ORIGINAL ARTICLE

In Quest of Sustainable Performance Advantage in the Fertilizer Manufacturing Firms: A Multi-Method Driven Supply Chain Risk Assessment Framework

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ABSTRACT

Purpose: In an era of escalating supply chain disruptions ranging from geopolitical conflicts to cyber threats, this study offers a practical framework for identifying, prioritizing and mitigating supply chain risks that impede firm performance and resilience.

Design/Method/Approach: Using a mixed-methods approach, we combine qualitative insights with the Analytical Hierarchy Process (AHP) to assess and rank key vulnerabilities based on their severity, likelihood and interdependence. Guided by expert evaluations and pairwise comparisons using Expert Choice 11, we categorize risks into operational, logistical, technological and external domains and assign weighted priorities to each. The methodology not only pinpoints high-impact risks but also reveals how these risks cascade across the organizational supply chains and affect the firm performance outcomes.

Findings/Results: The results of this study offer clear and evidence-based strategies for the fertilizer manufacturing firms, especially the small and medium firms, to transit from reactive problem-solving to proactive risk planning.

Originality: By integrating theoretical rigor with practical application, this study addresses a notable gap in the literature and equips decision-makers with a scalable and actionable risk mitigation tool.

Research Implications: Key contributions include an AHP validated risk taxonomy and recommendations that align with real-world resource constraints. Ultimately, this research reframes supply chain risk management as a strategic enabler of agility & competitive advantage. The future studies may build on this work by incorporating AI-driven analytics and industry-specific scenarios to enhance predictive accuracy & relevance in an increasingly complex supply chain ecosystem.

Keywords: Analytical Hierarchy Process, Regression Analysis, Supply Risks, Storage Risks, Transport Risks, Ethical Risks, Cyber Risks

JEL: L23, M11, L25

1 | INTRODUCTION

At a global business landscape, the contemporary SMEs have been facing risks and vulnerabilities related to their supply chain operations that hamper their operational continuity and consequently the market competitiveness (Dahri et al., 2025a; Ali et al., 2023). The vulnerabilities to these risks have further increased owing to the intricate nature of modern supply chains and ever-increasing environmental sustainability requirements of the governments across the globe. Cut-throat competition, business to business relations, outsourcing networks and contractual obligations have created a complex web of interdependencies among the supply chain partners, thus further augmenting the vulnerabilities and exposures to risk (Jia et al., 2025; Kt & Sarmah, 2021). For SMEs, these challenges are particularly frightening. Contrary to giant multinational corporations that possess diversified supplier options, cash reserves and high-budget risk management strategies, SMEs typically operate with limited to no access to contingency resources like reserved funds, material or equipment and often have to struggle to ensure their continued existence (Dahri et al., 2025b). According to the World Bank Global SME Survey (2023), about 65% of the SMEs around the globe experienced severe supply chain disruptions during the past three years. This number is as high as 80% for the SMEs of developing countries like Pakistan.

In case of Pakistan, the SMEs contribute as much as 40% to GDP, 25% of exports and employ 78% of non-agricultural labor force (Dahri et al., 2025b; State Bank of Pakistan, 2022). These figures highlight SME sector significance in boosting Pakistan's economy. However, lack of required support, country's poor economic infrastructure especially transportation, energy and other facilities including a lack of sophisticated technological advancements have made SMEs vulnerable to wide array of risks, inevitably leading them to severe supply chain shocks. A report by SMEDA (2022) revealed that less than 15% of Pakistani SMEs have formal risk management protocols and financial flexibility. Most of them rely on a single supplier source for critical inputs. Particularly, the fertilizer industry presents a compelling case study of supply chain vulnerabilities for Pakistan's industrial sector. According to Fertilizer Manufacturers of Pakistan Advisory Council (2023), the fertilizer sector, given its annual market size of $3.5 billion, plays a phenomenal role in supporting the agricultural output as high as 45%, while significantly ensuring the supply of essential food items to meet domestic and international demands (SMEDA, 2022).

The Supply Chain Risk Management (SCRM) has arisen as an operational imperative to help companies anticipate, calculate and mitigate risk exposures for a sustainable performance and growth (Kanyepe et al., 2025). The popular models for managing risk in supply chains include 'Supply Chain Risk Structure Model (SCRSM)' which explains the causes-&-effects of the supply chain risks i.e. their underlying factors and interrelationships among them. The other model is 'Supply Chain Risk Dynamics Model (SCRDM)' which is used for historical evolution of risk scenarios. Integrating these two popular models generates a comprehensive system that helps firms remain proactive, and forecast, analyze and reduce

the negative impact of the risks beforehand (Rashid et al., 2025). While there is an increasing interest of the global researchers towards SCRM, its scope and applicability has been largely understudied in the context of developing countries like Pakistan. Additionally, the current literature has been largely focused on resource-rich enterprises, often neglecting unique vulnerabilities of SMEs in emerging economies, leaving a huge gap in literature (Ali et al., 2023; Ganiyu et al., 2020).

The present study attempts to fulfill the gap by launching a sector-specific investigation to understand the modalities of multidimensional supply chain risk factors. The study's main focus is to identify and measure specific risk types like supply, storage, ethical, cyber, and transportation risks and their individual and comparative impact upon firm's performance. Moreover, SMEs face increased susceptibility towards supply chains risks due to lack of proper risk management tools, they often rely on intuition and fragmented practices which can be inaccurate and lead to inefficient practices and prolonged recovery from supply chain disruptions. Currently, there is dearth of literature on structured blueprints and data driven tools or frameworks that can guide prioritization and mitigation of the supply chain risks effectively. The current study also aims to provide a risk prioritization framework that enables SMEs to allocate limited resources more strategically, develop proactive plans, and sustain competitive advantage in uncertain environments.

The study is significant for its methodological approach i.e. we have adopted an integrated approach by combining qualitative expert inputs with the quantitative tool like Analytical Hierarchy Process (AHP) to construct SCRSM and SCRDM models. These two models not only capture interdependencies in the supply chains but also help design and provide a comprehensive risk assessment and mitigation blueprint (Khan & Emon, 2025). This approach is particularly valuable for SMEs in Pakistan's fertilizer sector, where operational decisions must be both timely and cost-effective. This study has important theoretical & practical contributions. Theoretically speaking, it adds value to the extant literature by extending SCRM discourse into manufacturing industry in emerging economies, more specifically the SME sector, which is often underrepresented in extant literature. Moreover, the study has adopted a sophisticated decision-support mechanism (AHP) which is rarely used in SCRM literature. The model can be replicated in other sectors and economies, as it is an effective tool to make informed decisions and gain actionable insights. Ultimately, the study findings underline an urgent need for SMEs in Pakistan's fertilizer industry to integrate a comprehensive system that can address the supply chain risks proactively and develop resilience and agility to ensure a sustainable growth and survival.

