UNDERSTANDING THE RELATIONSHIP BETWEEN SUPPLY CHAIN RISK AND LEAN OPERATIONS PERFORMANCE

Alsmairat M.A.K, Mushtaha A. S, Hammad M. S. A.[*]

Abstract: The main purpose of this study is to examine the effect of supply chain (SC) risk on lean operation performance (LOP) along with the role of supply chain resilience (SCR) as a mediator in this relationship among manufacturing companies. A quantitative approach was employed to investigate how supplier, demand, and transportation risks impact lean operations performance through the mediation of SCR. This study involved conducting an online survey of 255 manufacturing companies in the Middle East. The researchers used a hypothesis-testing deductive approach to test their conceptual model, and the results were analyzed using Smart PLS software. These findings indicate that supplier, demand, and transportation risks significantly affect SCR. Moreover, a direct path effect was found between SC risk and lean operational performance. This study emphasizes the relationship between SCR and its mediating effect on SC risk mitigation and lean operations performance. Through empirical evidence, this study demonstrated that SCR is a crucial characteristic of logistics that can aid in mediating the association between SC risk mitigation and lean operational performance. It provides valuable insights for managers, policymakers, and stakeholders regarding the significance of implementing these three enablers to enhance lean operational performance in manufacturing firms. This study presents a unique perspective on the mediating role of SC resilience in the Middle East, which has not been extensively studied in the literature. The findings could provide insights for practitioners in the region to enhance their SC risk management and lean operation performance.

Keywords: Supply chain risk, Lean Operations, Performance, Supply Chain Resilience

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Introduction

The recent focus on SC and SCR is due to the impact of globalization and global pandemics on manufacturing firms (Alkhatib, 2022). The integration of the overall SC has become essential for firms seeking to optimize resource utilization, enhance their capabilities, and guarantee business continuity. SCM encompasses all activities related to the flow of goods, money, and information aimed at managing these resources efficiently across organizations. Although SCM aims to improve the flow of goods and increase profitability, risks are associated with each operation due to undefined and unclear information disrupting SC operations (Al-Shboul and Alsmairat, 2023). Thus, SCR has emerged as an essential factor for mitigating SC disruptions and limiting their effects that do occur.

All firms encounter multiple risks that disrupt information flow. SCs are particularly susceptible to external and internal disruptions, including economic downturns, the loss of valued customers, inadequate technology, and unsatisfactory infrastructure quality. These disruptions can threaten the LOP in various areas within the SC. Additionally, firms function in an intensely competitive business environment that exposes SC to various challenges that negatively affect markets, industries, and future growth prospects. While some disruptions may be manageable, others may be more challenging and significantly affect the functioning of both the firm and SC (Abeysekara et al., 2019). LOP refers to the efficiency and effectiveness of a firm's manufacturing process. This involves the elimination of waste, improvement of process flow, and reduction of lead time. The concept of lean operations has been widely adopted by manufacturing firms globally, enabling them to produce high-quality goods at lower costs while maintaining customer satisfaction (Hernandez-Matias et al., 2020). Therefore, focusing on LOP is crucial for manufacturing firms seeking to improve their profitability and competitive advantage. However, LOP is vulnerable to disruptions within the SC, such as delays in material delivery or unexpected changes in demand. These disruptions can lead to a decline in productivity, increased lead time, and lower product quality, ultimately affecting a firm's profitability and customer satisfaction (Park, 2022). Therefore, studying SC risk management and its effect on LOP is critical for manufacturing firms seeking to mitigate the effects of disruptions on their operations.

The COVID-19 pandemic has significantly affected manufacturing SCs, resulting in negative consequences, including limited transportation, supply shortages, and impermanent shutdowns of manufacturing sites (Alsmairat, 2021), which hinder the continuation of manufacturing processes. The severity of this outbreak made it challenging to control and predict SCM. The World Economic Forum (2020) reported that COVID-19 had an overall negative economic impact, resulting in the loss of billions of dollars worldwide. Moreover, it is difficult to predict the overall duration of these

losses. Additionally, businesses lack the necessary awareness and knowledge to manage the COVID-19 crisis and maintain resilience in SCs (Belhadi et al., 2021).

