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Optimizing Organizational Agility: The Symbiotic Impact of AI-Enhanced Supply Chain Collaboration and Risk Management on Performance and Flexibility †

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Abstract: The purpose of this study is to examine whether there are complex interrelationships between supply chain collaboration, adoption of artificial intelligence, and the resulting risk management performance, with potential effects on organizational performance, supply chain performance, and supply chain flexibility. The data for this study were obtained from the answer questionnaires distributed in leading business and management universities in Karachi; out of 400 questionnaires disseminated, 384 were returned and filled with the responses. The data were analyzed using the Partial Least Squares–Structure Equation Modeling (PLS-SEM) approach. Among the six hypotheses tested in this particular study, it was revealed that none of the tested hypotheses were rejected at its level. These findings and recommendations gain more importance with the changing nature of the supply chain network and outlook toward sustainable practice.

Keywords: supply chain collaboration; risk management performance; supply chain resilience; artificial intelligence; organizational performance; supply chain flexibility; supply chain performance

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1. Introduction

Recent studies have mentioned that market instability, variable demand, shortening product lifecycles, and natural calamities contribute to serious supply chain disruptions to the concerned companies [1]. Researchers and practitioners must design the required supply chain systems whose robust structures will stand any interruptions and adverse changes that destroy the entire system [2]. The SCR concept has gained increasing popularity in recent years. Supply chain resilience has been defined by [3] as an organization's ability to resume programs that have been disrupted in some way by unforeseen shocks to their supply chain. Supply chain resilience (SCR) represents the inherent capacity of a supply chain against any uncertainty where the severity cannot be fully met by proactive engagement to absorb impacts, manage adaptation, and, after overcoming, maintain its initial performance [4]. Prior research on resilience and recovery in the supply chain has been focused on measuring the level of response and recovery resilience before development [5]. Many researchers and business experts opine that the food supply chain has to be better managed so that it can remain resilient in the face of significant disruptions posed by the raging pandemic [6]. This study seeks to establish the relationship that prevails between supply chain resilience and other factors that are associated with supply chain flexibility, organizational performance, supply chain performance, risk management performance, and artificial intelligence in the supply chain.

2. Theory Development and Literature Review

2.1. Organizational Information Process Theory (OIPT)

With respect to the sustainability and resilience of the supply chain, organizational information processing theory is a very fitting and relevant lens. This notion assumes the view that organizations can make decisions and change their environment by taking in, analyzing, and using information. Based on the adaptation of this notion, companies can form more resistant supply chains against any disturbances and consequently contribute to providing beneficial effects to social and environmental sustainability.

2.2. Supply Chain Collaboration

The complete term, with reference to collaboration in supply chains, can mean working with other intrinsic suppliers and outside partners to keep the flow across the supply chain at optimal levels. It enhances on-time delivery and completeness in meeting demand [7].

2.3. Artificial Intelligence

Artificial intelligence is "the power of learning by the observations of external world phenomena with a capacity of changing existing planes accordingly, or creation of totally new ones under changes in conditions [8]".

2.4. Performance in Risk Management

Risk-based performance management aims to help businesses maintain strategy realization by connecting business strategy, performance management, and risk management [9].

2.5. Supply Chain Resilience

This concept is defined as an operational capability of the supply chain through which a supply chain that has been disrupted recomposes itself in such a way that the state it acquires after the disrupting incident is no worse than its state before the occurrence of the disruption [10].

2.6. Performance in Supply Chains

It appraises the perfection level of each business supply chain division, which needs the integration of several player segments such that the business supply chain functions to meet and optimize costs, inefficiency, and speed [1].

2.7. Supply Chain Flexibility

Supply chain flexibility refers to the capacity of each participant in the chain to adapt to changing environmental circumstances and fulfill diverse consumer demands without incurring unanticipated expenses, delays, organizational disturbances, or performance setbacks [11].

2.8. Conceptual Framework and Hypotheses Development

Based on the above theories and theoretical discussion (in the following sections), we have proposed a model with six hypotheses. The conceptual framework presented in Figure 1 shows the developed hypotheses.

