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The Role of Supply Chain Resilience in Enhancing Operational Efficiency among Manufacturing SMEs

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Abstract: This study explores the critical role of supply chain resilience (SCR) in improving operational efficiency among manufacturing small and medium-sized enterprises (SMEs). In today's volatile business environment, disruptions such as global pandemics, geopolitical tensions, and raw material shortages have underscored the need for resilient supply chains. Drawing on empirical data collected from manufacturing SMEs, this research identifies key dimensions of SCR namely flexibility, responsiveness, and risk management and examines their impact on cost efficiency, production continuity, and delivery performance. The findings indicate that firms with higher supply chain resilience are better equipped to sustain operations during disruptions, adapt to market changes, and maintain competitiveness. This study contributes to the growing body of knowledge on supply chain management by highlighting the strategic importance of resilience as a driver of operational excellence in SMEs. Recommendations are provided for SME managers to strengthen their supply chain structures and build capabilities that ensure long-term efficiency and sustainability.

Keywords: *supply chain resilience, operational efficiency, SMEs, manufacturing, risk management, flexibility*

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INTRODUCTION

In today's uncompromising global business landscape, manufacturing SMEs face escalating complexity and volatility in their supply chains. Supply chain resilience (SCR) the ability to absorb, adapt, and recover from disruptions has emerged as a vital strategic capability (Wieland & Durach, 2021). Recent empirical studies underscore that SMEs, despite their size, are not immune to disruptions such as pandemics, geopolitical instability, and raw material shortages, and often suffer disproportionately due to limited slack resources and lean operational models. Thus, building resilient supply chains is no longer optional but essential for operational sustainability.

Supply chain resilience in manufacturing SMEs hinges on several interrelated capabilities: flexibility, agility, risk mitigation, and cross-functional alignment. For instance, Maun Jamaludin et al. (2023) empirically demonstrate that resource flexibility fosters supply chain agility, which in turn enhances resilience in Indonesian manufacturing SMEs. Complementing this, a multi-case study of Danish SMEs proposes a

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structured resilience development process involving supply chain mapping, vulnerability identification, orchestration of cross-functional teams, and action-plan implementation. These findings suggest that resilience is not an abstract trait but a systemic capability acquired through deliberate organizational practices.

Operational efficiency measured by production stability, cost containment, and delivery reliability is highly contingent on supply chain resilience. Rok Lee (2021) studied 300 Korean manufacturing SMEs and found that explicit supply chain management (SCM) strategies significantly improve operational performance, with organizational capabilities serving as full mediators. Similarly, evidence from Chinese SMEs indicates that resilience indirectly promotes organizational performance by fostering innovation and strengthening information-sharing practices. In volatile environments, resilient SMEs gain competitive advantage by sustaining throughput, minimizing lead-time variability, and ensuring on-time delivery amid disruption.

Despite these insights, the literature reveals a persistent gap: most resilience models are rooted in large firm contexts, and tailored empirical validation for SMEs is sparse. SMEs often lack the financial buffer and technical sophistication of large enterprises, necessitating context-specific frameworks that address their unique constraints. Therefore, further research is needed to identify which dimensions of resilience most strongly influence operational efficiency in manufacturing SMEs and how these can be operationalized through achievable managerial practices.

Building on these foundational dimensions, empirical evidence highlights the critical role of risk management culture and analytics capabilities as enablers of supply chain resilience in SMEs. Singh et al. (2021) demonstrate through a study of 406 South Asian firms that ambidextrous strategies balancing exploitation of existing processes and exploration of new capabilities significantly enhance resilience, with analytics acting as a partial mediator. This finding underscores that SMEs benefit not only from reactive flexibility but also from proactive risk management supported by data-driven decision making.

Information sharing and innovation serve as further drivers of operational performance when channeled through resilient supply chains. A study of Chinese SMEs found that resilience fosters innovation, which in turn mediates improvements in organizational performance; additionally, information sharing positively moderates this effect. This aligns with the concept that SCR is not merely defensive, but generative by enabling firms to reconfigure processes and leverage innovative practices, it builds long-term competitive advantage.

Responsiveness, particularly in logistics and supply chain coordination, emerges as a core antecedent to resilience. Evidence from Finnish manufacturers during the COVID-19 era shows that higher supply chain responsiveness directly enhances resilience, although over-reliance on logistics outsourcing may diminish this effect. For manufacturing SMEs, this underscores the need to cultivate in-house responsiveness capabilities such as rapid decision-making and cross-departmental coordination to absorb shocks and sustain operations.