Therefore, SCR denotes an SC's ability to either prevent or withstand the effects of instability. This can be achieved by reducing the consequences of disruptions and restoring LOP levels to normal operations at minimal costs (Hosseini et al., 2019). Manufacturing companies face continuous challenges that require them to constantly enhance their SC risk-management approaches. To remain successful in the long term, companies must implement both reactive and proactive approaches to strengthen their SCR (Belhadi et al., 2021). This will enable them to better navigate economic crises, as companies with robust SC are better equipped to manage large-scale disruptions. The significance of building SCR cannot be overstated, and companies that invest in this area are likely to be more successful in the long term (Pettit et al., 2019).

The relationship between SC risk management and LOP has been studied extensively in developed countries, where firms have implemented advanced SC risk management practices to improve their operational efficiency and effectiveness. However, little attention has been paid to developing nations, where firms face different risks and challenges. The manufacturing industry in the Middle East is particularly vulnerable to disruptions owing to geopolitical tensions, economic instability, and limited infrastructure. Therefore, studying the relationship between SC risk management and LOP is crucial for firms seeking to improve their operations and maintain business continuity.

Developing countries are integral to the global SC but are often exposed to various disruptions and risks due to cultural, economic, and political factors (Tukamuhabwa et al., 2017). However, SCR and disruptions have not been thoroughly explored in developing countries (Alkhatib, 2022). Previously, the correlation between SCR and LOP was predominant in developed nations, while little attention has been given to developing nations. Consequently, this study seeks to fill this gap by analyzing the relationship between SC risk management and LOP within the manufacturing industry in the Middle East, as explained below.

- Although the relationship between SC risk management and LOP has been studied extensively in developed countries, little attention has been paid to developing nations.

- Specifically, research exploring the correlation between SC risk management and disruptions in developing countries, including the manufacturing industry in the Middle East, is lacking.

- The manufacturing industry in the Middle East is vulnerable to disruptions owing to geopolitical tensions, economic instability, and limited infrastructure, making it an important context to study.

• This study aims to fill this gap by analyzing the relationship between SC risk management and LOP in the manufacturing industry in the Middle East and identifying the best practices for improving LOP.

This study aims to determine how effective SCR practices can mediate and mitigate risks in this particular context. By addressing this gap, this study contributes to a more comprehensive understanding of SCM in the region and identifies the best practices for improving LOP.

Literature Review and Hypothesis Development

Building resilient SCs requires more than just the ability to resist and recover from disruptions. Modern SC technologies and processes are necessary to rapidly predict and respond to various opportunities and risks. The significance of SCR is underscored by external and internal disruptions faced by SCs caused by human or environmental factors, resulting in weaknesses owing to the increased complexity of global interactions. Various disruptions, such as natural disasters, technological changes, supplier failures, and political instability, can potentially harm SCs and lead to significant financial and operational losses or even complete disruption (Tukamuhabwa et al., 2017). Such disruptions can also trigger a chain reaction of negative impacts that spread across the SC, known as ripple effects (Kinra et al., 2020).

SCR involves the capability to adapt, persevere, and expand while navigating tumultuous alterations in sourcing different products and services along with their delivery (Hasani and Khosrojerdi, 2016). Thus, resilience is essential in an organizational setting where SC risks, and uncertainties are significant, as it helps minimize ripple effects and reduce SC vulnerability, ultimately enhancing LOP (Dubey et al., 2021).

SC risk mitigation is an organizational effort that uses qualitative and quantitative methodologies to identify, evaluate, and mitigate unexpected conditions/events that negatively affect any part of the SC. Ho et al. (2015) state that the four functions of SC risk management are risk detection, estimation, observation and modification. The ultimate aim of SC risk management is to develop strategies to help manage and mitigate SC risks by conducting risk reviews and ensuring survival. In summary, SC risk management is a crucial process that minimizes the impact of risks and ensures SC endurance of SC (Simba et al., 2017).

In the management of SC, various risks exist that may affect sourcing, manufacturing, and delivery processes. These risks may include issues related to the quality of materials and relationships, production capacity and costs, logistics costs, and inventory disruption. To address these risks, it is necessary to implement effective processes to identify, assess, mitigate, and monitor SC risk. Effective SC risk-management practices include clear communication between all parties associated with the SC, providing

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training programs for risk management and business stability, and establishing a Chief Risk Officer. Additionally, it is important to conduct regular reviews of SC risks to minimize liability and ensure the continued success of SC.

