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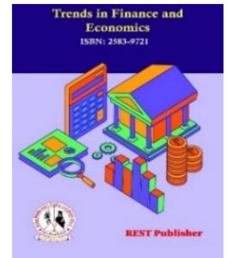

Analyzing Supply Chain Risk Mitigation Strategies in High-Technology Industries: A DEMATEL Approach

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Abstract: *This study investigates supply chain risk mitigation strategies in high-technology industries using the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method. The research focuses on five key strategies: Supplier Diversification Strategy, Real-Time Monitoring System, Dual Sourcing Policy, Inventory Buffering, and Collaborative Risk Sharing Contracts. Given the complex and interconnected nature of high-technology supply chains, understanding the relationships and effectiveness of these strategies is crucial for maintaining operational resilience. The DEMATEL analysis reveals significant insights into the cause-effect relationships between different mitigation strategies. The total relation matrix demonstrates that Supplier Diversification Strategy has the highest total influence value (-5.36), indicating its substantial impact on other strategies, particularly on Dual Sourcing and Inventory Buffering. The study also finds that Collaborative Risk Sharing Contracts, while ranking first in priority, shows lower total impact values (Ri=-3.23, Ci=-1.91), suggesting its role as a supportive rather than driving strategy. The research identifies that all five strategies function primarily as "effect" components, with varying degrees of influence on each other. The normalized direct relation matrix shows strong relationships between certain strategy pairs, such as Supplier Diversification's influence on Dual Sourcing (0.727) and Inventory Buffering (0.545). The findings suggest that an integrated approach to risk mitigation is essential, where strategies complement and reinforce each other rather than operating in isolation. This study contributes to the understanding of supply chain risk management in high-technology industries by providing a quantitative assessment of strategy interdependencies. The results can guide decision-makers in prioritizing and implementing risk mitigation strategies while considering their interconnected nature.*

Keywords: *Supply Chain Risk, DEMATEL Method, High-Technology Industries, Risk Mitigation, Strategy Analysis.*