2 | LITERATURE BACKGROUND & HYPOTHESES DEVELOPMENT

2.1 | Supply Chain Risk Management Process (SCRMP)

In its broadest sense, risk is the probability of an adverse outcome and refers to a possibility of loss, unwanted events and undesirable occurrences due to a firm's internal or peripheral susceptibilities (Tao et al., 2025). Supply chain risks vary significantly across industries and can stem from multiple sources including technological, operational, and geopolitical domains (Sharma et al. 2024). The development of integrated and flexible supply-chain risk mitigation framework could be a proactive step to minimize the adverse impact of these risk factors in volatile environment (Bag, 2025; Juma & Bushnaq, 2024). Currently, the two main systems are critical enablers to manage risk exposures i.e. The supply chain risk structure model (SCRSM), which helps assess the cause-and-effect relationship and interactional impact among risk factors and supply chain risk dynamics mod (SCRDM), which is an essential tool to identify how risk factors evolve over time. Combining the two models structures a functional blueprint that helps firms the forecast, assess, analyze and mitigate the risks with a proactive approach (Rashid et al., 2025).

Effectiveness of supply chain control policies and procedures depends upon its ability to capture and manage risks at three interrelated levels: strategic, tactical and operational, which can result in timely and accurate response to disruptions (Juma & Bushnaq, 2024; Dakhch & Benamar, 2024). Further, behavioral risk theory provides a viewpoint to understand decision making in supply chains through combination of three factors i.e. extent of risk, its probability of occurrence and overall supply chain disruption risk (Ellis et al., 2010). Because of varying degrees, types and sources of risks have surfaced, understanding its multidimensional perspective is important (Williams et al., 2008). For example, supply risks may originate from internal and external shocks like system failures or infrastructural gaps, on the other hand, ethical risk may arise from labour rights violation, workplace discrimination etc. Storage and transportation risks may arise due to improper handling of the inventory and lack of proper logistics (Rathore et al., 2017). The connectively among these risks necessitates a unified and coherent system that can address the inherent complexity and ensure agility for sustained operational excellence and resilience (Mokadem et al., 2025; Gurtu & Johny, 2021; Ganiyu et al., 2020). The current study highlights that integrating a risk management system can help firms become proactive rather than reactive in terms of enhancing response to unforeseen disruptions and safeguard long-term objectives of the firms (Bagwe, 2025; Javaid & Siddiqui, 2018).

2.2 | Supply Risks and Firm Performance

Supply risks entail unavailability of critical inputs, quality issues, supplier failures and market dynamics that can cause missed targets and jeopardize the operational continuity of supply chains (Richert & Dudek, 2023). These risks increase vulnerability when firms overly rely on a single source for the supply

of its critical inputs without a supplier back up (Saputro et al., 2024). Further aggravated by market shortages, technological lag and price volatility, it leads to increased costs to the firm, delayed shipments and failure to meet customer demands (Pellegrino et al., 2025). Management of the supply risks will enable firms to address these issues with professional excellence, diversify supplier base, build financial and operational buffering mechanism leading to better firm performance and resilient supply-chain operations (Mukherjee et al., 2024; Ali et al., 2023).

In Pakistan, the fertilizer industry is highly dependent industry, stemming from external factors like import of raw material and internal factors like power shortages, technological barriers and logistics and infrastructural weaknesses. To help with these measures it is essential to take pre-emptive measures like dual-sourcing, inventory stock, investing in advance forecasting and risk monitoring will empower firms gain more agility and response quickly to any disruptions forthcoming (Khan & Emon, 2025). This will ensure organizational sustainability and robust financial and operational performance (Dakhch & Benamar, 2024). Hence, we propose that:

H1: Effective management of Supply Risks impact positively on supply chain performance

2.3 | Storage Risks and Firm Performance

Storage risks stem from inadequate warehousing facilities, substandard inventory handling, and lack of proper monitoring and tracking systems. Poor management of these risks will result in high inventory costs, product damage and emergency restocking. The SMEs usually have limited capital base therefore they struggle with insufficient warehouse facilities creating troubles in inventory management and compromising on safety and quality of stored products.

In fertilizer companies, chemical stability and the way materials are stored and managed are very critical, inability to handle the materials carefully will lead to material loss and environmental hazards (Rathore et al., 2017). Minimizing storage risks such investing in capacity building, inventory spoilage, safety checks, automated tracking will not only reduce inventory costs, but will enhance inventory reliability (Sharma et al., 2024) and equip firms to better position themselves for improved customer satisfaction and greater market share (Bag, 2025; Chen, 2018). Therefore, we propose that:

H2: Effective management of Storage Risk positively influence supply chain performance

2.4 | Ethical Risks and Firm Performance

Ethical risks arise as a result of non-compliance with legal, social and environmental standards. Examples of such violations may include fraudulent procurement, abuse of labor rights, corruption, and negligence to environmental degradation. Ethical risks are deep rooted into weak governance and lack of transparency into organizational practices (Kanyepe, Musasa, & Wilbert, 2025). In supply chains, compromising on ethical standards can cause stakeholder backlash and reputational damage to the firm.

Therefore, building organizational integrity through compliance to the ethical standards is highly acclaimed. Many SMEs in Pakistan operate under informal economy and usually bypass laws relating to minimum wage, fair labor practices, cause environmental contamination through improper waste disposal. This calls for a thorough implementation of ethical framework into their operational activities like procurement, labor practices and waste disposal (Nguyen et al., 2021). By ensuring compliance audits and transparency protocols firms not only can avoid legal repercussions and reputational damage but also will be able to win stakeholder trust and foster sustainable performance (Juma & Bushnaq, 2024). Therefore:

H3: Effective management of Ethical Risks positively influence the supply chain performance

