Operational Research in Engineering Sciences: Theory and Applications
Vol. 7, Issue 2, 2024, pp. 373-394
ISSN: 2620-1607
eISSN: 2620-1747
DOI: https://doi.org/10.31181/oresta/070218

LOGISTICS INTEGRATION INFORMATION SYSTEM ENABLERS INFLUENCE ON OPERATIONS EFFICIENCY THROUGH SUPPLY CHAIN RISK MANAGEMENT: THE MODERATING ROLE OF SUPPLY CHAIN COMPLEXITY

Mohammed A. Al Doghan[1*], Sanjar Mirzaliev[2]

[1]Department of Management, College of Business, King Faisal University, Al-Ahsa 31982, Saudi Arabia.
[2]Tashkent State University of Economics, Uzbekistan.

Received: 20 February 2024
Accepted: 15 June 2024
First Online: 05 July 2024

Research Paper

Abstract: *The study aimed to analyze the impact of information sharing, management information systems, and technology integration on operations logistics integration to improve operational efficiency. The study also tested the mediating effect of supply chain risk management and the moderating role of supply chain complexities in the context of Saudi Arabian manufacturing companies. Cross-sectional quantitative data was collected from 320 manufacturing companies' employees through self-administered questionnaires which were distributed through a convenient sampling technique. The SEM results show that information sharing, management information sharing, and technology integration positively and significantly impact operational logistics integration. Further operations logistics integration and supply chain risk management also positively and significantly impact on operational efficiency. The indirect mediating effect showed that supply chain risk management was not significantly mediated between operations logistics integration and operational efficiency. In contrast, moderating effect results also show that supply chain complexity significantly strengthens the relationship between operations logistics integration and operational efficiency. These findings contributed that increasing, management information systems, information sharing, and technology integration is crucial for improving operational logistics integration. Besides, organizations should consider the role of supply chain complexity in strengthening the relationship between logistics integration and operational efficiency.*

Keywords: *Operational Efficiency, Management Information System, Supply Chain Risk Management, Technology Integration.*

*Corresponding Author: mdoghan@kfu.edu.sa (M. A. A. Doghan), s.mirzaliev@tsue.uz (S. Mirzaliev)

1. Introduction

In the current competitive environment, operational efficiency has become an important factor for the success of organizations (Nguyen et al., 2018). Operational efficiency represents how a company can deliver its products, minimize costs, and maintain the high quality of its products (Ajiga et al., 2024). This is the reason, the organization achieving operational efficiency is not only important for productivity but it is also important for increasing the satisfaction of the customers (Akinsulire et al., 2024). As companies strive to optimize their operations, logistics integration emerges as a key component in streamlining processes and aligning resources throughout the supply chain (Judijanto et al., 2024). Manufacturers can ensure a smoother flow of information and materials by effectively integrating logistics functions, ultimately improving operational efficiency (Mugoni et al., 2023). Logistics integration becomes an important factor in increasing the firm's operational efficiency because it involves coordinating different logistics activities like warehousing, inventory management, and transportation (Tongzon & Nguyen, 2021). Effective logistics integration also enhances prominence across the supply chain, allowing manufacturers to identify inefficiencies and areas for improvement (Zacharias & Boopathy, 2022). This holistic approach not only streamlines operations but also strengthens relationships with suppliers and customers, leading to a more resilient supply chain. Therefore, focusing on logistics integration is crucial for manufacturing firms looking to be competitive globally (Judijanto et al., 2024). In this regard, the study focused on the association concerning operational logistics integration and operational performance.

As logistics integration becomes an integral factor in improving operational efficiency. Researchers argued that different determinants contribute to enhancing logistics integration, especially information sharing, technology integration, and management information systems (Bhima et al., 2023; Uddin, 2023). Among these factors, information sharing in the supply chain partners helps in taking better decision making to handle the market changes (Ma & Zhang, 2024). By exchanging data which is a reality regarding the inventory level, and production schedules, manufacturers can coordinate their operations more effectively (Valashiya & Luke, 2023) which leads to improved operational efficiency. Moreover, technology integration also helps to encompass advanced technologies to boost logistics capabilities by automating processes and providing valuable insights through data analytics (Zheng & Zhou, 2023). Similarly, management information systems play an essential role in consolidating information and streamlining communication across the supply chain, making organizations operate more efficiently (Di Capua et al., 2023). Seeking, previous studies relationship study, it is important to test the impact of information sharing, technology integration, and management information on operational efficiency through logistics integration.