In the realm of SC risk management, various practices can be implemented to mitigate risks effectively. Two effective practices are sharing risk information and risk mechanisms (Li et al., 2015). Common practices include identifying, evaluating, monitoring, and mitigating risks (Ho et al., 2015; Simba et al., 2017). Wagner and Bode (2009) operationalized risk management practices in terms of risk causes and effects. Risk causes denote activities aimed at reducing the possibility of risk occurring, while risk effects refer to activities aimed at minimizing the impact of risks that do occur. These practices are essential for promoting SCR that can withstand and recover from various disruptions.

Wagner and Bode (2009) argued that SC risk management practices could be split into cause-directed and effect-focused activities. Cause-directed activities are preventive measures aimed at reducing the probability of risk occurrence. These activities include switching to financially stable suppliers, relocating production processes to safe regions, and providing employees with training to improve information security. On the other hand, effect-focused activities are contingency measures that aim to mitigate the consequences of risks. These activities can include diversifying the sourcing portfolio to increase the resilience of the SC and designing standardized products to enhance the firm's capability to cope with demand and supply uncertainties.

Various studies have highlighted the positive impact of SC risk-management processes on SCR. For instance, Simba et al. (2017) investigated the grocery industry and revealed that managing SC risks through risk detection, evaluation and moderation could enhance the SCR. In their research, Can Saglam et al. (2021) observed the impact of risk mitigation strategies, such as SC flexibility, SC risk management performance, and SCR. They found that SC responsiveness and resilience had a notable impact on SC risk management performance, implying that SC risk management might affect SCR and sustainability. Their findings provide insights into how firms can improve their SC risk management strategies to enhance their SCRS.

Another area of the literature focuses on the significance of innovative information technology solutions, such as the Internet of Things (IoT), to tackle SC challenges. Ben-Daya et al. (2022) argued that practical knowledge produced by IoT helps companies identify and resolve problems early, respond quickly to unexpected disruptions, acquire real-time data for decision-making, enhance SC visibility and agility, and improve SC organization. Li and Li (2017) emphasized the IoT's significance in distributing and analyzing data, matching supply and demand, improving quality, and integrating logistics.

After analyzing the studies mentioned above, it can be assumed that implementing SC risk management practices can improve SCR. Therefore, it is hypothesized that SC risk management practices positively influence SCRS.

- *H1: Supplier risk directly impacts supply chain resilience in manufacturing sector in the middle east region.*
- *H2: Demand risk directly impacts supply chain resilience in manufacturing sector in the middle east region.*
- *H3: Transportation risk directly impacts supply chain resilience in manufacturing sector in the middle east region.*

Previous research has focused on SC risk-mitigation practices. According to Pettit et al. (2019), there are three potential solutions for SCs to enhance resilience. One solution involves implementing tracking technology to help one learn from past experiences and adapt to risks and pressures. The second solution is shared values and building trust among individuals associated with SC. The third solution involves identifying weaknesses in the SC because vulnerabilities can occur anytime. Tukamuhabwa et al. (2017) identified four main SCR strategies: enhancing flexibility, creating redundancy, promoting SC collaboration, and strengthening supply chain agility.

Zhuo et al. (2021) identified the main dimensions of SCR for improving the SC risk management process. These dimensions included preparedness, response, adaptation, and recovery. In addition, some firms may be involved in different SC integration activities to gain financial benefits by reducing SC-associated risks (Jajja et al., 2018). Previous studies have also suggested the main potential strategies to enhance SCR, namely, initiative-taking and reactive strategies (Tukamuhabwa et al., 2017; Belhadi et al., 2021). To achieve these strategies, it is essential to develop capabilities that have long-lasting positive effects on SCR (Belhadi et al., 2021).

The ability of SCR to minimize the probability of encountering unforeseen disturbances, prevent them from spreading by managing structures and functions, recuperate from them, and act swiftly and efficiently to execute reactive plans for managing disruptions and restoring SC to its normal state of operation is believed to have a direct positive effect on LOP (Kamalahmadi and Parast, 2016). Chowdhury et al. (2019) investigate how SCR can improve the LOP of manufacturing firms in Bangladesh by studying the operating context. They found a moderate relationship between SCR and LOP, indicating that SCR positively affected LOP. Thus, we propose the following hypothesis:

- *H4: Supply chain resilience directly impacts Lean Operations Performance in manufacturing sector in the middle east region.*

The problem of SC interruption has been exacerbated by the current unpredictable circumstances and conditions. Such interruptions refer to any disturbance within or outside the SC that disrupts the flow of products and services. With the growing

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occurrence and intensity of these disruptions, ensuring SCR has become an essential requirement for managing SC (Pettit et al., 2019; Sabahi and Parast, 2020).

