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Supply Chain Resilience Post-Disruptions: Insights from Recovery, Sustainability, and Collaboration

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KEYWORDS

Resilient supply chains, post-disruptions, recovery capabilities, collaborative partnerships, and sustainable practices

ABSTRACT

Supply chain resilience has turned out to be one of the focuses businesses which want to cope with the existing disruptions. In that regard, this paper explores operational recovery, sustainability, collaboration as key dimensions of a resilient supply chain. By sampling 254 participants from different industries, the study seeks to examine how operating recovery capability, interfirm partnerships and operational sustainability contributes to supply chain resilience in the face of disruptions. Consequently, the research conclusions contain important suggestions to the researchers and scholars that will follow in a similar field, and for practitioners and policymakers who are challenged by restrictions in raising performance and coping with risks on a volatile business environment.

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1. INTRODUCTION

The disruptions of the supply chains due to natural calamities, geo-political conflicts, and presently through the coronavirus outbreak demonstrate the necessity of the reliability to provide operation continuity and to reduce the losses. A supply chain resilient can adapt to different circumstances, respond quickly to events, and gain strategic positions after an occurrence. Operational recovery, collaboration, sustainability forms a complex framework of resilience. Whereas operational recovery is concerned with actions on how to rapidly and efficiently respond to disruptions, collaboration deals with the way different entities in supply chain can share information and cooperate in managing risks. Sustainability which today is given high importance in supply chain management does not only guarantee long term sustainability in terms of environmental and social impacts but also withstands shocks. This work discusses these dimensions to evaluate factors that facilitate supply chain resilience after disruptions.

2. LITERATURE REVIEW

Ivanov and Dolgui (2023) pointed out on the use of digital twins that assist in improving on the position of the supply chain stressing that they can now mimic disruptions in real time hence improving on the rate of supply chain recovery. Nevertheless, limitations of utilizing digital twin technologies for SMEs are insufficiently investigated.

In his recently published article Remko (2022) discussed nearshoring and flexible sourcing after the pandemic and how they emphasised the need for resilience, but it was missing a discussion of their long-term cost and sustainability considerations.

Chowdhury et al. (2021) found that supply chain collaboration promotes information sharing and recovery speed, however, the application of digital technologies in supporting such collaboration is understudied.

In their study, Ivanov and Sokolov (2021) pointed to visibility and agility as pivotal for keeping the continuity during disruptions; however, they slipped off the fact of how small organisations can implement integrated risk monitoring systems.

Maghsoudi and Pazirandeh (2020) associated social sustainability to resilience labeling stakeholder trust as a practice Type however the studies connecting these concrete sustainability practices to recovery efficiency were scant.

Sodhi and Tang (2020) proposed balancing lean systems with redundancy to build resilience, but did not explore sector-specific variations of this approach.

Khalid et al. (2019) found that green logistics improves risk mitigation, but cost implications for industries with tight profit margins remain unclear.

Ivanov et al. (2019) introduced the “ripple effects” concept, demonstrating the value of collaborative planning, though practical validations across diverse industries were lacking.

Scholten et al. (2018) underscored trust-based partnerships in fostering resilience, yet the dynamics of trust in newly formed or culturally diverse collaborations were underexamined.

Tang and Musa (2018) identified predictive analytics as vital for operational recovery but did not address challenges of data integration in complex networks.

Gligor et al. (2018) emphasized agility in adapting to disruptions but provided limited frameworks for balancing agility with cost efficiency. Kumar and Sharma (2017) stressed contingency planning in reducing downtime, though their focus on manufacturing left service-oriented supply chains unexplored.

Dubey et al. (2017) connected sustainability to resilience, highlighting energy efficiency’s role, but lacked empirical evidence from non-renewable resource-intensive sectors.

Chopra and Sodhi (2017) advocated for diversified sourcing to enhance recovery, yet ignored the environmental and social trade-offs of this strategy.