1. INTRODUCTION

Supply chain risk mitigation is a critical component of ensuring operational continuity and resilience in high-technology industries. These industries are characterized by fast-paced innovation cycles, dependency on specialized suppliers, and globalized production networks, making them particularly vulnerable to disruptions. Companies in these industries must proactively adopt robust mitigation strategies to reduce their vulnerability and enhance adaptability to unforeseen challenges. [1]. The high-technology sector faces unique challenges due to its reliance on complex and interdependent supply chains. Components such as semiconductors, printed circuit boards, and rare earth materials are often sourced from specialized suppliers, sometimes concentrated in specific geographical regions. A disruption in any part of this intricate network can halt production and lead to significant delays. To address these vulnerabilities, companies adopt a range of risk mitigation strategies, including supplier diversification, real-time monitoring systems, dual sourcing policies, inventory buffering, and collaborative risk-sharing contracts. [2]. One key strategy is supplier diversification, which aims to reduce dependency on a single supplier or geographical region. By engaging multiple suppliers for critical components, companies spread their risk and ensure continuity of supply even if one supplier faces disruptions. For example, a high-tech company reliant on semiconductors might source from suppliers in different regions, reducing exposure to localized risks like natural disasters or political instability. However, while supplier diversification enhances resilience, it can lead to higher costs due to logistical complexities and the need to establish relationships with multiple suppliers. This trade-off between resilience and cost efficiency is a significant consideration for decision-makers. [3]. Real-time monitoring systems represent another crucial risk mitigation tool. These systems provide real-time visibility into the supply chain, enabling companies to detect disruptions and respond promptly. Advanced technologies such as IoT sensors, artificial intelligence, and block chain facilitate enhanced transparency and traceability, making it easier to pinpoint vulnerabilities and address them proactively. For instance, real-time monitoring can detect delays in shipping or production at a supplier's facility, allowing companies to adjust their schedules or seek alternative sources. While these systems improve responsiveness, their implementation can be costly and require substantial technological investment, making them less cost-efficient for smaller firms. [4]. Dual sourcing policies provide a middle ground between supplier diversification and cost control. By sourcing critical components from two suppliers instead of relying solely on one, companies reduce dependency while maintaining manageable costs.[5]. Dual sourcing can be particularly beneficial in high-tech industries, where some components are highly specialized, and finding multiple suppliers with comparable quality standards can be challenging. For example, an electronics manufacturer might source semiconductors from two leading suppliers, ensuring redundancy in case of supply disruptions. However, this strategy requires careful coordination and negotiation to balance cost efficiency and resilience.[6]. Inventory buffering is another widely used risk mitigation strategy, particularly in industries where just-in-time (JIT) practices dominate. High-tech companies often maintain safety stock levels to cushion against supply chain disruptions. Inventory buffering ensures that production can continue even when suppliers face delays or shortages.[7]. For instance, a smartphone manufacturer might maintain a buffer stock of critical components such as displays and batteries to avoid halting production due to supplier issues. While inventory buffering enhances resilience, it comes with trade-offs, including increased storage costs and the risk of obsolescence, especially in industries where components quickly become outdated due to rapid technological advancements.[8]. Collaborative risk-sharing contracts are a relatively newer approach to supply chain risk mitigation. These contracts involve closer collaboration between buyers and suppliers to share risks and benefits equitably. By fostering trust and mutual commitment, such contracts encourage suppliers to prioritize the buyer's needs during disruptions.[9]. For example, a high-tech company might enter into a contract with a supplier to guarantee a certain level of supply during crises, with penalties or incentives tied to performance. Collaborative contracts align the interests of both parties, promoting resilience without compromising cost efficiency. However, building such partnerships requires time, effort, and a willingness to share sensitive information, which can be challenging in competitive markets.[10]. The strategies outlined above address various dimensions of supply chain risk mitigation, each with its advantages and limitations.[11]. A comprehensive risk management framework often combines these strategies to achieve a balance between resilience, cost efficiency, and adaptability. For instance, a high-tech company might use supplier diversification for critical components, implement real-time monitoring systems for enhanced visibility, adopt dual sourcing for specialized materials, maintain buffer stock for essential items, and engage in collaborative contracts with key suppliers.[12]. This multi-pronged approach enables companies to build robust supply chains capable of withstanding a wide range of disruptions.[13]. However, implementing these strategies requires a nuanced understanding of the trade-offs involved. For instance, while inventory buffering improves resilience, excessive stock can lead to high carrying costs and obsolescence risks. Similarly, real-time monitoring systems enhance adaptability but may strain budgets, particularly for smaller firms. Decision-makers must carefully evaluate the cost-benefit equation for each strategy and tailor their approach vulnerabilities of their supply chains.[14]. In addition to individual strategies, high-tech companies must also consider broader systemic factors that influence supply chain risk. For example, geopolitical tensions, trade policies, and environmental regulations can significantly impact the availability and cost of critical materials.[15]. Companies must stay informed about these external factors and incorporate them into their risk mitigation frameworks. Scenario planning and stress testing can help firms prepare for various contingencies, enabling them to respond effectively to disruptions. Sustainability is another emerging consideration in supply chain risk mitigation. High-tech industries face increasing pressure to adopt environmentally responsible practices, which can sometimes conflict with traditional risk mitigation strategies. For example, maintaining large buffer stocks may lead to increased waste, while sourcing from multiple suppliers can raise the carbon footprint of transportation. Companies must strike a balance between resilience and environmental impact, adopting sustainable practices wherever possible. Initiatives such as green procurement, renewable energy integration, and circular economy practices can enhance both resilience and sustainability in supply chains.[16]. Technology plays a central role in modern supply chain risk mitigation, particularly in high-tech industries. Advanced analytics, machine learning, and predictive modeling enable companies to identify risks before they materialize, allowing for proactive intervention.[17]. For instance, predictive analytics can forecast potential disruptions based on historical data, weather patterns, and geopolitical developments. Blockchain technology enhances transparency and trust by providing a tamper-proof record of transactions and supply chain events. Meanwhile, automation and robotics can reduce dependency on human labor, minimizing the impact of workforce disruptions. By leveraging these technologies, high-tech companies can build smarter, more resilient supply chains.[18]. As global supply chains faced unprecedented disruptions, companies with diversified suppliers, buffer stocks, and real-time monitoring systems were better equipped to navigate the crisis. The pandemic also highlighted the need for agility and adaptability in supply chains, as companies had to pivot quickly to address changing demand patterns and logistical challenges. Lessons learned from the pandemic continue to shape supply chain strategies, with an emphasis on resilience, adaptability, and collaboration.[19]. Supply chain risk mitigation is a vital priority for high-technology industries, given their reliance on complex, globalized networks. Strategies such as supplier diversification, real-time monitoring systems, dual sourcing policies, inventory buffering, and collaborative risk-sharing contracts address different dimensions of risk, enabling companies to build resilient and adaptable supply chains. However, these strategies come with trade-offs, and their successful implementation requires careful planning and a nuanced understanding of the specific challenges faced by each company. By adopting a comprehensive and forward-looking approach to risk mitigation, high-tech companies can safeguard their operations, maintain competitive advantage, and thrive in an increasingly uncertain and dynamic global landscape.