As defined by Alsmairat (2023), resilience pertains to a system's capacity to withstand changes. Resilience pertains to the ability of the SC to restore normal operations within a reasonable timeframe after any sort of disruption (Brandon-Jones et al., 2014). SCR can be achieved using a three-phase process. The first phase is anticipation, which involves proactive planning to identify potential risks and challenges that may evolve in the future. The second phase is resistance, which focuses on maintaining the integrity and functionality of SC. This phase aims to prevent or minimize disruptions that may occur. Finally, response and recovery involve efficient and rapid actions to address disruptions, as stated by Kamalahmadi and Parast (2016).

Disruptions in SC significantly affect their smooth functioning as they interrupt the flow of finances and knowledge, ultimately resulting in decreased competitiveness and efficiency (Ramezankhani et al., 2018). To mitigate the negative consequences of such disruptions, it is essential to have an effective and prompt response. In this regard, SCR plays a crucial role not only in preventing the impact of disruptions but also in restoring the SC's performance to a desirable level within a reasonable timeframe (Wieland and Wallenburg, 2013).

Given the unpredictable and constantly changing business environment, SCR is no longer just an option but has evolved as a necessity (Gölgeci and Kuivalainen, 2020). Previous studies have demonstrated a positive correlation between resilience and LOP dimensions (Liu and Lee, 2018). Furthermore, Chowdhury et al. (2019) argued for using the SCR scale in predicting the operational vulnerability and overall performance of an SC.

According to Altay et al. (2018), an SC's ability to withstand and then recuperate from disruptions is a continuously evolving capability that significantly affects the SC LOP. This capacity for resilience enables the SC to quickly execute its business processes during disruptions, ensuring that services are delivered efficiently to fulfill customer demands (Liu and Lee, 2018). This not only results in satisfied customers but also leads to improved financial performance due to enhanced customer service and profitability (Wieland and Wallenburg, 2013).

Jain et al. (2017) expanded the concept of resilience capability in SCs using a set of 13 items. Several critical factors contribute to resilient SC. These factors include the SC's capability to adapt to changing circumstances, strong collaboration and trust among all players, a focus on sustainability throughout the SC, sharing of risks and revenues, open communication and information sharing, a strong and efficient SC structure, sensitivity to market conditions, agility in responding to changing situations, increased levels of visibility in the SC, a culture of risk management and preparedness, efforts to minimize uncertainty and technological abilities among SC partners. By prioritizing these factors,

companies can build resilient SC that is better equipped to withstand disruptions and maintain high levels of LOP.

Brusset and Teller (2017) identified four variables that determine different levels of resilience capability in an SC: evaluation of process vulnerabilities, deployment of alternative plans for risk mitigation, assessment of risk levels, and enhanced visibility across SC. Strong SCR capability is widely viewed as a crucial factor that allows businesses to adapt effectively to potential risks and disruptions. Additionally, the mediating effect of SCR is predicted to be more influential in shaping outcomes than the direct effect of SC risk on resilience. This underscores the significance of developing robust SCR capabilities to minimize the negative impacts of disruptions and risks on the overall LOP. Therefore, given the recognition of resilience capability as a significant factor in reducing SC risks and enhancing resilience, the following hypothesis is proposed.

- **H5:** *SCR mediates the relationship between Supplier risk and lean operations performance in manufacturing sector in the middle east region.*
- **H6:** *SCR mediates the relationship between Demand risk and lean operations performance in manufacturing sector in the middle east region.*
- **H7:** *SCR mediates the relationship between Transportation risk and lean operations performance in manufacturing sector in the middle east region.*

Considering the aforementioned literature, the current study has conceptualized the relationship between SC risk mitigation and the LOP of manufacturing industries in the Middle East, with SCR as a mediator (Figure 1).
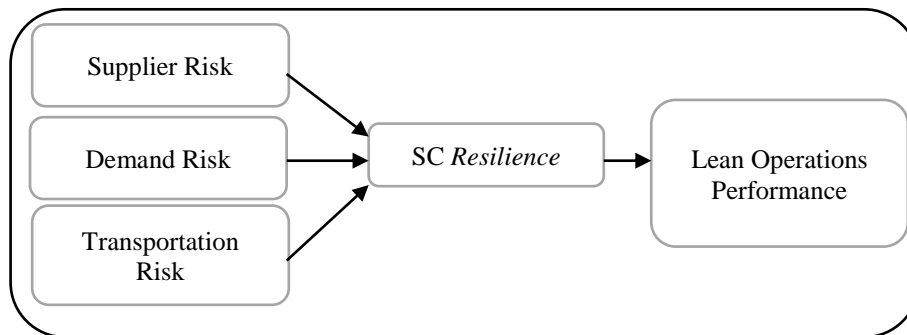