2.5 | Cyber Risks and Firm Performance

The current pace of digitalization and technological advancements not only create opportunities but also poses certain risks for the firms, often termed as cyber-attacks or cyber-risks (Tao et al., 2025). These risks are wide ranging from ransom-attacks to data breaches. The risks arise owing to fragile cyber-security protocols or system failures (Kanyepe et al., 2025). The cyber risks are detrimental to firms as it leads to system collapse, data theft and halted production leading to financial losses and lost customer confidence (Williams et al., 2008). It is imperative to install a digital infrastructure to secure data assets and turning a cyber-threat into a strategic advantage. The SMEs in Pakistan are in their transitioning phase towards digitalization, however, due to lack of technical expertise and underinvestment in cyber-security infrastructure they are highly exposed to the cyber risks. A single attack can cripple the entire electronic system implanted in supply chains causing turbulence in operational, financial and inventory networks. Therefore, safeguarding the digital supply chains needs strong cyber-security frameworks, risk assessments tools and IT-collaborations (Mokadem et al., 2025). Therefore, we suggest the following hypothesis:

H4: Effective management of Cyber Risks positively influence the supply chain performance

2.6 | Transportation Risks and Firm Performance

The delivery of supply chains goods can be delayed if the firm is exposed to transportation risks like improper planning of the routes, road safety concerns, vehicle breakdowns etc (Pellegrino et al., 2025). In Pakistan, the conditions of roads, fuel price volatility and bureaucratic hurdles increase the intensity of these challenges. SMEs, mostly rely on third party logistics which can be unreliable or uncertain, leading to higher exposure to the risk. The timely delivery of the goods to both national and international clientele is essential for customer trust and strong business relations as delayed supply not only frustrates the customer but also damage product quality as in case of perishable goods, compounding revenue losses. (Rathore et al., 2017). Firms can capitalize on the transportation resources by saving huge costs and increasing productivity and efficiency (Gholamizadeh et al., 2022). Resources like in transportation

planning, up-to-date inventory tracking systems, and preventive vehicle maintenance can reduce the costs and supply chain disruptions considerably and simultaneously can be a helpful tool to enhance operational agility and enhance supply chain agility and fostering business growth (Tao et al., 2025). Further, it will also strengthen business to business relations and boost firm performance (Bag, 2025). Hence, the study proposes that:

H5: Effective Management of Transportation Risks improve firm performance

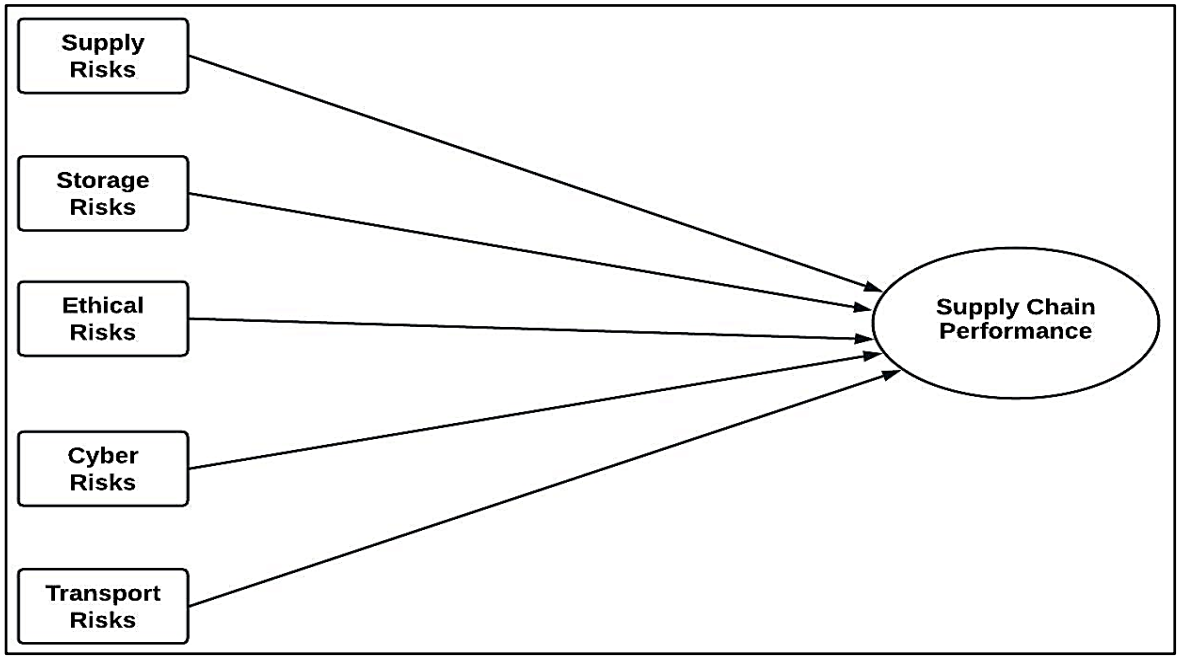

Figure 01: Theoretical Research Framework

3 | RESEARCH METHODOLOGY

3.1 | Sample Population and Data Collection

Based on pragmatist research paradigm, this study employed mixed-methods approach to investigate how effective management of supply chain risks leads to higher firm performance. For quantitative data collection, we utilized a survey-based methodology. A close-ended questionnaire was developed by adapting validated items from established studies. For the Supply Chain Risks, we adapted scale from Gaudenzi & Borghesi (2006) and Rathor et al. (2017). For Storage Risks, we adapted items from Rathore et al. (2017) and Keilhacker & Minner (2017). Moreover, the items for Ethical Risks were drawn from Heckman et al. (2015) and Faisal et al. (2007). Likewise, the items for Transport Risks were adapted from Gaudenzi & Borghesi (2006) and Rathor et al. (2017). Finally, the items for Cyber Risks were adapted from Li et al. (2013) and Heckmann et al. (2015). Using convenience sampling, the data were collected in person targeting experienced executives and managers across various organizational hierarchies within a large fertilizer firm of Pakistan. These included senior, middle and supervisor level managers who

possessed relevant academic qualifications and substantial managerial experience in supply chain operations. This strategic sampling approach guaranteed that respondents could provide informed, authoritative perspectives on SCRM practices and their organizational impact.

3.2 | Data Analyses Methods

Firstly, we used the Analytic Hierarchy Process (AHP) which helped in prioritizing different types of risks by getting experts to compare them. In this regard, we followed a step-by-step procedure which is detailed in the next section. Subsequently, using the SPSS software tool, we performed Regression Analysis for research model and hypothesis testing. A mix of expert insights and quantitative data analysis enhanced the reliability of the findings, especially for the firms working in a limited-resource environment. This approach also sets a strong example for future research in similar industries.

4 | RESULTS AND ANALYSIS

4.1 | Risk Identification Stages

Stage 1: Identification

In the first stage, we identified the key Risk factors from extensive literature review. Through the process, we identified 9 primary and 31 sub-variables that were used to measure firm performance and risk management. For a clear reference, we have presented these variables and their corresponding sub-variables in the figure 02.