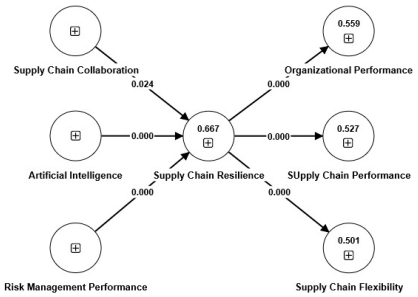


Figure 1. Conceptual framework.

2.8.1. Supply Chain Collaboration and Supply Chain Resilience

According to Nwagwu, Niaz, Chukwu, and Saddique [12], it is critical for the development of supply chain resilience for suppliers to establish collaborative relationships.

H1. *Supply chain collaboration has a positive influence on supply chain resilience.*

2.8.2. Artificial Intelligence and Supply Chain Resilience

There is a substantial effect on supply chain resilience from the widespread availability, high accuracy, and openness offered by digital technology [13].

H2. *Artificial intelligence has a positive influence on supply chain resilience.*

2.8.3. Risk Management Performance and Supply Chain Resilience

Research in the supply chain focuses on the relationship between the chain's resilience and the effectiveness of risk management. There is evidence to show that if appropriate risk management is in place, supply chains can be very resilient [14].

H3. *Risk management performance has a positive impact on supply chain resilience.*

2.8.4. Supply Chain Resilience and Organizational Performance

Even though substantial research on SCR and a significant amount of empirical evidence showing its importance exist, some have argued that it is a research area that has been neglected in recent years [15].

H4. *Supply chain resilience positively influences organizational performance*.

2.8.5. Supply Chain Resilience and Supply Chain Performance

The past literature indicates that the development of SCR is very crucial for minimizing risks and maintaining proper SCP levels [16].

H5. *Resilience in supply chain has a positive effect on supply chain performance*.

2.8.6. Supply Chain Resilience and Supply Chain Flexibility

According to [17], agility, also known as flexibility, greatly improves the resilience of supply chains. This is because agility offers strategic value in risk mitigation while requiring very little investment in flexibility.

H6. *Supply chain resilience has a positive influence on supply chain flexibility*.

3. Methodology

The study's sample size was 387, with a chance of error of around 5% and a 95% confidence level. We chose to focus on the top business schools in Karachi because their students have prior knowledge about supply chains. The authors selected six enumerators who visited the target universities and gathered the information. A total of 425 questionnaires were distributed, and 415 were returned, which is a respectable response rate.

3.1. Questionnaire Design

This study's questionnaire is divided into two sections. The first portion deals with demographic knowledge, which we calculated on a nominal scale. The second section discusses the main study. It has 21 items rated on a five-point scale and 7 factors, as shown in Table A1 in the annexure.

3.2. Common Method Bias

According to [18], a common method bias occurs as a result of variations in responses collected by the study instrument. As a result, by adhering to the necessary protocol, the study decreased the likelihood of the common method biases.

4. Results

4.1. Descriptive Analysis

The conclusion after the results show that the highest Cronbach's alpha values are for organizational performance (α 0.881) and the lowest are for supply chain performance (α 0.759), as shown in Table 1. Based on the information gathered from Karachi, Pakistan, it is suggested that the constructs have acceptable internal consistency.

Table 1. Descriptive analysis.

	Cronbach's Alpha	Composite Reliability	AVE
Artificial Intelligence	0.780	0.872	0.680
Organizational Performance	0.881	0.927	0.920
Risk Management Performance	0.875	0.923	0.656
Supply Chain Performance	0.759	0.861	0.916
Supply Chain Collaboration	0.854	0.911	0.944
Supply Chain Flexibility	0.801	0.883	0.960
Supply Chain Resilience	0.760	0.862	0.754

4.2. Discriminant Validity

The findings indicate that the constructs used in the study are distinct and one-of-a-kind because the square root of AVE values is higher than the Pearson correlation values [19]. The study has proposed six direct hypotheses, shown in Table 2. The bootstrapping method is used to check the hypotheses.

Table 2. Discriminant Validity.