Figure 1: Theoretical Model of the Research

Research Methodology

Literature on SC risk, SC resilience, OL and Lean Operations Performance was reviewed to identify the measurement scale. A structured modified survey was conducted. Data were collected using a conventional sampling technique. The target population

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comprised various manufacturing firms in the Middle East, specifically in Jordan, the UAE, Saudi Arabia and Kuwait. The target sample of this study was operations managers, logistics managers, and SC specialists at both the middle and top levels of the organization, who knew about the SC activities and operational processes of their firms. The study sample was drawn from a list of industrial firms registered with the Chamber of Industries in the respective countries. An online survey based on a five-point Likert scale was built, 600 managers were contacted via email, and the data were collected from January to March 2022. In addition, 255 responses were collected, with a response rate of 42.5%. The number of managers based in the country was 75 in Jordan, 60 in the UAE, 85 in Saudi Arabia, and 35 in Kuwait.

In terms of sample characteristics, out of the 255 responses, the majority were male (82.4 %), while only 17.6% were female. Additionally, the largest age group among the respondents was those under 35, representing 84.7%. Those between the ages of 36 and 50 comprised only 7.5%, while those over 50 comprised 7.8% of the sample. Finally, in terms of education level, most respondents had a bachelor's degree, representing 64.3%; those with a diploma or less made up 26.7%, while those with a postgraduate degree represented only 9% of the sample. Partial Least Squares (PLS) analysis was employed to test the model and hypotheses. This approach enabled researchers to test the interrelationships among dependent, independent, and mediation variables as well as multi-item constructs. Several previous studies used PLS for similar purposes, making it a suitable choice for this study. PLS was selected as the data analysis tool because it effectively analyses complex data structures (Hair et al., 2019). Furthermore, the research variables include supplier risk, demand risk, transportation risk, SC resilience, and lean operation performance. The instrument was developed based on a points Likert scale with 19 items. Table 1 lists these items.

Table 1. Instrument item

Construct	Measurement items
Supplier Risk	The supplier's capability to consistently meet our quality requirements is a key consideration in assessing their level of risk.
	Timely delivery of products/services by the supplier is critical in minimizing risk to our business.
	The supplier's reputation in the industry plays a major role in determining the level of risk associated with doing business with them.
	We have confidence in the supplier's ability to handle unexpected disruptions in the supply chain.
	The level of uncertainty in demand for our products/services poses a significant risk to our business operations

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Demand Risk	The potential for changes in consumer behavior and preferences represents a major source of demand risk for our business
	Fluctuations in demand for our products/services throughout the year create uncertainty and risk for our business
	The degree of competition and the resulting impact on demand for our products/services is a key consideration in assessing our level of demand risk
Transportation Risk	The risk of transportation delays or disruptions poses a significant threat to our supply chain operations.
	Our level of dependence on a particular transportation mode or carrier creates a significant risk in our supply chain operations.
	The degree of visibility and control we have over our transportation network is critical in mitigating transportation risk
	The cost and availability of transportation options presents a major challenge in managing transportation risk
SC Resilience	Our supply chain is capable of recovering quickly from unexpected disruptions.
	We have contingency plans in place to mitigate supply chain disruptions and maintain business continuity.
	Our supply chain is flexible enough to adapt to changing business conditions and market demands.
Lean Operations Performance	Our organization has implemented lean principles and practices to improve efficiency and reduce waste
	We have a culture of continuous improvement, with ongoing efforts to identify and eliminate inefficiencies in our operations.
	Our supply chain operations are highly synchronized and coordinated, resulting in minimal lead times and high levels of customer satisfaction
	Our organization places a high value on maximizing value for customers while minimizing waste in our operations

Research Results

The validity and reliability of the scales were examined during the first stage of the analysis, and the results are presented in Table 2. Cronbach's alpha was used to test the reliability of the scale. The values ranged from 0.800 to 0.722, indicating an acceptable level of reliability as all values were >0.7. The average variance extracted (AVE) computed in this study ranged from 0.568 to 0.625, surpassing the recommended threshold value of 0.5 (Hair et al., 2019). Composite reliabilities (CR) were also examined, and values ranging from 0.723 to 0.870 exceeded the threshold value of 0.6 (Fornell and Larcker, 1981). The final validity test was discriminant validity (DV),

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which ensured the values were <0.85. Table 3 clearly shows that the values met this requirement, indicating that the DV of the study model was established.