Christopher and Holweg (2017) demonstrated how visibility through real-time data sharing accelerates recovery but did not address technological barriers in achieving it.

Hohenstein et al. (2017) proposed flexibility and redundancy as key enablers of resilience but did not consider how resource-constrained environments prioritize investments.

Barroso et al. (2017) highlighted collaborative recovery plans but did not examine data security risks in shared systems.

Ali et al. (2017) linked green practices to reduced disruptions but overlooked the balance between sustainability and operational efficiency.

Fan and Stevenson (2018) advocated understanding adaptabilities for disruption, but it is still fuzzy on whether it has applicability in global or local supply chains.

In examining resilience for emerging markets through local partners, while Agarwal and Shankar documented important findings in 2017, the theme of political and regulatory pressures was relatively underdeveloped. In aggregate, these studies outline key Supply Chain Management strategies for supply chain resilience but reveal that existing knowledge suffers from research neglect in terms of effectively elaborating strategies to assist SMEs, strategies for balancing cost and sustainability, and developing Supply Chain Management strategies relative to different types of Supply Chains.

Research objectives:

1. To identify factors affecting supply chain resilience in the context of operational recovery and sustainability.
2. To examine the influence of select factors on supply chain resilience after disruptions.

Hypotheses:

H1: Operational Recovery Capabilities significantly influence supply chain resilience.
H2: Collaboration and Partnerships significantly influence supply chain resilience.
H3: Sustainable Practices Adoption significantly influences supply chain resilience.

Research methodology:

A quantitative research design was employed, gathering data from 254 respondents across industries, including manufacturing, retail, and logistics. A structured questionnaire measured the impact of operational recovery capabilities, collaboration, and sustainability practices on supply chain resilience. Data analysis included regression techniques to test the proposed hypotheses and identify the strength of relationships between variables.

3. RESULTS AND DISCUSSION

Table 1. Demographic details of respondents (N=254)

Demographic Variable	Category	Frequency (N)	Percentage (%)
Gender	Male	152	59.8%
	Female	102	40.2%
Age Group	18–30 years	89	35%
	31–45 years	114	45%
	46 years and above	51	20%
Education Level	Bachelor's Degree	122	48%
	Master's Degree	94	37%
	Other Qualifications/Certifications	38	15%
Industry Representation	Manufacturing	76	30%
	Retail	64	25%
	Logistics and Transportation	51	20%
	IT and Technology	38	15%
	Other	25	10%
Work Experience	Less than 5 years	64	25%
	5–10 years	102	40%
	Over 10 years	88	35%
Organizational Role	Supply Chain Managers	102	40%
	Operations Managers	76	30%
	Logistics Coordinators	38	15%
	Other	38	15%

Source: Primary data

The demographic profile of the 254 respondents reveals a diverse composition across several key variables. In terms of gender distribution, males constituted 59.8% (152), while females made up 40.2% (102), ensuring a balanced representation of perspectives. The respondents spanned three age groups, with the majority aged between 31–45 years (45%), followed by those aged 18–30 years (35%) and 46 years and above (20%). Regarding education levels, nearly half of the participants held a bachelor's degree (48%), while 37% had a master's degree, and 15% possessed other qualifications or certifications.

The respondents represented various industries, with manufacturing being the most prominent (30%), followed by retail (25%), logistics and transportation (20%), IT and technology (15%), and other sectors (10%). Work experience varied significantly, with 40% of respondents having 5–10 years of experience, 35% with over 10 years, and 25% with less than 5 years, highlighting a range of expertise in the field.

In terms of organizational roles, supply chain managers constituted the largest group (40%), followed by operations managers (30%), logistics coordinators (15%), and others (15%). Geographic representation showed a strong urban focus, with 70% of respondents from urban areas, 20% from semi-urban areas, and 10% from rural regions.