2. MATERIALS & METHODS

Supply chain risk mitigation in high-technology industries is a critical area of focus due to the intricate and interconnected nature of global supply chains. High-technology industries, characterized by rapid innovation, short product life cycles, and global sourcing, are particularly vulnerable to supply chain disruptions.[21]. These disruptions, stemming from natural disasters, geopolitical tensions, technological failures, or supplier insolvencies, can have far-reaching consequences. Using the dataset provided, the DEMATEL method is employed to understand the interrelationships between various supply chain risk mitigation strategies and to identify their relative importance and influence.[22]. The DEMATEL method systematically evaluates the causal relationships among factors, helping decision-makers identify the most influential elements in a system. supply chain risk mitigation, this method is invaluable for discerning how different strategies, such as supplier diversification, real-time monitoring, dual sourcing, inventory buffering, and collaborative risk-sharing contracts, interact and contribute to overall resilience. The dataset provided quantifies these interrelations, capturing the direct influence of one strategy on another. For instance, the influence of Supplier Diversification Strategy on Real-Time Monitoring System is rated as 2, indicating a moderate causal relationship, while the influence of Dual Sourcing Policy on Inventory Buffering is rated as 4, signifying a stronger link.[23]. The matrix in the dataset serves as the foundation for applying the DEMATEL method. This is followed by constructing a total influence matrix that combines direct and indirect influences among strategies. From this, a cause-effect diagram is generated, illustrating which strategies act as causes (influencers) and which are effects (influenced). For example, in the given dataset, Inventory Buffering has a high aggregate influence on other strategies, indicating its centrality in mitigating supply chain risks.[24]. Supplier diversification emerges as a cornerstone strategy in this analysis. By spreading procurement across multiple suppliers, companies can reduce dependency on a single source and mitigate the risk of supply disruptions. The dataset highlights that Supplier Diversification Strategy significantly influences Dual Sourcing Policy (8) and Inventory Buffering (6), suggesting a strong interplay. Dual sourcing complements diversification by maintaining parallel sources for critical components, further enhancing supply chain resilience. Together, these strategies reduce vulnerability to localized disruptions, ensuring continuity in supply.[25]. Real-time monitoring systems, another key strategy, enable proactive risk identification and management. By leveraging advanced technologies such as IoT and AI, companies can track supply chain activities in real time, identify potential disruptions, and respond swiftly. The dataset underscores the reciprocal relationship between Real-Time Monitoring Systems and Inventory Buffering, with mutual influences of 5. This synergy highlights the importance of integrating technology with traditional risk mitigation strategies to create a dynamic and responsive supply chain.[26]. Collaborative risk-sharing contracts also play a vital role in high-technology industries. By fostering partnerships with suppliers, manufacturers, and other stakeholders, these contracts distribute risks equitably and incentivize collective resilience. The dataset indicates a notable influence of Collaborative Risk-Sharing Contracts on Dual Sourcing Policy (6), emphasizing their role in aligning incentives and ensuring mutual commitment to risk mitigation. Inventory buffering, while often considered a traditional approach, remains indispensable in high-technology industries. By maintaining safety stock levels, companies can absorb supply chain shocks and meet demand fluctuations. However, excessive buffering can lead to increased holding costs and obsolescence, particularly in industries with rapid product obsolescence. The dataset shows Inventory Buffering as both an influencer and an influenced strategy, reflecting its dual role in mitigating risk and adapting to other strategies.[27]. The DEMATEL analysis derived from the dataset provides actionable insights for high-technology firms. It identifies Inventory Buffering and Supplier Diversification as primary drivers of supply chain resilience, with strong causal relationships with other strategies. Real-Time Monitoring Systems act as an intermediary, facilitating the implementation of other strategies through enhanced visibility and responsiveness. Collaborative Risk-Sharing Contracts and Dual Sourcing Policies, while impactful, are more influenced by the primary strategies, underscoring the importance of a holistic approach.[28]. The DEMATEL method offers a structured approach to analyzing and optimizing supply chain risk mitigation strategies in high-technology industries. The interdependencies captured in the dataset highlight the need for an integrated strategy that combines traditional and modern approaches. Supplier Diversification, Inventory Buffering, and Real-Time Monitoring emerge as pivotal strategies, driving overall resilience and adaptability. By understanding the causal relationships among these strategies, companies can prioritize investments, foster collaboration, and create robust supply chains capable of withstanding the uncertainties of the global marketplace.[29].

Alternatives: Supplier Diversification Strategy, Real-Time Monitoring System, Dual Sourcing Policy, Inventory Buffering , Collaborative Risk Sharing Contracts.

Evaluation Parameters: Supplier Diversification Strategy, Real-Time Monitoring System, Dual Sourcing Policy, Inventory Buffering , Collaborative Risk Sharing Contracts.

Supplier Diversification Strategy: The Supplier Diversification Strategy emerges as a cornerstone alternative for mitigating supply chain risks. By engaging multiple suppliers, companies reduce dependency on a single source, minimizing the impact of disruptions caused by supplier failures, geopolitical events, or regional risks. This strategy has significant influence over other alternatives, such as Dual Sourcing Policy and Inventory Buffering, as evidenced in the dataset. Its preference as a foundational strategy is attributed to its ability to create redundancy and flexibility in procurement processes, making it an indispensable part of resilient supply chains.

Real-Time Monitoring System: The Real-Time Monitoring System plays a critical role as a technological enabler in the evaluation framework. This alternative facilitates proactive risk identification and swift response by leveraging advanced technologies such as IoT, AI, and data analytics. Its strong reciprocal relationship with Inventory Buffering highlights its importance in ensuring that stock levels are optimized in real-time to meet demand fluctuations. The evaluation preference for this alternative lies in its ability to integrate seamlessly with other strategies, enhancing the visibility and responsiveness of the supply chain.

Dual Sourcing Policy: The Dual Sourcing Policy complements the diversification strategy by maintaining multiple sources for critical components, ensuring continuity of supply during disruptions. It is particularly impactful in industries where supply chains are highly specialized and prone to bottlenecks. The dataset shows moderate influence from and on other strategies, indicating its role as both an independent risk mitigation approach and a supporting element for diversification. Its evaluation preference is strengthened by its capacity to reduce the risk of complete supply chain failure.

Inventory Buffering: a traditional yet essential strategy, ensures that companies maintain adequate stock levels to absorb supply chain shocks. While it incurs holding costs, its ability to mitigate the impact of sudden disruptions makes it a preferred alternative in highly volatile industries. The dataset underscores its dual role as both an influencer and a receiver of influence from other strategies, particularly Real-Time Monitoring Systems and Supplier Diversification. Its evaluation preference stems from its effectiveness in stabilizing operations despite external uncertainties.

Collaborative Risk Sharing Contracts: focus on fostering partnerships between stakeholders to distribute risks equitably. By aligning incentives, these contracts encourage collective investment in resilience measures, such as infrastructure upgrades or supplier capacity expansion. The dataset indicates that this alternative strongly influences Dual Sourcing Policy, emphasizing its role in fostering trust and mutual commitment among supply chain partners. Its evaluation preference lies in its ability to create a shared responsibility framework, reducing the burden on any single entity.