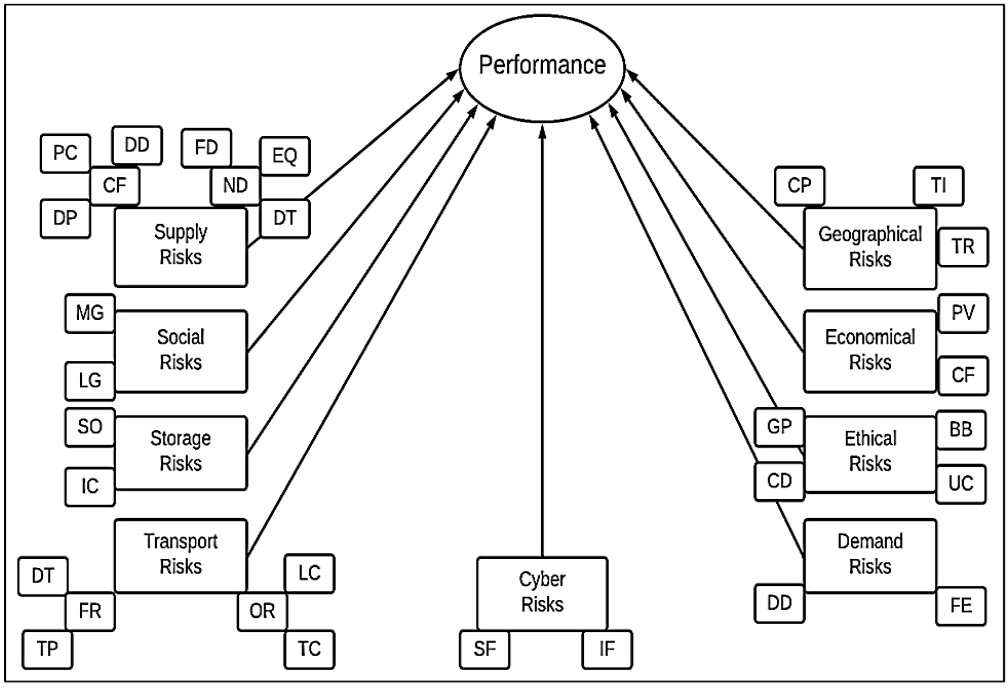

Figure 02: AHP Risk Factors Identification

Stage 2: Selection of Variables and Sub-variables

In the second stage, a bi-polar questionnaire (Saaty, 1987) was developed based upon the variables and sub-variables identified in stage 1. The questionnaire was sent to experts of Fauji Fertilizer Bin Qasim Limited (FFBL) for their professional evaluations of the relative importance of each variable. Out of 20 questionnaires distributed, we received 16 fully completed questionnaire, making our response rate as 80%, which was sufficient to proceed to the analysis phase.

Risks Variables & Sub-variables	**Prior Risk Factors**									
	9	**7**	**5**	**3**	**1**	**3**	**5**	**7**	**9**	
Supply Risk-1					1					Transportation Risks
Supply Risk-2					1					Social Risks
Supply Risk-3					1					Storage Risks
Supply Risk-3					1					Ethical Risks
Supply Risk-4					1					Demand Risks
Supply Risk-5					1					Cyber Risks
Supply Risk-6					1					Geographical Risks
Supply Risk-7					1					Economical Risks
Social Risk-1					1					Storage Risks
Social Risk-2					1					Cyber Risks
Social Risk-3					1					Transportation Risks
Social Risk-4					1					Demand Risks
Social Risk-5					1					Geographical Risks
Social Risk-6					1					Economical Risks
Social Risk-7					1					Ethical Risks
Storage Risk-1					1					Cyber Risks
Storage Risk-2					1					Transportation Risks
Storage Risk-3					1					Demand Risks
Storage Risk-4					1					Economical Risks
Storage Risk-5					1					Ethical Risks
Storage Risk-6					1					Geographical Risks
Transportation Risk-1					1					Economical Risks
Transportation Risk-2					1					Cyber Risks
Transportation Risk-3					1					Geographical Risks
Transportation Risk-4					1					Demand Risks

Transportation Risk-5					1					Ethical Risks
Cyber Risk-1					1					Geographical Risks
Cyber Risk-2					1					Economical Risks
Cyber Risk-3					1					Ethical Risks
Cyber Risk-4					1					Demand Risks
Demand Risk-1					1					Geographical Risks
Demand Risk-2					1					Economical Risks
Demand Risk-3					1					Ethical Risks
Ethical Risk-1					1					Geographical Risks
Ethical Risk-2					1					Economical Risks
Communication Failure Risk-1					1					Dependability
Communication failure Risk-2					1					Delay Delivery
Communication Failure Risk-3					1					Poor Communication
Economical Risk					1					Geographical Risks
Dependability Risk-1					1					Delay Delivery
Dependability Risk-2					1					Poor Communication
Natural Disasters Risk-1					1					Drought
Natural Disasters Risk-2					1					Earthquake
Natural Disasters Risk-3					1					Flood
Flood Risk-1					1					Earthquake
Flood Risk-2					1					Drought
Delay Delivery					1					Poor Communication
Migration Risk					1					Language
Earthquake Risk					1					Drought
Financial Risk-1					1					Third-Party Credit Rating
Financial Risk-2					1					Default-Over-Time
Inventory Cost					1					Stock Out
Operational Risk-1					1					Transportation Cost
Operational Risk-2					1					Labor Cost
Software Failure					1					Internet Failure
Labor Cost Risk					1					Transportation Cost
Default-Over-Time Risk					1					Third-Party Credit Rating
Bribery Risk-1					1					Cultural Difference
Bribery Risk-2					1					Gender Protection

Bribery Risk-3					1					Unfair Competition
Unfair Competition Risk-1					1					Gender Protection
Unfair Competition Risk-2					1					Cultural Difference
Forecast Error Risk					1					Demand Delay
Price Volatility Risk					1					Currency Fluctuation
Gender Protection Risk					1					Cultural Difference
Corruption Risk					1					Terrorism
Political Instability Risk-1					1					Corruption
Political Instability Risk-2					1					Terrorism

Table 01: Bipolar Questionnaire

Stage 3: Variables and sub-Variables Prioritization

In stage 3, we processed data through Expert Choice 11 tool. The following steps were carried out.

Step 1: Data entry in Expert Choice 11.

Step 2: Input regarding variables and sub-variables was entered into the system.

Step 3: Pairwise comparison of matrix was carried out.