	AI	OP	RMP	SCP	SCC	SCF	SCR
Artificial Intelligence	0.834						
Organizational Performance	0.696	0.899					
Risk Management Performance	0.646	0.560	0.894				
Supply Chain Performance	0.704	0.905	0.585	0.823			
Supply Chain Collaboration	0.833	0.706	0.632	0.648	0.880		
Supply Chain Flexibility	0.835	0.687	0.626	0.656	0.932	0.847	
Supply Chain Resilience	0.777	0.748	0.688	0.726	0.714	0.707	0.822

4.3. Findings and Discussion

The results obtained from Table 3 show that AI builds a foundation for the development of a resilient supply chain for both operation and organizational performance. This resilience further increased as a result of efficient risk management with collaboration efforts made within the supply chain. According to [20], this is because AI enhances resiliency in the supply chain. More importantly, supply chain resilience ensures outstanding organizational performance, enhances flexible supply chain performance, and increases the ability to manage change effectively—all key qualities necessary for firms to adapt to dynamic markets. According to [21], the concept of supply chain resilience is characterized by a source of competitive advantage through its capacity or ability to recover from the impact of disruptions within the system promptly. [22] It is posited that building flexibility into supply chains for enhancing resiliency is yet one more measure to gain a competitive edge in the market.

Table 3. Hypotheses Results.

	B	T Stats	*p* Values	Results
Artificial Intelligence → Supply Chain Resilience	0.066	7.202	0	Accepted
Risk Management Performance → Supply Chain Resilience	0.049	6.153	0	Accepted
Supply Chain Collaboration → Supply Chain Resilience	0.057	2.25	0.024	Accepted
Supply Chain Resilience → Organizational Performance	0.025	29.532	0	Accepted
Supply Chain Resilience → Supply Chain Performance	0.027	27.055	0	Accepted
Supply Chain Resilience → Supply Chain Flexibility	0.027	26.062	0	Accepted

5. Conclusions

The study has increased and spread the theoretical support to develop a model to examine supply chain resilience. The study has examined and proposed the effect of factors (i.e., supply chain collaboration, artificial intelligence, risk management performance, organizational performance, supply chain performance and supply chain flexibility) on supply chain resilience. Artificial intelligence (AI), risk management performance, and supply chain collaboration are significant predictors of supply chain resilience, with each demonstrating a positive and statistically significant impact. The robust results confirm the acceptance of these relationships. Furthermore, supply chain resilience is shown to have a crucial influence on organizational performance, supply chain performance, and supply chain flexibility, confirming the hypothesis that resilience within the supply chain is not only beneficial but essential for the overall health and adaptability of an organization. These findings highlight the importance of investing in AI and fostering a collaborative and well-managed risk environment to build a resilient supply chain that supports and drives organizational success.

5.1. Theoretical Implications

This study's theoretical contributions come from its conceptual framework. Supply chain resilience can be better understood by using OIPT, DCT, and SCRT in the field. This will allow us to identify the factors that influence supply chain performance, organizational performance, and SCM flexibility.

5.2. Practical and Managerial Implications

Businesses that want to build SCR and perform better under difficult situations might benefit from this study's contributions to two important managerial concerns. The primary objective is to maximize the firm's performance by utilizing its absorptive power. Interorganizational ties are a treasure trove of useful information for most companies. However, some of these crucial assets risk going unused if they are not put to use in the fight against threats and hardships. Companies should build up their collaboration ability and improve it if they want to obtain the most out of SCR.

5.3. Limitations and Future Recommendations

The difficulty of determining causality and directionality among variables, the influence of unaccounted contextual factors, evolving technology dynamics, inadequate consideration of practical implementation challenges, and the need for a deeper understanding of the mechanisms underlying supply chain resilience are some examples of limitations. Future studies should consider longitudinal studies, sector-specific analyses, qualitative research for useful insights, intervention studies to test strategies, examination of the influence of external factors, and benchmarking to identify best practices, all of which will advance our understanding of the complex dynamics that shape modern supply chains.

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Appendix A

Table A1. Scale and Measurement.

Variables	Reference's	Items
Supply Chain Resilience	[23]	3
Supply Chain Collaboration	[23,24]	3
Artificial Intelligence	[24]	3
Risk Management Performance	[25]	3
Organizational Performance	[26]	3
Supply Chain Performance	[27]	3
Supply Chain Flexibility	[23]	3

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