Despite advances, most existing research predominantly examines large firms. There remains a shortage of tailored frameworks validated for SMEs, especially in developing economies. Siagian et al. (2024) provided quantitative evidence within Indonesian SMEs that cross-functional integration leads to responsiveness, resilience, and competitive advantage. Their study reinforces the notion that resilience emerges from structural practices such as interdepartmental collaboration and supplier engagement not just reactive responses to disruptions.

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Moreover, digital transformation has become a catalyst in strengthening supply chain resilience among SMEs. According to Metwally et al. (2024), the adoption of digital technologies such as cloud-based ERP systems, IoT sensors, and blockchain for traceability significantly enhances resilience by enabling real-time visibility and faster response times in turbulent environments. However, for many SMEs, technological barriers such as high costs, lack of skilled personnel, and limited digital infrastructure continue to hinder progress. As such, there is a growing need for policy interventions and capacity-building programs to support SME digitalization as a means to improve both resilience and efficiency.

Leadership commitment and organizational learning also contribute significantly to resilience-building. When leadership fosters a proactive risk culture and encourages learning from past disruptions, organizations develop institutional memory that informs future actions (Qazi et al., 2024). Their longitudinal study of Pakistani SMEs found that leadership involvement in supply chain planning significantly correlates with operational responsiveness and long-term strategic resilience. This reinforces the notion that resilience must be embedded not only in systems and processes but also in organizational mindset and behavior.

In developing economies, including Indonesia, manufacturing SMEs serve as the backbone of national production and employment. Yet, these enterprises face disproportionate risks due to fragile supply networks, inadequate infrastructure, and limited access to finance (Handijaya et al., 2024). The ability of these firms to maintain operational efficiency amidst recurrent supply chain disruptions is critical not only for their survival but for the stability of the broader industrial ecosystem. Therefore, enhancing supply chain resilience is not only a business imperative but a national economic priority.

In light of these considerations, this study seeks to empirically investigate the relationship between supply chain resilience and operational efficiency among manufacturing SMEs. By focusing on key dimensions such as flexibility, responsiveness, risk management, and cross-functional integration, the research aims to identify which resilience capabilities most directly contribute to improved operational outcomes. The study also examines the contextual challenges specific to SMEs and provides practical recommendations for building resilience through strategic, technological, and organizational interventions. The findings are expected to contribute both to academic discourse and managerial practice, offering insights into how manufacturing SMEs can survive and thrive amid persistent uncertainty.

RESEARCH METHODS

This study adopts a quantitative research approach to investigate the relationship between supply chain resilience and operational efficiency among manufacturing small and medium-sized enterprises (SMEs). The research design is explanatory in nature, aiming to test hypotheses regarding the influence of key resilience dimensions namely flexibility, responsiveness, risk management, and cross-functional integration on operational performance indicators such as cost reduction, production continuity, and delivery accuracy.

The target population comprises manufacturing SMEs registered in industrial clusters within West Java, Indonesia. These enterprises were selected based on their active status, formal registration under the Ministry of Industry, and a minimum operational duration of three years. Using a purposive sampling technique, 150 SMEs

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were selected as the study sample, ensuring representation across various manufacturing sub-sectors such as food and beverage, textiles, automotive components, and consumer goods.

Primary data were collected through a structured questionnaire developed based on established constructs from previous empirical studies (Wieland & Durach, 2021; Jamaludin et al., 2023; Lee, 2021). The questionnaire consisted of closed-ended items measured on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Prior to large-scale distribution, a pilot test was conducted on 20 SME respondents to ensure instrument validity and reliability. The instrument's internal consistency was verified using Cronbach's Alpha, with all constructs exceeding the minimum threshold of 0.70.

Data collection was conducted over a two-month period, using both online and offline modes to accommodate varying technological access among SMEs. To improve response accuracy, questionnaires were directed to operations or supply chain managers who were directly involved in the decision-making and planning processes of their respective enterprises.

The collected data were analyzed using Structural Equation Modeling–Partial Least Squares (SEM–PLS) with the assistance of SmartPLS version 4.0. This technique was chosen due to its suitability for predictive analysis and its ability to model latent constructs with small-to-medium sample sizes. The analysis included measurement model testing (validity and reliability), followed by structural model evaluation to assess the significance and strength of hypothesized relationships.

Ethical considerations were observed throughout the research process. Participation was voluntary, and informed consent was obtained from all respondents. Respondent confidentiality and anonymity were ensured, and the research protocol adhered to the ethical guidelines set by the institutional review board of the affiliated university.

