risk assessment into ongoing supply chain planning.

The third hypothesis, concerning supplier diversification, was also supported. Supplier diversification showed a statistically significant positive relationship with supply chain resilience, although its correlation coefficient of 0.42 and regression coefficient of $\beta = 0.15$ were lower than those of the other predictors. This result suggests that maintaining multiple sources of supply contributes to resilience by reducing dependence on a single supplier, geographic region, or logistical corridor, yet its influence may be less direct than that of flexibility, collaboration, or risk management. This finding is consistent with the logic of resilient network design, in which redundancy and substitutability can prevent localized failures from escalating into system-wide disruptions. Babagoli et al. demonstrated that resilient and responsive supply chain network design requires the consideration of multiple sources and structural alternatives in order to improve continuity under disruption (Babagoli et al., 2025). Similarly, Lin and Lin emphasized the importance of network reliability and the ability of multistate supply chain systems to maintain performance when individual components experience reduced capacity or failure (Lin & Lin, 2025).

The relatively weaker effect of supplier diversification may also indicate that diversification alone does not automatically generate resilience. Multiple suppliers can increase managerial complexity, monitoring requirements, transaction costs, and coordination challenges. The resilience value of supplier diversification therefore depends on whether alternative suppliers are genuinely capable of replacing disrupted sources in terms of capacity, quality, geography, lead time, and contractual readiness. Cohen et al. emphasized that resilience strategies must be tailored to the specific characteristics of the firm and its operating environment rather than applied as standardized solutions (Cohen et al., 2022). The present result supports this interpretation because supplier diversification appears to contribute to resilience, but its contribution is weaker than

that of capabilities that directly support adaptation and coordinated response. In practical terms, the number of suppliers may matter less than the strategic quality and substitutability of those supplier relationships.

The strongest result of the study concerns interorganizational collaboration. This variable had the highest correlation with supply chain resilience ($r = 0.65$) and the highest standardized regression coefficient ($\beta = 0.35$), indicating that collaboration is the most influential predictor among the variables examined. This finding highlights the fundamentally networked nature of supply chain resilience. Organizations do not operate in isolation, and their ability to respond to disruption depends heavily on the willingness and capacity of suppliers, distributors, logistics providers, and other partners to coordinate activities, exchange information, share resources, and jointly solve problems. The result aligns strongly with Hosseini Shekarabi et al., who demonstrated that collaboration can significantly strengthen resilience and that the interaction between collaboration and flexibility is especially important in uncertain operating environments (Hosseini Shekarabi et al., 2025). The present finding therefore confirms that relational capabilities are not secondary to structural resilience measures; rather, they constitute a central mechanism through which supply chain partners collectively adapt to disruption.

The strong effect of collaboration may also be explained by the importance of timely and accurate information during crises. Effective response requires knowledge of supplier capacity, inventory availability, demand changes, logistics constraints, and alternative operating options. Without information sharing, even firms with substantial internal resources may respond slowly or make poorly coordinated decisions. Dura et al. emphasized that technology contributes to resilience by improving supply chain visibility, communication, coordination, and decision-making (Dura et al., 2025). However, digital technologies can produce resilience benefits only when organizations are willing to share information and use it collaboratively. The high explanatory effect of collaboration in the present study suggests that trust, transparency, and coordinated decision-making are critical complements to technological capability. Consequently, supply chain visibility should be understood not merely as access to data but as the capacity to translate shared data into coordinated action.

The findings also have relevance beyond pandemic-specific disruptions. Global supply chains currently operate in an environment characterized by geopolitical tensions, trade restrictions, economic sanctions, and strategic uncertainty. Iftikhar and Vlachos emphasized that geopolitical turmoil creates new forms of supply chain vulnerability that require broader resilience strategies involving sourcing adaptation, network reconfiguration, and contingency planning (Iftikhar & Vlachos, 2025). The results of the present study suggest that the same capabilities that were critical during COVID-19—particularly collaboration, flexibility, risk management, and diversification—are likely to remain relevant in addressing geopolitical and other systemic disruptions. This supports the argument that post-COVID resilience should not be conceptualized narrowly as preparedness for future pandemics. Instead, it should be understood as a broader capacity to function effectively under persistent and multidimensional uncertainty.

The regression results provide additional support for an integrated perspective on resilience. The four predictors collectively explained 62% of the variance in supply chain resilience, with an adjusted R^2 of 0.60, indicating that the model possesses substantial explanatory power. The significant F statistic confirms that the combination of variables provides a meaningful explanation of resilience outcomes. This result is important because it demonstrates that resilience emerges from the simultaneous operation of multiple capabilities rather than from isolated interventions. Amoozad Mahdiraji et al. similarly emphasized the need for integrated decision frameworks that combine risk mitigation, resilience, and broader supply chain objectives under pandemic-related uncertainty (Amoozad Mahdiraji et al., 2024). The present study extends this integrated perspective by showing empirically that relational collaboration, flexibility, risk-management capability, and supplier diversification jointly constitute a strong explanatory framework for supply chain resilience.