Extant studies of the association of logistics integration with operational efficiency have been tested but various authors argued that supply chain complexity helps to increase the logistics integration to increase the organization's efficiency (Al-Rawashdeh et al., 2023). The supply chain consists of different factors for the management of different interdependent components, such as multiple suppliers, distribution channels, and diverse customer requirements (Iftikhar et al., 2023). As supply chains grow more complex, the effectiveness of logistics integration efforts can vary which influences how well operational efficiency is achieved. This complexity can

introduce significant challenges in communication and coordination, potentially undermining the positive impacts of logistics integration on operational efficiency (Chatha & Jalil, 2022). Understanding how supply chain complexity increases logistics integration helps to increase operational efficiency for manufacturing firms (Isik, 2011). It can help them make informed strategic decisions and allocate resources effectively in an increasingly complex operational environment (Isik, 2011). Addressing these complexities is crucial for manufacturers to fully leverage logistics integration to enhance their operational efficiency and maintain competitiveness in the market (Al-Rawashdeh et al., 2023). Therefore, the study focused on the impact of operations logistics integration through supply chain complexities.

After seeking the significant relationship in the extant studies, various gaps still exist in the extant literature that could be addressed in the current study. For instance, most of the previous studies are mainly directed or individual variable influence namely information sharing, technology integration, and management information systems on operational performance, without adequately addressing the interconnectedness of these factors within a holistic logistics framework systems (Bhima et al., 2023; Kedi et al., 2024; Uddin, 2023; Zheng & Zhou, 2023). Previous studies found that supply chain risk management significantly mediates (Waqas et al., 2023). Furthermore, in the study of Uddin (2023), supply chain risk management was used as a mediating effect between information sharing and operational performance but ignored the management information system. Therefore, to address previous gaps, the study focused on the supply chain risk management as a mediator. Furthermore, the relationship between logistics integration and operational efficiency is not clear (Kedi et al., 2024; Uddin, 2023). Extant studies have also shown the lack of empirical evidence specifically examining the moderating effects of supply chain complexity on the logistics integration-efficiency relationship, especially in the context of manufacturing firms (Bhima et al., 2023; Kedi et al., 2024; Uddin, 2023; Zheng & Zhou, 2023). This oversight limits the understanding of how these complex dynamics affect operational outcomes in a rapidly evolving business environment. Furthermore, much of the extant literature tends to concentrate on Western contexts, leaving a substantial gap regarding the applicability of these findings to the unique cultural and economic conditions of Saudi Arabia. Addressing these gaps could provide valuable insights for manufacturers in the region, enabling them to leverage logistics integration effectively to enhance operational efficiency. Therefore, to address previous gaps, the study aimed to test the impact of information sharing, management information systems, and technology integration on logistics integration to improve operational efficiency. The study also tested the mediating effect of supply chain risk management and supply chain complexities in the context of Saudi Arabian manufacturing companies.

The study with the objective holds significant values from both theoretical and practical perspectives of Saudi Arabian manufacturing companies' context. Theoretically, the study contributed to a body of literature to extend the knowledge by clarifying the interrelationships among logistics integration, information sharing, technology integration, management information systems, and operational efficiency within the context of the Saudi manufacturing sector. Through integrating these constructs into a cohesive framework, the study enhances understanding of how these elements interact, especially regarding the moderating effects of supply chain complexity. From a practical perspective, study findings contributed different valuable

insights for the manufacturing firms to raise operational efficiency by recognizing the critical role of logistics integration and supply chain complexities. This study serves as a foundational reference for policymakers and industry leaders seeking to raise a more integrated and efficient manufacturing environment in Saudi Arabia

2. Literature Review

2.1 Information Sharing and Operations Logistics Integration

Information sharing is an important component of the management of supply chain operations which provides transparency that supports logistics integration in various operational activities (Xu & He, 2024). In other words, Valashiya & Luke, (2023) defined that it also helps to increase collaborations and enable faster response timely. Extant studies highlighted the importance of information-sharing capabilities for logistics integration (Valashiya & Luke, 2023). Sundram et al. (2020) further established that data sharing helps coordinate logistics activities, reducing lead times and improving service delivery across the supply chain. Similarly, Vafaei-Zadeh et al. (2020) found that robust information-sharing systems directly correlate with enhanced operational logistics integration, especially in data-driven environments where supply chain disruptions are frequent. Zheng & Zhou, 2023) also added that such integration allows firms to manage their logistics operations efficiently, achieving higher flexibility and alignment in dynamic market conditions. However, some researchers argued that information sharing can only be effective if data is reliable and security measures are in place to maintain trust between partners (Ma & Zhang, 2024). The research is further consistent with the study of (Bhima et al., 2023; Uddin, 2023) where they highlighted that transparent information exchange leads to reduced lead times and improved inventory management. In an environment where manufacturing firms face increasing competition and pressure to meet customer demands, the ability to share timely and accurate information becomes paramount Based on extant studies confirm that information sharing significantly affects operational logistics integration by improving visibility, raising trust, and reducing operational friction.