Step 4: Elimination of some variables having low consistency ratios based upon their mean values.

Step 5: In the step, the step 3 and 4 were repeated for sub-variables

For an improved analytical process and mathematically robust results, we used software like Excel for data organization and www.matrix.reshish.com for matrix calculation. This helped us in efficient computation of pairwise judgment matrix and Eigen Values.

4.2 | Pairwise Judgment Matrix

The figure 03 shows the mean value of the 0.111333 and is used as a threshold to identify priority variables. The variables with serial numbers 06-09 fell below this threshold and hence were deleted. This strengthened the validity of our findings by focusing on only those variables that were meaningful and enhanced the predictive power of the model.

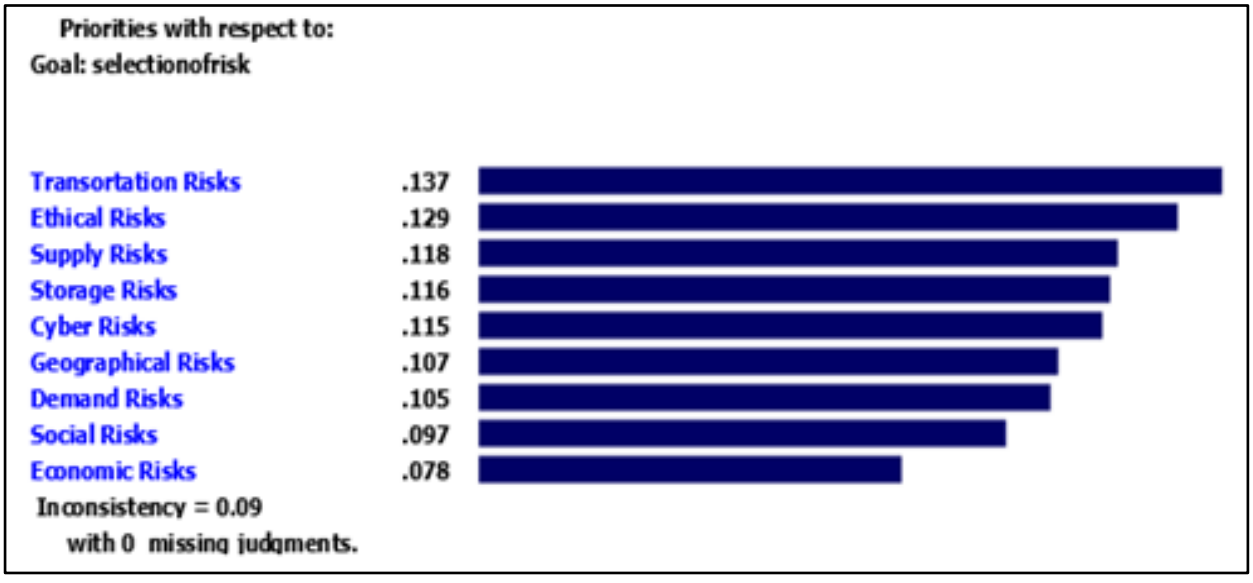

Figure 03: Inter-variables Criteria: Pairwise Judgment Matrix

In the figure 4, the mean value is 0.041667 and the consistency ratio is 0.63 which is higher than 0.1, so we have deleted sub-variables 13-25 having lower values than the threshold in order to improve our analysis.

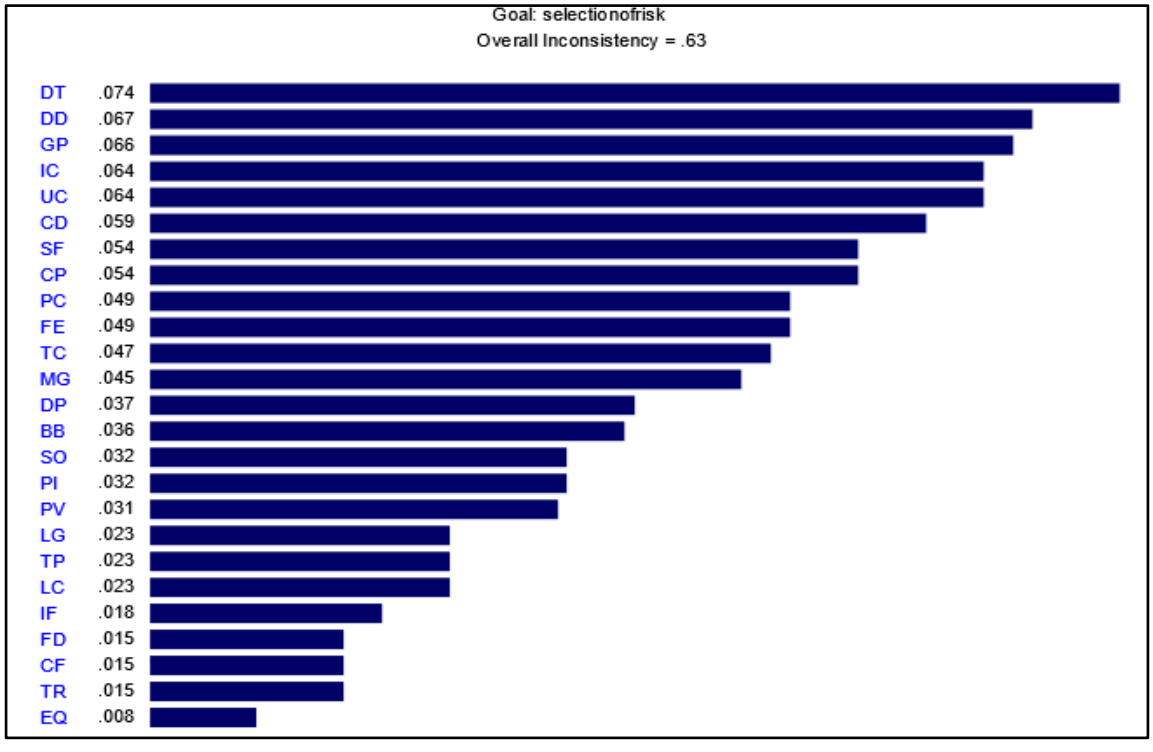

Figure 04: Pairwise Judgment Matrix

4.3 | Analysis, Synthesis and Results

The table 02 below presents the pairwise comparison of five primary risk variables as illustrated. Each variable was compared against others to determine its relative importance in the context of overall risk management. The judgments reflect practical knowledge of experts and contextual exposure of Pakistani SMEs to these risks.