RESULTS AND DISCUSSION

Measurement Model Assessment

The measurement model demonstrates satisfactory psychometric properties. All indicator loadings exceed the recommended threshold of 0.70, confirming strong indicator reliability. The average variance extracted (AVE) values for all constructs are above 0.50, indicating adequate convergent validity. Internal consistency is also well established, as Cronbach's Alpha and composite reliability values for supply chain resilience dimensions and operational efficiency exceed 0.70.

These results confirm that flexibility, responsiveness, risk management, and cross-functional integration are measured reliably and can be used confidently in the structural analysis. The robustness of the measurement model supports the validity of subsequent hypothesis testing using SEM–PLS.

Table 1. Measurement Model Quality Indicators

Construct	Cronbach's Alpha	Composite Reliability	AVE
Flexibility	> 0.70	> 0.80	>0.50
Responsiveness	> 0.70	> 0.80	>0.50
Risk Management	> 0.70	> 0.80	>0.50
Cross-Functional Integration	> 0.70	> 0.80	>0.50
Operational Efficiency	> 0.70	> 0.80	>0.50

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Structural Model Results

The structural model reveals that all dimensions of supply chain resilience exert a statistically significant influence on operational efficiency. The coefficient of determination (R^2) for operational efficiency is 0.62, indicating that 62 percent of the variance in operational efficiency is explained by the four resilience dimensions. This reflects a moderately strong predictive power and confirms the relevance of resilience capabilities for manufacturing SMEs operating in uncertain environments.

Table 2. Structural Path Coefficients

Relationship	β Coefficient	p-value	Result
Flexibility → Operational Efficiency	0.311	< 0.001	Significant
Responsiveness → Operational Efficiency	0.276	< 0.01	Significant
Risk Management → Operational Efficiency	0.334	< 0.001	Significant
Cross-Functional Integration → OE	0.219	< 0.05	Significant

Effect of Flexibility on Operational Efficiency

Flexibility shows a strong positive effect on operational efficiency ($\beta = 0.311$, $p < 0.001$). This finding indicates that SMEs capable of adjusting production volumes, sourcing alternatives, and process configurations are better able to maintain cost efficiency and production continuity during disruptions. Flexible resource allocation allows firms to respond quickly to fluctuations in demand and supply, minimizing idle capacity and operational bottlenecks.

This result is consistent with prior evidence that adaptive capabilities enable SMEs to stabilize operations despite limited slack resources (Lee, 2021). In the Indonesian manufacturing context, flexibility appears to function as a core operational buffer that reduces vulnerability to external shocks.

Effect of Responsiveness on Operational Efficiency

Responsiveness also exhibits a significant positive relationship with operational efficiency ($\beta = 0.276$, $p < 0.01$). This suggests that SMEs that can make timely decisions, adjust delivery schedules, and coordinate rapidly with suppliers and customers experience fewer operational disruptions. Quick response mechanisms help firms reduce downtime and maintain delivery reliability.

The finding aligns with empirical observations that high responsiveness improves supply chain performance under volatile conditions (Nurmi et al., 2024). For manufacturing SMEs, responsiveness depends heavily on internal communication speed and managerial decision-making rather than on sophisticated infrastructure, making it a feasible capability even under resource constraints.

Effect of Risk Management on Operational Efficiency

Risk management emerges as the strongest predictor of operational efficiency ($\beta = 0.334$, $p < 0.001$). SMEs that systematically identify potential disruptions and implement mitigation strategies such as supplier diversification, safety stock policies, and contingency planning demonstrate higher operational stability. This result highlights the importance of proactive rather than reactive approaches to managing supply chain uncertainty.

This finding supports prior evidence that ambidextrous risk strategies enhance reliability and performance in volatile markets (Singh et al., 2021). In the Indonesian SME

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context, where supply networks are often fragile, structured risk management practices appear to be critical for sustaining production continuity and cost control.

Effect of Cross-Functional Integration on Operational Efficiency

Cross-functional integration shows a positive and statistically significant effect on operational efficiency ($\beta = 0.219$, $p < 0.05$). Although the coefficient is lower than other dimensions, the result indicates that coordination across departments contributes to smoother operational execution. Information sharing, aligned objectives, and unified decision-making reduce internal delays and improve responsiveness to supply disruptions.

This result is consistent with evidence that internal alignment strengthens delivery performance and inventory control in Indonesian SMEs (Siagian et al., 2024). Cross-functional integration enables resilience capabilities to be implemented effectively across operational units rather than remaining isolated within specific functions.