Identification of factors

The current study conducted Factor Analysis using Principal Component Analysis with varimax rotation to identify the key components influencing supply chain resilience. The Kaiser-Meyer-Olkin (KMO) measure of sample adequacy yielded a value of 0.872, surpassing the recommended threshold of 0.60. This high KMO value indicates that the sample size is suitable for factor analysis. Additionally, Bartlett's test of sphericity confirmed the adequacy of the data, with a highly significant result at the 1% level. Using the criterion of retaining factors with an Eigenvalue greater than 1, three factors were identified and named as **operational recovery capabilities**, **sustainable practices adoption**, and **collaboration and partnerships**. These three factors collectively accounted for 78.65% of the total variance, indicating a strong factor structure.

- **Reliability Analysis**: The internal consistency of the scale items was evaluated using Cronbach's alpha. The values for all constructs exceeded the recommended threshold of 0.70 (Hair et al., 2010), confirming the reliability of the scales used in the study.
- **Normality Assessment**: Skewness and kurtosis values indicated that the data met the normality assumption, as all values fell within the acceptable range of ±2 (Hair et al., 2010).

Table 2: Constructs loadings, descriptives and reliability

	Loadings	Mean	SD	Skewness	Kurtosis	Alpha
Q1	.879	3.37	.818	-.166	.202	0.905
Q2	.813	3.28	.756	.267	1.029	
Q3	.849	3.43	.781	-.277	.539	
Q4	.822	3.35	.744	.365	.566	
Q5	.895	3.28	.854	-.409	-.690	0.884
Q6	.745	3.47	1.001	-.389	-.327	
Q7	.902	3.34	.968	-.101	-.679	
Q8	.889	3.41	.993	.278	-.261	0.908
Q9	.817	3.27	.776	.255	.829	
Q10	.798	3.19	.767	.140	1.517	
Q11	.893	3.37	.927	.268	.038	

Source: Primary survey

The interpretation of **Table 2** demonstrates the psychometric evaluation of the constructs, focusing on loadings, descriptive statistics, and reliability measures derived from the primary survey. The factor loadings for all items range from 0.745 to 0.902, indicating strong convergent validity, as they exceed the commonly accepted threshold of 0.7. This suggests that the items robustly measure the intended constructs.

The mean values of the items vary between 3.19 and 3.47, reflecting a moderate to slightly positive agreement among respondents. The standard deviation (SD) ranges from 0.744 to 1.001, highlighting moderate variability in responses. Skewness values are close to zero, indicating a symmetrical distribution of data, while kurtosis values range from -0.690 to 1.517, suggesting a distribution shape that is close to normal, with no extreme deviations.

Reliability analysis, measured using Cronbach's Alpha, confirms internal consistency within the constructs. The alpha values for the grouped items (Q1–Q4, Q5–Q7, Q8–Q11) are 0.905, 0.884, and 0.908, respectively, all surpassing the 0.7 threshold. This indicates that the scales are highly reliable for measuring the underlying constructs.

Structure Equation model: The SEM model for **supply chain resilience** was developed using the Maximum Likelihood Estimation method. Hypotheses were evaluated based on the criteria of path coefficients having p-values less than 0.05 and critical ratios (T-values) greater than 1.96.