The evaluation preference of these alternatives highlights their interconnected nature, where each strategy complements the others to form a cohesive risk mitigation framework. Supplier Diversification Strategy and Inventory Buffering serve as primary drivers, while Real-Time Monitoring System acts as an enabler. Dual Sourcing Policy and Collaborative Risk Sharing Contracts play supportive roles, rounding out a comprehensive approach to enhancing supply chain resilience in high-technology industries.[30].

3. ANALYSIS AND DISCUSSION

TABLE 1. Supply chain risk mitigation in high-technology industries

	Supplier Diversification Strategy	Real-Time Monitoring System	Dual Sourcing Policy	Inventory Buffering	Collaborative Risk Sharing Contracts	Sum
Supplier Diversification Strategy	0	2	8	6	1	17
Real-Time Monitoring System	5	0	4	5	1	15
Dual Sourcing Policy	4	4	0	3	1	12
Inventory Buffering	6	2	4	0	2	14
Collaborative Risk Sharing Contracts	1	1	6	2	0	10

The table presented seems to represent the relationship between different supply chain risk mitigation strategies in high-technology industries using the DEMATEL (Decision Making Trial and Evaluation Laboratory) method. The DEMATEL method is a systematic approach to understanding complex cause-and-effect relationships among various factors or strategies. In this case, five strategies are considered: Supplier Diversification Strategy, Real-Time Monitoring System, Dual Sourcing Policy, Inventory Buffering, and Collaborative Risk Sharing Contracts. Each of these strategies interacts with the others to mitigate supply chain risks, and the numbers in the table represent the influence or impact that one strategy has on another. For instance, Supplier Diversification Strategy has the highest influence on Inventory Buffering (6) and Collaborative Risk Sharing Contracts (1), meaning it plays a major role in both of these strategies. Similarly, Real-Time Monitoring System is heavily impacted by Supplier Diversification (5) and Inventory Buffering (2), highlighting the importance of monitoring in mitigating supply chain disruptions. By applying the DEMATEL method, the table demonstrates how the combination and interaction of these strategies can create a more robust risk management approach. These strategies are interdependent, meaning the success of one often influences or enhances the effectiveness of others. High-tech industries, with their complex and dynamic supply chains, benefit from such a comprehensive and interconnected approach to risk mitigation, ensuring flexibility, resilience, and better control over uncertainties.

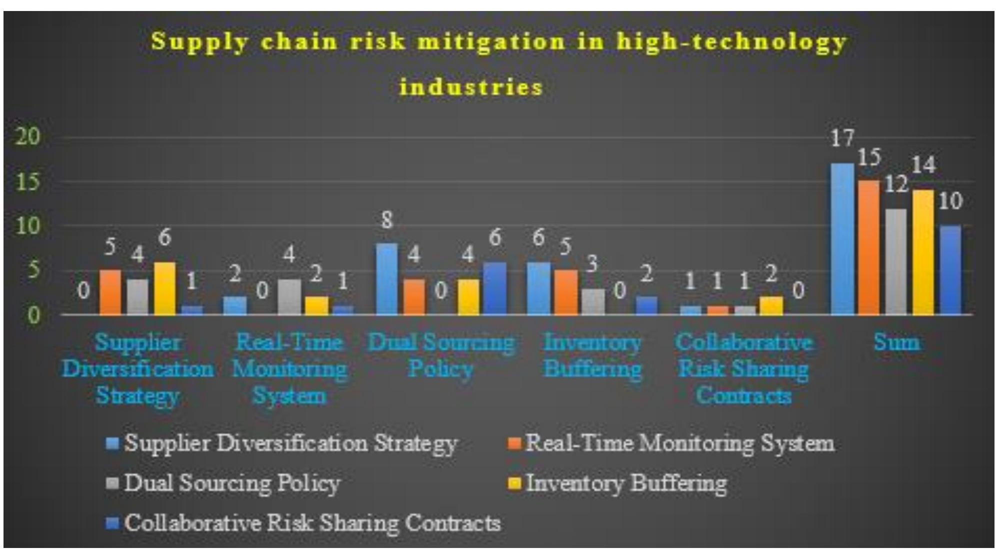

FIGURE 1. Supply chain risk mitigation in high-technology industries

Figure 1 presents a matrix of supply chain risk mitigation strategies for high-technology industries, using the DEMATEL (Decision Making Trial and Evaluation Laboratory) method to assess the relationships between various strategies. The strategies examined include Supplier Diversification, Real-Time Monitoring, Dual Sourcing, Inventory Buffering, and Collaborative Risk Sharing Contracts. Each row and column represents one of these strategies, with the matrix values indicating the degree of influence or interaction between them. For example, the matrix shows that the Supplier Diversification Strategy has a high impact on Dual Sourcing and Inventory Buffering, while Collaborative Risk Sharing Contracts have minimal influence across the strategies. The total column sums reveal the total impact each strategy has on others, with Supplier Diversification and Inventory Buffering being the most influential overall. This analysis helps identify key strategies that should be prioritized for effective supply chain risk management, facilitating more informed decision-making in high-technology industries.