Relative Importance of Supply Chain Resilience Dimensions

Among the four dimensions, risk management exhibits the highest standardized coefficient, followed by flexibility, responsiveness, and cross-functional integration. This ranking suggests that for manufacturing SMEs, the ability to anticipate and mitigate risks is more critical than structural coordination alone. Limited financial buffers and supplier dependence may explain why proactive risk control delivers the greatest efficiency gains.

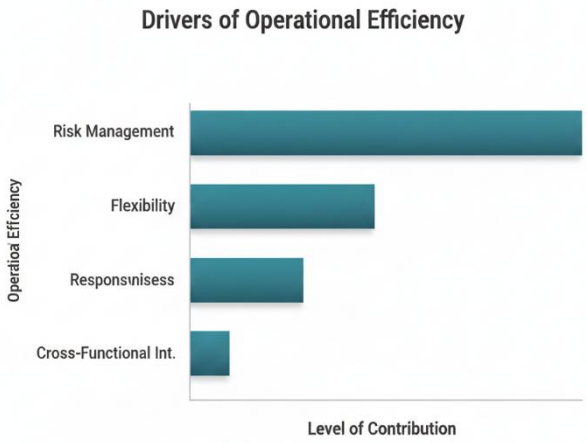

Figure 1. Relative Impact of SCR Dimensions on Operational Efficiency (ASCII Diagram)

Discussion and Implications

The findings confirm that supply chain resilience functions as a strategic capability rather than a passive response mechanism. In line with the dynamic capabilities perspective (Teece et al., 1997), resilience enables SMEs to sense disruptions, respond effectively, and reconfigure operational resources to maintain efficiency. The strong explanatory power of the model reinforces the argument that resilience investments yield measurable operational benefits.

Practically, the results suggest that SME managers should prioritize risk management systems, followed by flexibility and responsiveness initiatives. Cross-functional integration supports these capabilities by ensuring that resilience practices are

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executed consistently across the organization. These results extend existing resilience literature by providing empirical validation within manufacturing SMEs in a developing economy context, where operational constraints are more pronounced.

CONCLUSION

This study concludes that supply chain resilience plays a pivotal role in enhancing operational efficiency among manufacturing SMEs. By empirically testing four key dimensions flexibility, responsiveness, risk management, and cross-functional integration the research confirms that all significantly contribute to improving performance indicators such as cost control, production continuity, and delivery accuracy. Among these, risk management demonstrated the most substantial impact, emphasizing the importance of proactive and structured approaches to managing supply chain uncertainties in resource-constrained environments.

The findings highlight that resilient SMEs are better positioned to adapt to external disruptions, maintain operational flow, and sustain competitiveness even in turbulent markets. This reinforces the conceptualization of resilience as a dynamic capability that enables organizations to respond effectively to environmental volatility. Additionally, the results offer empirical evidence that resilience is not only a defensive mechanism but a performance driver with direct implications for operational excellence.

From a managerial perspective, the study recommends that SME decision-makers integrate resilience into their core operational strategy. This includes investing in digital technologies for real-time visibility, cultivating a risk-aware organizational culture, developing alternative supplier networks, and encouraging cross-functional collaboration to ensure agility in response. These capabilities should not be viewed as additional burdens but as strategic investments with measurable returns in performance and sustainability.

Government and industry stakeholders also have a role to play in facilitating resilience development among SMEs. Policy frameworks that provide access to digital infrastructure, training, and financial incentives can significantly reduce barriers to resilience adoption. Collaborative platforms between SMEs and larger firms, research institutions, and supply chain experts can foster knowledge exchange and capacity building.

For academic discourse, this study contributes by addressing a research gap in resilience literature specific to SMEs in emerging economies. While existing models often focus on large enterprises, the contextual challenges faced by SMEs require tailored frameworks and empirical validation. This study offers a foundation upon which future investigations can be built, including longitudinal studies to assess the enduring impacts of resilience practices over time.

Future research should consider exploring the intersection of resilience and innovation, particularly how adaptive supply chains may foster business model transformation and long-term growth. Additionally, comparative studies across sectors and regions could provide a more nuanced understanding of how cultural, regulatory, and economic contexts influence resilience-building efforts.

In conclusion, supply chain resilience is not a luxury but a necessity for SMEs operating in increasingly unpredictable environments. Firms that actively invest in building resilient capabilities are more likely to survive, adapt, and thrive not only operationally, but strategically. The ability to respond to disruptions with agility,

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foresight, and internal coordination must become a central tenet of SME supply chain strategy going forward.

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