Figure 1: SEM model for supply chain resilience

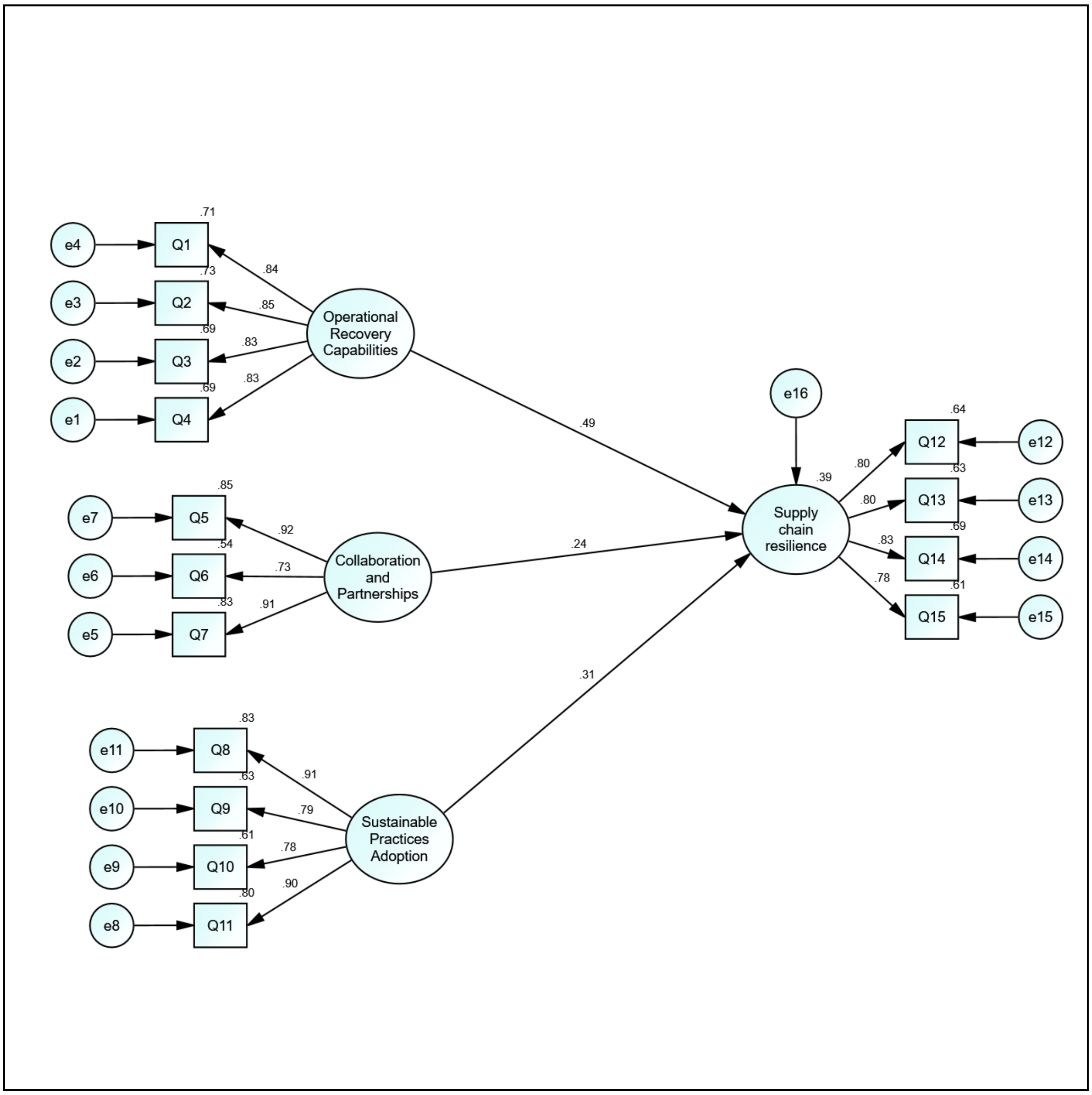

Table 3: Hypothesis results using SEM

Hypotheses	Standardized regression weights (β)	Standard error	Critical ratio (T value)	P value	Result
Operational Recovery Capabilities → Supply chain resilience	0.494	.060	7.510	0.000	H1 accepted
Collaboration and Partnerships → Supply chain resilience	0.235	.038	3.975	0.000	H2 accepted
Sustainable Practices Adoption → Supply chain resilience	0.307	.040	5.109	0.000	H3 accepted

The model fit indices confirm the adequacy of the SEM model. As shown in Table 4, all values meet or exceed the recommended thresholds, indicating strong model fitness.