The variance inflation factor (VIF) was calculated to assess the degree of collinearity. A VIF value of less than five is acceptable, indicating that collinearity is not a major concern in the current study. Smart PLS was applied to further validate the model, and the results are discussed.

Table 2. Assessing measurement model

	Cronbach's alpha	Composite reliability	AVE
Demand Risk	0.795	0.830	0.620
Lean Operations Performance	0.800	0.870	0.625
SC Resilience	0.722	0.798	0.569
Supplier Risk	0.749	0.832	0.599
Transportation Risk	0.722	0.778	0.568

Table 3. Discriminant validity

	DR	LOP	SCR	SR	TR
Demand Risk (DR)	0.787				
Lean Operations Performance (LOP)	0.457	0.791			
SC Resilience (SCR)	0.642	0.654	0.754		
Supplier Risk (SR)	0.617	0.595	0.720	0.706	
Transportation Risk (TR)	0.519	0.563	0.582	0.549	0.684

To examine the research hypotheses, two methods are recommended. The first method includes using a path model that permits the assessment of statistical significance based on the outcomes (Hair et al., 2021). The latter method applies the bootstrapping technique (Henseler et al., 2015), which can assist in determining possible causal associations between the research constructs. Following the suggestions made by Hair et al. (2019), the findings are deemed significant if the t-value is less than 1.96 and a p-value <0.05.

According to the data presented in Table 3, the study found that supplier, demand, and transportation risks have a direct impact on SCR, which is statistically significant at p < 0.01 (b = 0.261, t = 3.708, b = 0.449, t = 7.355, b = 0.200, t = 3.690). These results support hypotheses H1, H2, and H3, which were proposed in this study. The study also predicted that SCR would significantly affect lean operations performance, as

hypothesized in H4. Moreover, the study found a direct path effect between the constructs, and H4 was supported, which means it is statistically significant at p < 0.01 (b = 0.654; t = 14.950).

Table 4. Test results of direct pathway

	Original sample	Sample mean	Standard deviation	T statistics	P value
Demand Risk -> SC Resilience	0.261	0.262	0.070	3.708	0.000
Supplier_ Risk -> SC Resilience	0.449	0.450	0.061	7.355	0.000
Transportation _Risk -> SC Resilience	0.200	0.204	0.054	3.690	0.000
SC Resilience -> Lean Operations_ Performance	0.654	0.658	0.044	14.950	0.000

In the proposed model, SCR plays a mediating role, analyzed through indirect effect analysis at a 95% confidence interval (Preacher et al., 2007). Table 5 displays the results of these indirect analyses (mediation effect) and reveals that SCR significantly mediates the indirect pathway between SC mitigation risks and lean operation performance (b = 0.294, t = 6.329, b = 0.170, t = 3.567, b = 0.130, and t = 3.529).

Table 5. Test results of indirect pathway (mediation effect of SCR)

	Original sample	Sample mean	Standard deviation	T statistics	P values
Supplier Risk > SC Resilience > Lean Operations Performance	0.294	0.296	0.046	6.329	0.000
Demand Risk > SC Resilience > Lean Operations_ Performance	0.170	0.172	0.048	3.567	0.000
Transportation Risk > SC Resilience>Lean Operations Performance	0.130	0.134	0.037	3.529	0.000

Discussion

This study explores how SC risk mitigation (supplier risk, demand risk, and transportation risk) impacts lean operation performance through SCR. The findings reveal that SC risk mitigation in supply, demand, and transportation positively impacts LOP. These results further suggest that firms in highly risky environments are expected

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to achieve a highly efficient LOP. However, demand and transportation risks are not guaranteed to provide an efficient and favorable outcome for improving LOP.

In terms of mediation impact, the result confirms that SCR mediates the relationship between SC risk mitigation and LOP. SC risk-mitigation strategies aim to reduce the probability and impact of disruptions on the supply chain. These disruptions can arise from various sources, including natural disasters, political instability, and supplier bankruptcy. Firms can develop strategies and contingency plans to manage and mitigate these risks by investing in SC risk mitigation.