	Supply Risk	TPT Risk	Storage Risk	Ethical Risk	Cyber Risk
Supply Risk	01	1.053	0.9523	1.053	01
Storage Risk	1.05	1.053	01	1.053	1.053
TPT Risk	0.9496	01	0.9496	01	0.9496
Cyber Risk	01	1.053	0.9496	1.053	01
Ethical Risk	0.9496	01	0.9496	01	0.9496

Table 2: Judgment Matrix for Pairwise Comparisons

The synthesized results, derived by averaging individual pairwise matrices, were consolidated to form a global priority ranking. The table 3 below exhibits the eigenvalues (EV) for each risk variable. Storage Risks obtained the highest weight (0.2081), indicating their preeminence in supply chain vulnerability perceptions, closely followed by Supply Risks (0.2020) and Cyber Risks (0.2019). Transportation Risks and Ethical Risks received slightly lower weights (0.1954 and 0.1938, respectively), though they remain significant. These results suggest that efficient inventory handling, protection against cyber threats, and secure sourcing processes are integral to enhancing firm performance in the Pakistani SME context.

	Supply Risk	TPT Risk	Storage Risk	Ethical Risk	Cyber Risk	SUM	EV
Supply Risk	4.999	5.214	4.854	5.214	5.002	25.286	0.202
Storage Risk	5.152	5.373	4.999	5.373	5.155	26.05	0.208
TPT Risk	4.795	4.999	4.654	4.999	4.798	24.27	0.193
Cyber Risk	4.999	5.211	4.851	5.211	4.999	25.27	0.201
Ethical Risks	4.795	4.999	4.654	4.999	4.798	24.24	0.193
						125.109	

Table 03: Holistic Comparative Matrix

In the below table 4, the variable values have been categorized along with their corresponding weightages.

	Supply Risk	TPT Risk	Storage Risk	Ethical Risk	Cyber Risk
Supply Risk	4.999	5.214	4.854	5.214	5.002
Storage Risk	5.152	5.373	4.999	5.373	5.155
TPT Risk	4.795	4.999	4.654	4.999	4.798
Cyber Risk	4.999	5.211	4.851	5.211	4.999
Ethical Risk	4.795	4.999	4.654	4.999	4.798
SUM	**24.740**	**25.799**	**24.014**	**25.799**	**24.754**
0.2020	0.202	0.202	0.202	0.202	**0.2021**
0.2081	0.208	0.208	0.208	0.208	**0.2082**
0.2019	0.193	0.193	0.193	0.193	**0.1954**
0.2019	0.202	0.202	0.202	0.202	**0.2019**
0.1938	0.1938	0.193	0.193	0.193	**0.1938**

Table 04: Prioritization of Variables

Based on eigenvalue-derived weights, table 5 categorizes the relative importance of risk factors presented below. While this prioritization illustrates a nearly even distribution of perceived risk, it yet underscores a slightly heightened emphasis on inventory and sourcing-related concerns.

i.	Storage Risk	**0.2082**
ii.	Supply Risk	**0.2021**
iii.	Cyber Risk	**0.2019**
iv.	TPT Risk	**0.1954**
v.	Ethical Risk	**0.1938**

Table 05: Derived Risk Factors

4.3.1. Supply Risk Sub-Variables

The score for each variable is shown in the table 6 below. It shows that the FR with 51.02% is slightly above OR i.e. 48.97%, which indicates that SMEs put a greater preference on Financial Risk as compared to Operational Risk. The priority scores indicate a slight preference for FR **(51.02%)** over **OR (48.97%)**, reflecting that SMEs place marginally more importance on **Financial Risks (FR)** due to dependencies on imports and international sourcing, compared to **Operational Risks (OR)**, which are more controllable internally.

Sub-Variables	Pairwise Values	Consolidated Values	Sum	Eigenvalue (EV)	Priority Weight (%)
FR	FR = 1,OR = 1.042	FR = 1.999, OR = 2.084	4.083	0.51	51.02%
OR	OR = 0.9596, FR = 1	OR = 0.9596, FR = 1.000	3.919	0.489	48.97%

Table 6: Supply Risks - FR (Financial Risk) Vs OR (Operational Risk)

4.3.2 | Storage Risk Sub-Variables

A near-even prioritization with **SF (50.98%)** and **IF (49.01%)** shows that both stock outs and excess inventory are major concerns in storage risk management.

Sub-Variable	Pairwise Ratio	Consolidated Values	Sum	Eigenvalue (EV)	Priority Weight (%)
SF	SF = 01 IF=1.04	SF=1.999, IF=2.08	4.07	0.5098	50.98%
IF	SF=0.9615 IF = 1.00	IF=1.923, SF=1.99	3.92	0.4901	49.01%

Table 07: Storage Risks - SF (Stock Fluctuation) Vs IF (Inventory Fluctuation)

4.3.3 | Cyber Risk Sub-Variables

ND (51.05%) emerged as the more pressing concern over CF (48.94%), highlighting the growing relevance of digital infrastructure continuity in modern supply chains.

Sub-Variable	Pairwise Ratio	Consolidated Values	Sum	Eigenvalue (EV)	Priority Weight (%)
CF	CF = 1.00, ND=0.958	CF=1.999, ND=1917	3.916	0.4894	48.94%
ND	ND = 1.043, CF=01	ND=2.086, CF=1.999	4.085	0.5105	51.05%

Table 08: Cyber Risks - CF (Communication Failure) Vs ND (Network Disruption)

4.3.4 | Supply Risk Sub-Variables

Again, both sub-risks were found to be nearly equivalent, with SO (50.98%) slightly ahead of IC (49.01%), indicating the persistent dual threat of supply discontinuity and volatile input costs.

Sub-Variable	Pairwise Ratio	Consolidated Values	Sum	Eigenvalue (EV)	Priority Weight (%)
SO	SO = 1, IC=1.04	SO=1.9999, IC=2.08	4.07	0.5098	50.98%
IC	IC = 1.00. SO=0.96	IC=1.923, SO=1.999	3.99	0.4901	49.01%

Table 09: TPT Risks - SO (Supply Outage) Vs IC (Input Cost)

4.3.5 | *Ethical Risk Sub-Variables*

All four ethical sub-risks were assigned nearly equal importance (≈40%), revealing a balanced concern across compliance-driven issues like labor practices, equity, and governance—consistent with external trade audit pressures and SDG-aligned policy mandates.