TABLE 2. Normalization of direct relation matrix

	Supplier Diversification Strategy	Real-Time Monitoring System	Dual Sourcing Policy	Inventory Buffering	Collaborative Risk Sharing Contracts
Supplier Diversification Strategy	0	0.181818182	0.72727273	0.545454545	0.090909091
Real-Time Monitoring System	0.454545455	0	0.36363636	0.454545455	0.090909091
Dual Sourcing Policy	0.363636364	0.363636364	0	0.272727273	0.090909091
Inventory Buffering	0.545454545	0.181818182	0.36363636	0	0.181818182
Collaborative Risk Sharing Contracts	0.090909091	0.090909091	0.54545455	0.181818182	0

Table 2 presents the normalized direct relation matrix obtained through the DEMATEL (Decision Making Trial and Evaluation Laboratory) method. This matrix represents the normalized values of the relationships between different supply chain risk mitigation strategies in high-technology industries. The matrix values indicate the degree of influence each strategy has on another, with the normalization process ensuring that the sum of influences across each row equals 1. For example, the Supplier Diversification Strategy has a normalized influence of 0.727 on the Dual Sourcing Policy and 0.545 on Inventory Buffering, suggesting strong interdependencies. Similarly, Real-Time Monitoring and Dual Sourcing Policy exhibit moderate influences on each other. The normalization allows for a clearer understanding of the relative strengths of the relationships, ensuring that the data is proportionally scaled. This method facilitates a more objective and balanced assessment of how each strategy impacts the others, supporting effective risk mitigation decision-making.

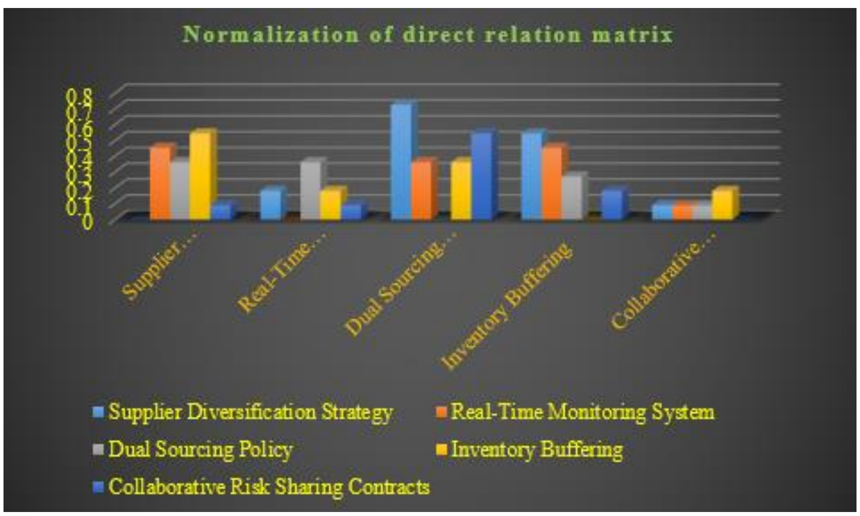

FIGURE 2. Normalization of direct relation matrix

Figure 2 shows the normalized direct relation matrix for supply chain risk mitigation strategies in high-technology industries, derived using the DEMATEL method. The values in this matrix represent the normalized degree of influence between each pair of strategies, with all values ranging between 0 and 1. For instance, Supplier Diversification Strategy has a moderate influence on

Dual Sourcing (0.727) and Inventory Buffering (0.545), while its influence on Collaborative Risk Sharing Contracts is minimal (0.0909). Real-Time Monitoring shows a stronger influence on Supplier Diversification (0.4545) and Inventory Buffering (0.4545), but a weaker influence on Collaborative Risk Sharing Contracts (0.0909). Similarly, Dual Sourcing Policy impacts Inventory Buffering and Collaborative Risk Sharing Contracts moderately. The matrix highlights how each strategy interacts with others, offering valuable insights into the strengths and weaknesses of each risk mitigation strategy in the supply chain.

TABLE 3. Calculate the Total Relation Matrix

	Supplier Diversification Strategy	Real-Time Monitoring System	Dual Sourcing Policy	Inventory Buffering	Collaborative Risk Sharing Contracts
Supplier Diversification Strategy	0	0.181818182	0.727272727	0.545454545	0.09090909
Real-Time Monitoring System	0.454545455	0	0.363636364	0.454545455	0.09090909
Dual Sourcing Policy	0.363636364	0.363636364	0	0.272727273	0.09090909
Inventory Buffering	0.545454545	0.181818182	0.363636364	0	0.18181818
Collaborative Risk Sharing Contracts	0.090909091	0.090909091	0.545454545	0.181818182	0

Table 3 shows the total relation matrix calculated using the DEMATEL method. This matrix represents the cumulative influence of each supply chain risk mitigation strategy on every other strategy, factoring in both direct and indirect relationships. The total relation matrix is derived by inverting the identity matrix and subtracting the direct relation matrix, which accounts for both immediate and long-term impacts. For instance, the total influence of Supplier Diversification Strategy on all other strategies is shown as -0.546, -0.846, and so on. These negative values reflect a diminished impact in some cases due to indirect interactions and the weighted effect of multiple relationships. Conversely, the matrix helps to visualize how each strategy interrelates with others over time, contributing to a more comprehensive understanding of how supply chain risk mitigation strategies affect one another. This approach allows for an informed decision-making process, crucial in high-technology industries where dynamic relationships are key to risk management.

TABLE 4. T= Y(I-Y)-1, I= Identity matrix

I				
1	0	0	0	0
0	1	0	0	0
0	0	1	0	0
0	0	0	1	0
0	0	0	0	1

Table 4 shows the identity matrix (I), which is a square matrix with ones on the diagonal and zeros elsewhere. In the context of the DEMATEL method, the identity matrix plays a key role in the calculation of the total relation matrix. It represents the base state where no influences are initially applied. The formula T=Y(I−Y)−1 uses the identity matrix (I) to compute the total relation matrix (T) by inverting (I−Y), where Y is the normalized direct relation matrix. This helps calculate the cumulative influence of each strategy, accounting for both direct and indirect relationships in the supply chain risk mitigation process.