However, even with effective risk-mitigation strategies, disruptions may still occur, and their impact may be significant. This is where SCR comes into play, as firms with high SCR are better equipped to respond to disruptions and maintain their performance. These findings are also prominent in other studies (Brusset and Teller, 2017; Jain et al., 2017). Abeysekara et al. (2019) further stated that firms with high SC risk mitigation and SCR in their records are more likely to achieve a high level of LOP in the upcoming years. Accordingly, it has been witnessed that in many cases, SC risk mitigation was measured in terms of transportation and cost only. However, the same approach was adopted in other studies, which indicated an inconsistent effect of cost and transportation on SC risk mitigation (Santoso et al., 2022; Khan et al., 2022). The findings are consistent with previous studies reporting a highly positive correlation between the positive impact of SC risk mitigation and SC reliance (Belhadi et al., 2019; Belhadi et al., 2021). Other studies came forward with an in consist outcome while evaluating the impact of SC risk on SC resilience (Kamalahmadi and Parast, 2016; Yu et al., 2018). However, it has been stated that high investment for increasing resilience capacity has a promising return on investment with a quality product service to maintain customer trust, and vice versa for customized production. Therefore, within various sectors and contexts, sustaining a good understanding of SC risk mitigation for SC resilience is important.

In the present study, supplier risk was the strongest construct (t-value = 7.355), although all dimensions of SC risk mitigation significantly impacted SC resilience in manufacturing firms. Therefore, the supplier risk t-value is more efficient in measuring the capacity of SC risk-mitigation changes regarding SC resilience. Owing to the highly unpredictable working environment, SC risk mitigation can positively impact SC resilience to enhance mass production and create flexible and robust changes to match market necessities and variations (Centobelli et al. 2020). The results of the present study agree with those of Yu et al. (2018), who suggested a proactive approach to rectify the effect of a negative factor and provide proactive and reactive flexibility that can help improve SCR by sharing precise information promptly. Another study found that SCR is a significant mediating factor for SC risk mitigation and the LOP approach (Routroy et al., 2018; Shahbaz et al., 2018; Khanuja and Jain, 2021). The author further argued

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that a better relationship between SC risk-mitigation factors could enhance the LOP of the SC.

Furthermore, the results indicate a significant impact of SC resilience on LOP in manufacturing firms. This outcome is consistent with the study by Panigrahi et al. (2022), who demonstrated the direct impact of SC reliance on lean operational performance. Hence, manufacturing firms in countries that have suffered from various SC disruptions in the past few years need to emphasize the importance of SCR in improving LOP.

Conclusion

This study has several implications that sufficiently contribute to the gap in the literature and provide administrative guidance to address SC challenges. The results provide detailed and precise results for lean operations and SC expert pondering. The research findings suggest appropriate risk management practices for each SC risk category can be adopted. The implementation of more robust risk-management strategies can enhance SC resilience. However, this study indicates that relying solely on a single strategy may not always yield the most effective outcomes. Therefore, combining strategies tailored to specific risks could provide better risk management and improve overall SCR. This study highlights the importance of having the necessary capabilities to support SCR, which is crucial in mediating the relationship between risks and resilience. Improving SCR capability is the key to achieving better overall resilience. By understanding the interplay between risks, strategies, and resilience capability, managers can better detect and respond to risks, ultimately contributing to a company's sustainability.

Based on these findings, this study suggests that manufacturing firms should invest more in relevant SCR. By adopting this strategy, firms can improve their overall LOP and enhance their SCR. These findings suggest that the surveyed sample was well suited to conduct the study and encourage managers within this sector to continue prioritizing these factors. Considering the outcomes of the SCR dimensions, this study recommends that there should be more focus on enhancing SCR levels to effectively prepare manufacturing SCs for various disruptions. By prioritizing resilience, firms can better manage risks and improve their ability to respond to unexpected events in SC.