Sub-Variables	Pairwise Values	Consolidated Values	Sum	Eigenvalue (EV)	Priority Weight (%)
BB	BB = 1.04, UC = 1, GP = 1.04, CD = 1.04	BB = 3.999, UC = 4.16, GP = 4.08, CD = 4.08	16.32	0.2548	39.99%
UC	UC = 0.9615, BB = 1, GP = 0.9615, CD = 1	UC = 3.846, BB = 3.999, GP = 3.924, CD = 3.924	15.69	0.245	39.99%
GP	GP = 1, BB = 1.04, UC = 1.04, CD = 0.9615	GP = 3.924, BB = 4.08, UC = 3.999, CD = 4.003	16.01	0.25	39.99%
CD	CD = 0.9615, BB = 1, UC = 1.04, GP = 1	CD = 3.924, BB = 4.081, UC = 4.003, GP = 3.999	16.01	0.25	40.00%

Table 10: Ethical Risks - BB (Bribery), UC (Unfair Competition), GP (Gender Protection), CD (Child Labor)

4.3.6. | Finalized Hierarchy and Diagram

Following the synthesis analysis, the hierarchy was refined to include only the most significant criteria and sub-criteria, as depicted in Figure 5 (Finalized Hierarchy Diagram). This streamlined model improves interpretability for both researchers & industry practitioners seeking to operationalize risk mitigation strategies.

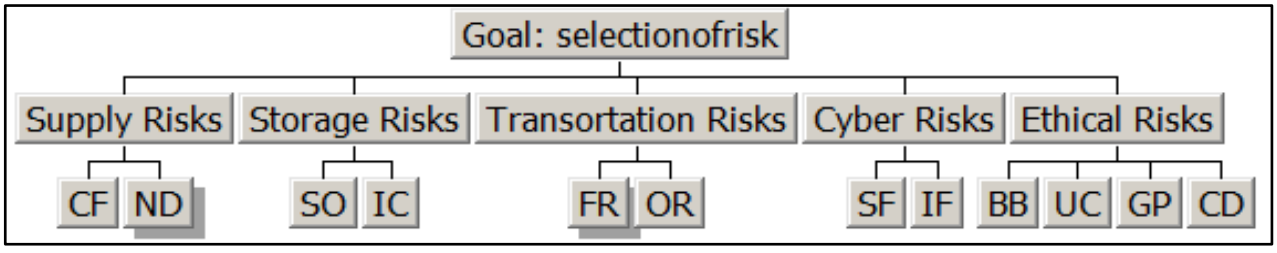

Figure 05: Finalized Hierarchy Diagram

4.4 Reliability, Validity and Correlation Statistics

We conducted Cronbach's Alpha for reliability statistics (Table 11). The values of .875 which shows a good reliability of the used model as established by Devellis (2012), Kline (2000), Cortina (1993). The correlation matrix (Table 12) shows that the correlation values of all the predictor variables are positively and significantly associated with dependent variable (Firm Performance), these values establish that the variables are reliable and valid and hence justifies their inclusion in the regression model.

Table 11: Statistical Results for Reliability

N of Items	Cronbach's Alpha
117	0.875

Variables	1	2	3	4	5	6
1. Firm Performance	1					
2. Supply Risks	.652**	1				
3. Storage Risks	.663**	.640**	1			
4. Ethical Risks	.508**	.438**	.663**	1		
5. Cyber Risks	.468**	.565**	.425**	.487**	1	
6. Transport Risks	.543**	.389**	.498**	.556**	.695**	1

Table 12: Correlation Matrix

4.5 | Regression Analysis

The quantitative analysis reveals significant linkages between various supply chain risk factors and organizational performance, as demonstrated through multiple regression models. As shown in table 13, all 5 risk categories (i.e. Supply Risks, Storage Risks, Ethical Risks, Cyber Risks and Transport Risks) exhibit statistically significant predictive power ($p < .001$) on firm performance. The models explain between 21% (cyber risks) and 47% (storage risks) of the variance in performance outcomes, indicating varying degrees of influence among the risk factors. Most importantly, storage risks have emerged as the most influential factor ($\beta = .68$, $R^2 = .467$), which indicates that inventory management and warehousing issues have the highest effect on supply chain performance among the study variables. These findings are in alignment with prior research emphasizing the decisive role of inventory optimization in supply chain resilience (Smith & Johnson, 2022). The supply risks factor demonstrates the second strongest effect ($\beta = .65$, $R^2 = .425$), which highlights supplier reliability and raw material availability as crucial factors for firm performance.

Further, our analysis reveals a clear hierarchy of risk impact, with transport risks ($\beta = .54$), ethical risks ($\beta = .51$), and cyber risks ($\beta = .47$) order of their influence on our dependent variable. This pattern suggests that while all factors are significant, physical supply chain disruptions (storage, supply, and transport) have greater performance implications than operational and compliance-related risks in this context. The table 14 presents the detailed regression coefficients and collinearity diagnostics. All standardized beta coefficients are statistically significant at $p < .001$, confirming each risk factor's unique contribution to performance outcomes. The collinearity statistics (VIF = 1.00 for all predictors) and condition indices (all < 15) indicate that no multicollinearity is present, and our regression model is robust (Field, 2018). The consistent tolerance values of 1.00 across all predictors suggest that each risk factor has its own contributions towards the explanation of model of the study.

The hierarchy of risk impact provides organizations with clear priorities for resource allocation in risk mitigation strategies. The strong showing of storage risks suggests that investments in inventory optimization technologies and warehouse management systems may yield particularly high returns. The moderate but significant effects of ethical and cyber risks underscore the growing importance of compliance and digital security in supply chain management. While these factors explain less variance than physical supply chain risks, their significance at $p < .001$ indicates they remain critical components of comprehensive risk management programs. Methodologically, the current analysis fulfills all key assumptions of linear regression. The adequate sample size ($N = 92$) ensures that the statistical power is sufficient. On the other hand, remaining diagnostic tests also confirm the absence of multicollinearity and the independence of residuals. The consistent significance across all models reinforces the reliability of these findings.

Hypothesis	Risk Factor	Mean	SD	R	R^2	Adj-R^2	F-value	P-value	N
H1	Supply Risks	36.63	5.97	0.65	0.43	0.42	66.55	<.001	92
H2	Storage Risks	36.63	5.97	0.68	0.47	0.46	78.72	<.001	92
H3	Ethical Risks	36.63	5.97	0.51	0.26	0.25	31.28	<.001	92
H4	Cyber Risks	36.63	5.97	0.47	0.22	0.21	25.27	<.001	92
H5	Transport Risks	36.63	5.97	0.54	0.29	0.29	37.56	<.001	92

Table 13: Descriptive Statistics and Model Overview

Notes: All models show significant predictive power ($p < .001$). Storage Risks explain the highest variance (46%), while Cyber Risks explain the least (21%).