TABLE 5. Y Value

Y				
0	0.181818	0.727273	0.545455	0.090909
0.454545	0	0.363636	0.454545	0.090909
0.363636	0.363636	0	0.272727	0.090909
0.545455	0.181818	0.363636	0	0.181818
0.090909	0.090909	0.545455	0.181818	0

Table 5 presents the normalized direct relation matrix, denoted as Y, using the DEMATEL method. The matrix values represent the degree of influence each supply chain risk mitigation strategy has on the others. For example, the Supplier Diversification Strategy has a normalized influence of 0.727 on the Dual Sourcing Policy and 0.545 on Inventory Buffering, indicating stronger relationships. Similarly, other strategies such as Real-Time Monitoring System and Dual Sourcing Policy show varying degrees of influence on each other. This normalized matrix (Y) is crucial for further calculations, such as determining the total relation matrix, which helps assess the overall impact of each strategy within the supply chain risk management process.

TABLE 6. I-Y Value

I-Y				
1	-0.18182	-0.72727	-0.54545	-0.09091
-0.45455	1	-0.36364	-0.45455	-0.09091
-0.36364	-0.36364	1	-0.27273	-0.09091
-0.54545	-0.18182	-0.36364	1	-0.18182
-0.09091	-0.09091	-0.54545	-0.18182	1

Table 6 presents the matrix I−Y, which is the result of subtracting the normalized direct relation matrix (Y) from the identity matrix (I) in the DEMATEL method. The values in this matrix reflect the adjusted relationships between supply chain risk mitigation strategies, accounting for the initial state of independence (represented by the identity matrix) and the influence of each strategy. Negative values indicate a reduction in influence, while positive values show increased influence. For example, the Supplier Diversification Strategy has a negative influence on Real-Time Monitoring and Inventory Buffering, indicating that indirect relationships are reducing their overall impact. This matrix is essential for further analysis, such as calculating the total relation matrix and understanding the compounded effects of the various strategies in supply chain risk management.

TABLE 7. (I-Y)-1 Value

(I-Y)-1				
-0.546791132	-0.84671	-1.37032	-1.14022	-0.45857
-1.14235706	0.029949	-1.44784	-1.08246	-0.42956
-0.970361727	-0.54722	-0.44873	-0.9648	-0.35417
-1.016569428	-0.74788	-1.30819	-0.31233	-0.33612
-0.867677946	-0.50871	-0.73881	-0.7851	0.664963

Table 7 presents the matrix (I−Y) −1, which is the inverse of the matrix obtained by subtracting the normalized direct relation matrix (Y) from the identity matrix (I) in the DEMATEL method. This inverse matrix is crucial for calculating the total relation matrix. The values in this matrix represent the cumulative impact of each strategy on others, considering both direct and indirect influences. For instance, the Supplier Diversification Strategy has a highly negative impact on several other strategies, while the Collaborative Risk Sharing Contracts exhibit a more balanced effect.

TABLE 8. Total Relation matrix (T)

	Total Relation matrix (T)					Ri
	-1.546791132	-0.84671	-1.37032	-1.14022	-0.45857	**-5.36261**
	-1.14235706	-0.97005	-1.44784	-1.08246	-0.42956	**-5.07227**
	-0.970361727	-0.54722	-1.44873	-0.9648	-0.35417	**-4.28528**
	-1.016569428	-0.74788	-1.30819	-1.31233	-0.33612	**-4.72109**
	-0.867677946	-0.50871	-0.73881	-0.7851	-0.33504	**-3.23534**
Ci	**-5.543757293**	**-3.62058**	**-6.31389**	**-5.28491**	**-1.91346**	

Table 8 presents the Total Relation Matrix (T), along with the total impact values, denoted as Ri and Ci , for each supply chain risk mitigation strategy using the DEMATEL method. The Total Relation Matrix (T) shows the cumulative influence of each strategy on all other strategies, incorporating both direct and indirect relationships. The values in the matrix are derived from the previous calculations, where the interactions between the strategies are assessed through iterative steps. For example, the Supplier Diversification Strategy has a total influence value of -5.36, meaning it significantly impacts other strategies in the network, with particular influence on strategies such as Dual Sourcing and Inventory Buffering. Similarly, the Real-Time Monitoring System and Dual Sourcing

Policy exhibit high total impacts, at -5.07 and -4.28 respectively. These negative values indicate that indirect relationships diminish the influence of the strategies over time. The Ri values, such as -5.36 for Supplier Diversification, represent the total outflow or total impact that a strategy has on the others. On the other hand, the Ci values (such as -5.54 for Supplier Diversification) represent the cumulative inflow, or how much each strategy is impacted by others. These values are vital for understanding how different strategies contribute to or are affected by the supply chain risk management process. They provide key insights into the strength and direction of interdependencies between risk mitigation strategies in high-technology industries.