Table 4: Model Fit indices:

Goodness of fit indices	CMIN/DF	CFI	GFI	AGFI	TLI	NFI	RMSEA
Calculated value	2.121	0.966	0.910	0.872	0.957	0.938	0.067
Criterion	<3	>0.95	>0.8	>0.8	>0.9	>0.8	<0.08

The results in Table 3 and Figure 1 highlight that **Operational Recovery Capabilities** significantly influence supply chain resilience ($\beta = 0.494$, $p < 0.05$), aligning with previous studies that emphasize the importance of swift operational recovery in mitigating supply chain disruptions (Sheffi, 2005). Similarly, **Collaboration and Partnerships** demonstrate a significant influence on supply chain resilience ($\beta = 0.235$, $p < 0.05$), corroborating studies that emphasize collaborative networks as key drivers of resilience (Wieland & Wallenburg, 2013). Lastly, **Sustainable Practices Adoption** shows a positive and significant impact on resilience ($\beta = 0.307$, $p < 0.05$), supporting prior research on the role of sustainable practices in enhancing supply chain agility and long-term performance (Dubey et al., 2017). The p values for all the path is less than 0.05 and T value above 1.96, confirming the acceptance of hypotheses H1, H2 and H3 respectively. The coefficient of determination (R^2) for supply chain resilience is 0.452, indicating that approximately 45.2% of the variance is explained by the selected factors.

4. IMPLICATIONS AND CONCLUSION:

The study offers actionable insights for organizations aiming to enhance supply chain resilience:

Strengthening operational recovery capabilities: Hence there is evidence that organisations should ensure that resources, technologies and training programs are established so that operation recovery speed during disruption is enhanced.

Adopting sustainable practices: Managers are advised to work on the full incorporation of sustainability into the supply chain within their organizations, for example , in enhanced resource management and minimized negative effects on the environment.

Enhancing collaboration and partnerships: This improves flow of information vital during the disruptions with suppliers and other stakeholders in order to ensure close cooperation.

The study proves that operational recovery capacities endurance and cooperation and supply chain integrated resilience is affected. However, future studies may embrace other variables including digitisation, and risk management strategies to add value to best understanding supply chain resilience. Longitudinal investigations might also support temporal and cross industrial patterns of these relations.

Suggestions

1. Integrating Digital Technologies: The actors in the supply chain need to embrace artificial intelligence and other emerging technologies such as predictive analysis, block chain technology and digital twin to improve vision and response time to disruptions. It is most helpful in the development of true cooperation in real time.

2. Strengthening Collaborative Networks: Vendor relations are critical, and a company needs to maintain cooperative relationships with its suppliers, logistics companies and other associates. There is a need also for the organizations to have partnership relationships and contracts in terms of resources, knowledge and risk management measures in disruption events.

3. Emphasizing Sustainable Practices: Sustainability does not only limit harm to the environment but also brings new resources into play and increases stakeholders' confidence. This is green logistics, efficient uses of energy and gaining of products and services from environment friendly sources.

4. Tailored Resilience Strategies for SMEs: Public policies and business initiatives should take into consideration that SMEs usually have a lack of resources and poor IT adoption. Such PC is fill up by subsidised provision of these instruments and training programs.

5. Scenario Planning and Training: Having set schedules for running through potential disaster scenarios and frequently providing the necessary employee training means that performance of supply chain teams is faster and more efficient in the

case of disruptions.

5. CONCLUSION

This research emphasizes the role and significance of operational recovery capabilities, integration, and n collaborations to creating a sustainable supply chain. The results corroborate that quick restoration of the operational state supported by solid structures and procedures, is the starting point. Additionally, Integration promotes information and resource sharing and Supply chain sustainability addresses environmental and social risk in supply chain management for the future. To achieve the desired organizational resilience organizations will need to take a systems level approach involving technology, strategic partnerships and sustainability. These measures do not only help in providing protection against disruption but also prepare the supply chain to excel in the uncertain and complex world economy.

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