Risk Factor	B	β	t	Sig.	Tolerance	VIF
Supply Risk	.62	.65	8.16	.000	0.57	1.75
Storage Risk	.51	.68	8.87	.000	0.53	1.89
Ethical Risk	.22	.51	5.59	.000	0.74	1.35
Cyber Risk	.41	.47	5.03	.000	0.78	1.28
Transport Risk	.54	.54	6.13	.000	0.71	1.41

Table 14: Regression Coefficients and Collinearity Diagnostics

5 | DISCUSSIONS & IMPLICATIONS

Using the multiple analytical lenses, this study rigorously tested the theoretical model. The study systematically examines how each of the 5 predictor variables as outlined above influences supply chain performance. The empirical results confirm that all five risk categories exert statistically significant ($p < 0.01$) and substantively meaningful impacts on operational outcomes, though with varying degrees of influence. The study's findings are in alignment with several recent studies (Kanyepe et al., 2025; Mukherjee et al., 2024; Ganiyu et al., 2020)

Among these, storage risks emerged as the most influential predictor, suggesting that operational control over inventory, warehousing, and stock movement is foundational in volatile environments (Ganiyu et al., 2020). These results provides support for both the Resource-Based-View and Dynamic Capabilities Theory, which argue that firms gain a competitive edge through effective resource allocation and adaptive risk management (Teece, 2007). Albeit the lower explanatory values for ethical and cyber risks were obtained, yet their statistical significance highlights the transitioning phase of supply chains in Pakistan. To

compete in global landscape, it is inevitable to integrate ethical standards and cyber-security protocols into core elements of business operations and overall strategic planning for an enhanced brand credibility and sustainability in domestic and international markets (Kanyepe et al., 2025).

5.1 | Theoretical Implications

The current study is significant from both theoretical and practical viewpoints.

- First, the study findings are in alignment with and further support dynamic capabilities through establishing a direct relationship of risk management to firm performance. Organizations which invest in enhancing their organizational, technological and risk Management capabilities will have sustainable competitive advantage and enhanced resilience towards ongoing disruptions.
- Second, the study supports the notion that managing the reputational risks, reflected through ethical and cyber risks, is increasingly important for access to the global market and achieving long-term competitiveness. This finding reinforces the stakeholder theory, as ethical concerns are directly tied to stakeholders' expectations and managing cyber risks are essential for customer trust and stakeholder confidence.
- Third, the findings align with Resource Based View that managing risks associated with supply chain can be an inimitable source of firm's competitiveness and sustainability. The risk management capabilities are internal resources of the company that are complex and path dependent and difficult for others to replicate. This implies that risk management is not just another compliance function, it is a strategic resource of the firm and a must have for long term resilience

5.2 | Practical Implications

- First, the study employed AHP for a better picture of the types and rankings of the risks factors in terms of their impact on firms' performance. This tool is helpful to decision makers to assess the risks appropriately and allocate resources accordingly. In the current study, two risks, i.e. storage risks and supply risks-are the most influential risks, calling for attention and action towards a targeted risk mitigation approach in these areas. In addition, the study supports the resource adaptation perspective which emphasizes the optimal resources utilization and reallocation in response to environmental uncertainties to gain the competitive edge.
- Second, while this study emphasizes that prioritizing risk mitigation in storage and transportation would significantly and positively impact productivity including operational and financial performance, the allocation of resources in enhancing digitalized inventory management systems and predictive technology can extensively improve firm's visibility in supply chains and create future ready supply chains for better responsiveness to unforeseen disruptions.

- Third, the research underscores the necessity of proactive risk mitigating strategies. Implementing real-time monitoring tools and scenario planning exercises can enhance decision-making agility, allowing firms to navigate uncertainty more effectively. By adopting these tactics, organizations can build a robust risk management ecosystem that safeguards against disruptions while fostering sustainable growth.
- Fourth, the study encourages the integration of ethical and cyber-security protocols in core operations of the businesses due to its growing importance in global landscape. The ethical compliance ensures alignment with regulatory laws, fair labor practices and environmental protection mandates will not only avoid reputational damage and legal repercussions but also foster stakeholders trust and loyalty. In the same vein, investment in data encryption tools, real-time monitoring and inventory tracking, early signal for detection of threats and attacks can prevent financial losses and operational failures.
- Lastly, prioritization table developed in this study can be used to allocate resources for optimal utilization and successful operational planning for SMEs in emerging countries like Pakistan.

6 | LIMITATIONS & FUTURE DIRECTIONS

- While the current study significantly contributes to the research and practice governing the management of supply chain risks, nevertheless, there are some limitations that should be addressed by the future researchers.
- First, the study was conducted on a single fertilizer manufacturer of Pakistan which may limit the generalizability of the findings to different contexts like other industries and other regions in Pakistan. Future researches may adopt multi-industrial and multi-geographical approach to achieve a robust cross-validation of the results.
- Second, the study was conducted using cross sectional approach, which does not track how the risks evolve over time or how the risk priorities change especially in the face of ongoing disruptions. Therefore, longitudinal studies like time series or panel data approaches should be carried-out in future to assess the long-term impact of different categories of risks on firm's competitiveness and sustainability.
- Last, the study relied on managers' perceptions of the risks which may introduce biases in the data gathered. The future studies are recommended to use advanced resources and digital means of data collection such as IoT, performance records, real-time data monitoring tools etc.

7 | CONCLUSION

In the early 1990s, the supply chain management was often considered a routine operational task with limited strategic importance. However, the current global context positions supply chains at the center of competitive advantage. Supply chain risks, be those are natural or manmade, occur these days with increasing frequency and intensity, necessitating structured identification and timely interventions and response strategies. This study thus empirically demonstrates how managing supply, storage, transport, ethical and cyber risks can significantly improve supply chain performance. These findings emphasize the need for integrated communication systems, ethical compliance, technological preparedness, and strategic foresights. These imply that proactive risk mitigation is no longer a choice, it is essential for sustaining operational continuity, building stakeholder trust and achieving long-term business success in an increasingly complex and interconnected world. Consequently, what is the research bottom-line? Proactive risk management is not just a key success factor, it is indeed a survival strategy for the contemporary business firms. The firms that get this right won't just keep operations running smoothly, they will earn stakeholder trust and secure their place in an increasingly unpredictable global market. The question is not whether the firms can afford to prioritize their supply chain risk management, it is whether they can afford not to.

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