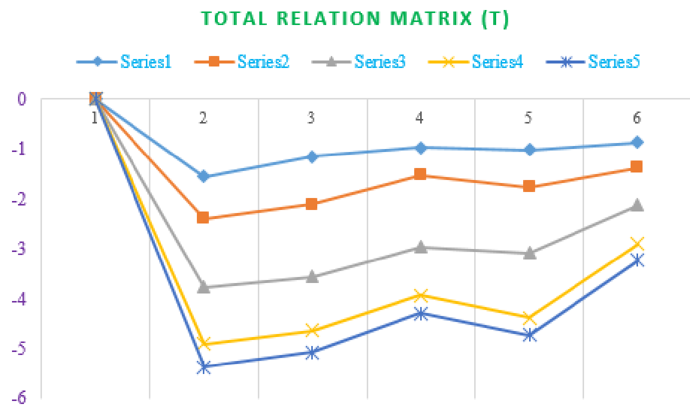

FIGURE 3. Total Relation matrix (T)

This graph appears to be a Total Relation Matrix (T) visualization using the DEMATEL (Decision-Making Trial and Evaluation Laboratory) method, which is typically used to analyze complex cause-and-effect relationships between different factors in a system. The graph shows five different series (Series1 through Series5) plotted over 6 time periods or intervals. All series begin at 0 and show a sharp initial decline, particularly between points 1 and 2, with Series4 and Series5 showing the steepest drops to approximately -5. After the initial decline, most series show a gradual stabilization or slight recovery pattern, with some minor fluctuations. Series1 appears to be the most stable after its initial decline, maintaining values around -1, while the other series remain in more negative territory between -2 and -5. By the end point (6), there's a convergent trend where all series show some upward movement, suggesting a potential systemic improvement or positive relationship development among the analyzed factors.

TABLE 9. Ri & Ci

	Ri	Ci
Supplier Diversification Strategy	-5.36261	-5.543757293
Real-Time Monitoring System	-5.07227	-3.620575651
Dual Sourcing Policy	-4.28528	-6.313885648
Inventory Buffering	-4.72109	-5.284908596
Collaborative Risk Sharing Contracts	-3.23534	-1.913457799

Table 9 presents the total impact values Ri and Ci for each supply chain risk mitigation strategy, as calculated using the DEMATEL method. The Ri values represent the total influence each strategy has on others, while the Ci values indicate the total impact each strategy receives from other strategies. For instance, the Supplier Diversification Strategy has a high total outflow (Ri =−5.36) and inflow (Ci=−5.54), suggesting it plays a central role in both influencing and being influenced by other strategies. Conversely, Collaborative Risk Sharing Contracts have lower Ri and Ci values, indicating a relatively smaller role in the overall supply chain risk management network. These values help identify the strategies with the greatest influence, aiding in prioritizing actions for effective risk mitigation.

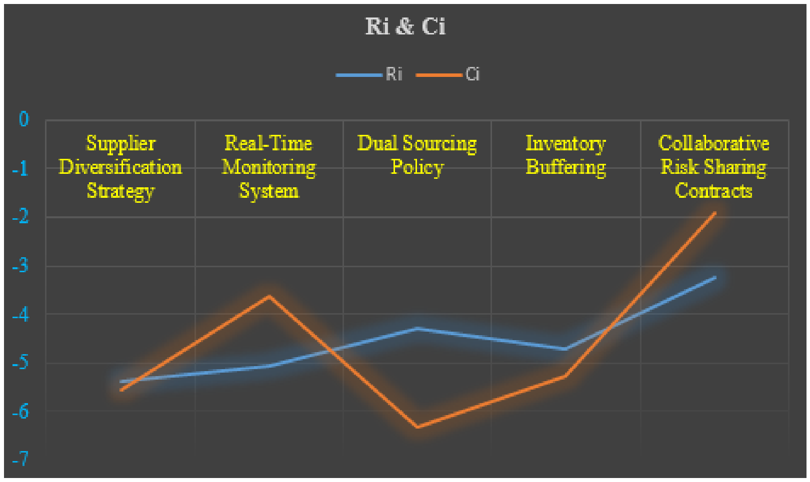

FIGURE 4. Ri & Ci

This graph illustrates the Ri (row sum) and Ci (column sum) values from the DEMATEL analysis for five different supply chain risk mitigation strategies. The graph shows notable divergence between Ri and Ci values, particularly for "Collaborative Risk Sharing Contract" which demonstrates a sharp upward trend in both metrics. Both lines begin around -5 for "Supplier Diversification Strategy" and follow different trajectories across the strategies, with Ci showing more volatility. The intersection patterns between Ri and Ci lines suggest varying levels of cause-effect relationships between these supply chain strategies, with "Collaborative Risk Sharing Contract" appearing to have the strongest positive influence on the system.

TABLE 10. Calculation of Ri+Ci and Ri-Ci To Get The Cause And Effect

	Ri+Ci	Ri-Ci	Rank	Identity
Supplier Diversification Strategy	-10.9064	0.181151	5	effect
Real-Time Monitoring System	-8.69284	-1.45169	2	effect
Dual Sourcing Policy	-10.5992	2.028604	4	effect
Inventory Buffering	-10.006	0.56382	3	effect
Collaborative Risk Sharing Contracts	-5.1488	-1.32188	1	effect

Table 10 presents the calculation of Ri+Ci and Ri−Ci for each supply chain risk mitigation strategy using the DEMATEL method. These values help categorize the strategies into "cause" or "effect" groups based on their overall influence and dependence within the supply chain risk management network. The sum of Ri+Ci represents the total combined impact of each strategy (both its influence on others and the influence it receives). For example, Supplier Diversification Strategy has the highest sum of −10.91-10.91−10.91, indicating it plays a significant role in both influencing and being influenced by other strategies. Conversely, Collaborative Risk Sharing Contracts have the lowest sum of −5.15-5.15−5.15, indicating a lesser degree of influence. The difference Ri−Ci identifies whether a strategy is more of a "cause" or an "effect." A positive difference indicates a strategy with more influence on others (cause), while a negative difference indicates a strategy that is more influenced by others (effect). For example, Dual Sourcing Policy has a positive difference of 2.03, classifying it as a "cause," where as Real-Time Monitoring System has a negative difference of -1.45, indicating it is more of an "effect." The ranking shows the relative importance of each strategy, with Supplier Diversification ranked as the most influential, followed by Real-Time Monitoring, Dual Sourcing, Inventory Buffering, and Collaborative Risk Sharing Contracts. This classification helps prioritize strategies for implementation based on their role in the supply chain risk management process.