Additionally, this study underscores the importance of considering regional and international differences when designing and implementing SC strategies. Manufacturing firms operating in different regions may face unique challenges and risks, and it is important to develop strategies considering these differences. Future research should identify these differences and develop region-specific strategies for enhancing SCR. In addition, it explores the unique challenges faced by international SCs and develops strategies for managing these challenges effectively. This suggests that manufacturing firms need to understand the perspectives of managers better to ensure a

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suitable level of consensus and harmony among individuals at the management level. This study highlights the need for more comprehensive and region-specific research on SCM and emphasizes the importance of internationalization in SC strategies. By considering these implications and building on the findings of this study, researchers and practitioners can develop more effective strategies for managing SC risks and enhancing SCR in the face of unexpected disruptions. Other factors contributing to achieving superior LOP should also be explored. Another area for future research is understanding how the impact of SCR and digital technologies differs between downstream and upstream firms in the SC. Overall, this study's limitations and future directions highlight the need for further research to better understand the complex relationship between SCR and LOP in different contexts.

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ZROZUMIENIE ZWIĄZKU MIĘDZY RYZYKIEM ŁAŃCUCHA DOSTAW A SKUTECZNOŚCIĄ OPERACJI LEAN

Streszczenie: Głównym celem niniejszego opracowania jest zbadanie wpływu ryzyka związanego z łańcuchem dostaw (Supply Chain - SC) na skuteczność operacji lean (Lean Operation Performance - LOP) wraz z rolą odporności łańcucha dostaw (Supply Chain Resilience - SCR) jako pośrednika w tej relacji między firmami produkcyjnymi. Zastosowano metodę ilościową w celu zbadania, w jaki sposób ryzyko związane z dostawcami, popytem i transportem wpływa na skuteczność operacji lean poprzez pośrednictwo SCR. Badanie obejmowało przeprowadzenie ankiety internetowej wśród 255 firm produkcyjnych na Bliskim Wschodzie. Badacze wykorzystali dedukcyjną metodę testowania hipotez do sprawdzenia swojego modelu

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koncepcyjnego, a wyniki przeanalizowano za pomocą oprogramowania Smart PLS. Wyniki wskazują, że ryzyko związane z dostawcami, popytem i transportem znacząco wpływa na SCR. Ponadto stwierdzono bezpośredni efekt ścieżki między ryzykiem SC a skutecznością operacyjną lean. Badanie to podkreśla związek między SCR i jego pośredniczącym wpływem na ograniczanie ryzyka SC i LOP. Dzięki dowodom empirycznym badanie to wykazało, że SCR jest kluczową cechą logistyki, która może pomóc w pośredniczeniu w powiązaniu między ograniczaniem ryzyka SC a skutecznością operacji lean. Dostarczają one cennych informacji dla menedżerów, osób odpowiedzialnych za wyznaczanie kierunków polityki i innych interesariuszy na temat znaczenia wdrożenia tych trzech czynników w celu zwiększenia skuteczności operacyjnej lean w firmach produkcyjnych. Badanie to przedstawia unikalną perspektywę pośredniczącej roli odporności SC na Bliskim Wschodzie, która nie była szeroko badana w literaturze. Wyniki badania mogą zapewnić praktykom w regionie wgląd w poprawę zarządzania ryzykiem SC i skuteczności operacji lean.

Słowa kluczowe: Ryzyko łańcucha dostaw, Operacje Lean, Skuteczność, Odporność Łańcucha Dostaw

了解供应链风险与精益运营绩效之间的关系

摘要：本研究的主要目的是检验供应链 (SC) 风险对精益运营绩效 (LOP) 的影响，以及供应链弹性 (SCR) 在制造企业之间的这种关系中的中介作用。 采用定量方法来调查供应商、需求和运输风险如何通过 SCR 的中介影响精益运营绩效。 这项研究涉及对中东 255 家制造公司进行在线调查。 研究人员使用假设检验演绎法来检验他们的概念模型，并使用 Smart PLS 软件分析结果。 这些发现表明供应商、需求和运输风险显着影响 SCR。 此外，在 SC 风险和精益运营绩效之间发现了直接路径效应。 本研究强调了 SCR 及其对 SC 风险缓解和精益运营绩效的中介作用之间的关系。 通过实证证据，本研究表明 SCR 是物流的一个重要特征，可以帮助调节 SC 风险缓解与精益运营绩效之间的关联。 它为管理者、政策制定者和利益相关者提供了关于实施这三个推动因素以提高制造企业精益运营绩效的重要性的宝贵见解。 本研究对中东 SC 恢复力的中介作用提出了独特的视角，这在文献中尚未得到广泛研究。 调查结果可以为该地区的从业者提供见解，以加强他们的 SC 风险管理和精益运营绩效

关键词：供应链风险、精益运营、绩效、供应链弹性