The findings are also compatible with evidence from highly sensitive supply environments, including healthcare and vaccine supply chains. Mousavizadeh et al. showed that resilience under emerging pandemics and viral mutations requires dynamic adaptation because demand, production constraints, and disruption characteristics can change over time (Mousavizadeh et al., 2025). This dynamic interpretation corresponds closely with the present results, particularly the strong effects of flexibility and collaboration. In environments where disruption conditions evolve rapidly, rigid contingency plans may become obsolete, whereas adaptive and coordinated supply chains can modify their responses as new information becomes

available. Therefore, resilience appears to depend not only on preparedness before disruption but also on the continuous capacity to update decisions during disruption.

The findings collectively reinforce the argument that resilience should be treated as a multidimensional supply chain capability rather than a single recovery outcome. Kania's theoretical framework emphasizes the evolutionary development of resilience toward a broader construct incorporating anticipation, adaptation, resistance, recovery, and learning (Kania, 2026). The relatively high mean score for resilience in the present study may therefore reflect the accumulated learning of organizations following the COVID-19 crisis. Firms that experienced severe disruptions during the pandemic may have subsequently strengthened their contingency planning, developed alternative suppliers, increased digital visibility, improved partner communication, or introduced more flexible operating arrangements. The post-COVID context is therefore especially important because it captures resilience after organizations have had an opportunity to translate crisis experience into institutionalized capabilities.

At the same time, the results suggest that structural measures alone are insufficient. Supplier diversification had the smallest effect among the four predictors, whereas collaboration and flexibility had the strongest effects. This pattern implies that resilience depends not simply on creating redundancy but on developing the capacity to mobilize and coordinate alternatives when needed. A diversified supplier network that lacks communication, rapid decision-making, and flexible processes may still perform poorly during disruption. Conversely, highly collaborative and flexible organizations may be able to derive greater value from a limited set of alternative resources by coordinating their use more effectively. This interpretation is consistent with the bespoke resilience argument advanced by Cohen et al., according to which effective resilience configurations differ according to organizational context and cannot be reduced to a universal set of structural prescriptions (Cohen et al., 2022).

The study also has implications for the relationship between resilience and sustainability. Contemporary supply chains face pressure not only to survive disruption but also to reduce environmental impacts and support long-term sustainability. Amoozad Mahdiraji et al. demonstrated that resilient closed-loop supply chain decisions can simultaneously address disruption risks and decarbonization objectives (Amoozad Mahdiraji et al., 2024). Similarly, Babagoli et al. incorporated sustainability, responsiveness, and resilience within integrated supply chain network design (Babagoli et al., 2025). The present findings suggest that capabilities such as flexibility, collaboration, and risk management may provide the organizational foundation required to balance these objectives. An organization that can collaborate effectively with partners and dynamically adjust its operations may be better positioned to implement both resilience-oriented and sustainability-oriented strategies without treating them as mutually exclusive goals.

Several limitations should be considered when interpreting the findings of this study. First, the cross-sectional research design captures respondents' perceptions at a single point in time and therefore does not permit strong causal conclusions regarding the direction of the observed relationships. Second, the study relied on self-reported questionnaire data, which may be influenced by common method bias, social desirability, recall error, or differences in respondents' interpretations of the questionnaire items. Third, although participants were selected from different industries and organizational levels, the sample may not fully represent the diversity of global supply chains across countries, institutional environments, firm sizes, and sectors. Fourth, the study examined four major determinants of resilience, whereas other potentially influential variables such as digitalization, organizational learning, inventory redundancy, supply chain visibility, leadership capability, financial slack, and geopolitical exposure were not included in the model. Finally, the relatively broad operationalization of post-COVID supply chain conditions may obscure differences between industries that experienced substantially different disruption patterns during and after the pandemic.

Future research should employ longitudinal designs to examine how supply chain resilience capabilities evolve over time and whether the relative importance of flexibility, collaboration, risk management, and supplier diversification changes as organizations move further away from the COVID-19 crisis. Comparative studies across countries, industries, firm sizes, and different levels of supply chain complexity would also provide a more nuanced understanding of contextual influences on resilience. Future studies could incorporate additional variables such as digital transformation, artificial intelligence, supply chain visibility, organizational learning, inventory buffers, financial resilience, leadership capability, sustainability practices, and geopolitical risk. Structural equation modeling could be used to examine mediating and moderating relationships among these factors, while qualitative or mixed-method designs could provide deeper

insight into how organizations actually operationalize resilience strategies during disruption. Future research could also investigate whether collaboration mediates the effect of technology on resilience or whether environmental uncertainty moderates the relationship between flexibility and resilience.

From a practical perspective, managers should avoid treating supply chain resilience as a single contingency plan or a purely operational issue and should instead develop it as an integrated strategic capability. Organizations should strengthen interorganizational collaboration by establishing transparent information-sharing mechanisms, joint crisis-response protocols, shared performance indicators, and trust-based relationships with key suppliers and logistics partners. They should also enhance flexibility by maintaining alternative sourcing routes, adaptable production and distribution plans, cross-trained personnel, and prequalified substitute resources. Risk-management systems should be updated continuously through scenario analysis, early-warning indicators, periodic risk assessments, and structured learning from previous disruptions. Supplier diversification should focus not merely on increasing the number of suppliers but on ensuring that alternative suppliers are geographically dispersed, operationally capable, and rapidly deployable when disruptions occur. Managers should therefore prioritize a coordinated portfolio of relational, structural, and adaptive capabilities so that their supply chains can continue operating effectively under future crises and prolonged uncertainty.

Authors' Contributions

Authors contributed equally to this article.

Declaration

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

Transparency Statement

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