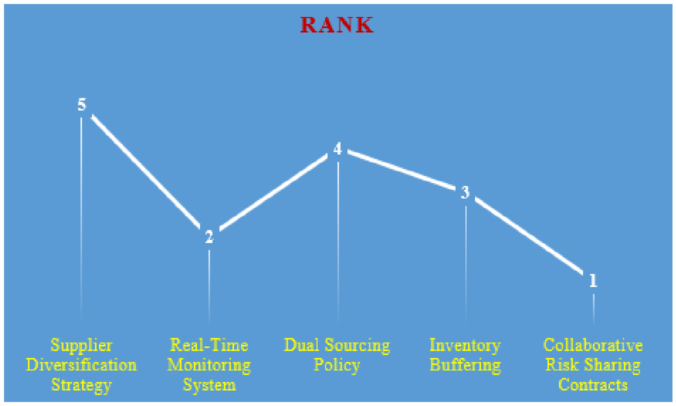

FIGURE 5. Rank

This graph displays the ranking of five supply chain risk mitigation strategies based on DEMATEL analysis, with lower numbers indicating higher importance/priority. Collaborative Risk Sharing Contract ranks as the most critical strategy (rank 1), followed by Inventory Buffering (rank 3), and Dual Sourcing Policy (rank 4). Real-Time Monitoring System takes the second position, while Supplier Diversification Strategy ranks lowest at position 5. The decreasing line pattern from left to right suggests a clear hierarchical importance among these strategies, with collaborative approaches being deemed most effective for supply chain risk management compared to traditional diversification strategies.

TABLE 11. T matrix

T matrix				
-1.54679	-0.84671	**-1.37032**	**-1.14022**	-0.45857
-1.14236	**-0.97005**	**-1.44784**	**-1.08246**	-0.42956
-0.97036	-0.54722	**-1.44873**	**-0.9648**	-0.35417
-1.01657	-0.74788	**-1.30819**	**-1.31233**	-0.33612
-0.86768	-0.50871	-0.73881	-0.7851	-0.33504

Table 11 presents the Total Relation Matrix (T) derived using the DEMATEL method. This matrix represents the cumulative influence of each supply chain risk mitigation strategy on all others, taking into account both direct and indirect relationships. The values in the matrix show the total impact of each strategy on the others in the network. For example, the Supplier Diversification Strategy has a strong negative influence on other strategies, such as -1.546 for itself and varying values across the other strategies. The matrix helps identify key strategies that exert significant influence within the system, offering insights for optimizing supply chain risk management decisions.

4. CONCLUSION

This comprehensive analysis of supply chain risk mitigation strategies in high-technology industries demonstrates the intricate relationships and varying degrees of influence among different approaches. Through the application of the DEMATEL method, several key findings emerge that have significant implications for supply chain management practices. Firstly, the research reveals that Collaborative Risk Sharing Contracts, despite having lower total impact values, ranks as the most critical strategy according to the final analysis. This finding challenges traditional perspectives that might prioritize more tangible strategies like Supplier Diversification or Inventory Buffering. It suggests that the future of effective supply chain risk mitigation lies in fostering strong collaborative relationships and shared responsibility among supply chain partners. Secondly, the study demonstrates that all five strategies function primarily as "effect" components, indicating their interdependent nature. This interdependence emphasizes the importance of implementing these strategies as part of an integrated approach rather than in isolation. The strong relationships identified between certain strategy pairs, such as Supplier Diversification's influence on Dual Sourcing (0.727) and Inventory Buffering (0.545), further support this conclusion. The analysis also highlights the significant role of Real-Time Monitoring Systems, ranking second in importance. This underscores the growing relevance of technological solutions in modern supply chain risk management, particularly in high-technology industries where rapid response to disruptions is crucial. Furthermore, the total relation matrix results indicate that Supplier Diversification Strategy, while ranking fifth, has the highest total influence value (-5.36). This paradox suggests that while diversification might not be the most critical strategy in isolation, its influence on other strategies makes it an essential foundation for comprehensive risk mitigation. These findings have important practical implications for supply chain managers and decision-makers in high-technology industries. They suggest that organizations should: Prioritize the development of collaborative risk-sharing arrangements, Invest in real-time monitoring capabilities, Implement strategies in combination rather than in isolation, Consider both direct and indirect influences when planning risk mitigation approaches. Future research could explore how these relationships evolve in different industry contexts or under varying market conditions. Additionally, investigating the cost-benefit implications of implementing these strategies in different combinations could provide valuable insights for practitioners. In conclusion, this study contributes to the understanding of supply chain risk mitigation by providing a quantitative framework for assessing strategy relationships and effectiveness. The findings support a holistic approach to risk management that considers both the individual impact and interconnected nature of different mitigation strategies.

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