2.2 Technology Integration and Operations Logistics Integration

Technology integration helps to integrate digital tools in the logistics functions to improve the operational coordination in the organization. Technology integration helps to improve the logistics integration of the organization by providing proper digital technology and good infrastructure (Judijanto et al., 2024). The same findings have been concluded where the technology integration and logistics integration relationship was positive and significant (Fernando, Wahyuni-TD, et al., 2023). Zheng & Zhou, (2023) also found that digital transformation enables real-time tracking and predictive analytics, which directly enhance logistics integration. Dexter and Richardson (2020) also found that companies adopting advanced technological tools reported greater logistics cohesion and adaptability to market changes. Rejeb et al, (2021) further highlighted that firms with a high level of technological integration can streamline logistics activities, therefore reducing costs and enhancing operational performance. These findings underscore the positive effect of technology integration on logistics integration, although some scholars argued that technological investments

require careful alignment with company strategies to achieve full benefits (Sun et al., 2022). In another study, Ewuga et al. (2023) also found the positive and significant impact of technology integration on logistics integration. They also further argued that further relationships could be tested in other countries to know the variation in the results. Previous studies are further consistent with the study of (Samad et al., 2023; Zheng & Zhou, 2023) who support this finding by noting that technology enables quicker decision-making and more agile responses to market demands. In a rapidly changing business setting, the ability to adapt to fluctuations in demand is crucial for maintaining a competitive edge. These previous studies have shown that technology integration plays a significant role in facilitating logistics integration, provided that companies align their tech adoption strategies with operational needs.

2.3 Management Information System and Operations Logistics Integration

The management information system also plays an integral role in the handling and managing of information in the organization which helps to provide better decision-making in organizations (Purnomo et al., 2023). In another context, MIS also increases logistics integration through the restructuring of information flow across various logistics functions (Ragazou et al., 2023). This argument is further supported by the study of Bhima et al, (2023) where the findings also show that MIS enhances visibility and control over logistics processes (Ragazou et al., 2023). Diawati et al, (2023) also found that companies with strong MIS capabilities improved logistical coordination, allowing for timely responses to operational challenges. Furthermore, Rachmad et al, (2024) observed that MIS implementations are essential for reducing communication gaps and promoting process standardization, which raises logistics integration. However, it is also argued d that the success of MIS depends on user competency and data quality, signifying that firms need to invest in training and system maintenance to maximize integration benefits (Okolo et al., 2024). A further empirical study of Ajiga et al, (2024) also found a positive and significant impact of management information systems on logistics integration. The results are consistent with the study of (Bhima et al., 2023; Uddin, 2023) where they highlighted that transparent information exchange leads to reduced lead times and improved inventory management. In an environment where manufacturing firms face increasing competition and pressure to meet customer demands, the ability to share timely and accurate information becomes paramount Extant literature has shown that management information sharing has a substantial impact on logistics integration through centralizing data and enhancing decision-making capabilities, although it requires adequate user training to achieve optimal results.

2.4 Operations Logistics Integration and Operational Efficiency

Operational efficiency which shows the ability how minimize waste could help to maximize the output which is increased from the better logistics integration in a company (Al-Dweiri et al., 2024). This argument is reflected in the study of lo Storto & Evangelista, (2023) where they found that logistics integration enhances efficiency by creating a cohesive flow of goods and services, reducing redundancies. Mugoni et al, (2023) add that firms with high logistics integration experience smoother operations, which improves their general response time and adaptability in competitive environments. Similarly, Mpuon et al, (2023) demonstrated that logistics integration

supports operational efficiency by ensuring resource optimization, ultimately leading to cost savings. However, the degree of this impact may vary and this could affect differently to improve operational efficiency (Sriboonlue et al., 2024). Another empirical study also found that logistics integration has an impact on the operational efficiency of organizations. Sriboonlue et al, (2024) also concluded that logistics integration significantly influences operational performance and they also argued that further research could be explored on other countries with other relationships. Previous studies have shown that logistics integration significantly contributes to operational efficiency.

2.5 Supply Chain Risk Management and Operational Efficiency

The supply chain risk management should that how the risk could be identified during the supply chain operations performance (Munir et al., 2020). In other words, supply chain risk management increases operational efficiency by providing better risk assessment operations (Fernando, Tseng, et al., 2023). Wong et al. (2024) also explored SCRM practice's effect on operational efficiency where they found proactive risk management minimizes disruptions, thus maintaining efficient operations. Zhan et al. (2024) also observed that SCRM contributes to operational stability by reducing vulnerabilities and ensuring smoother production flows. Additionally, (Kauppi et al., 2016) found that companies that integrated SCRM into their logistics operations managed to maintain higher levels of efficiency, especially in industries prone to high variability and uncertainty. However, critics argued that SCRM practices can sometimes increase operational costs, potentially offsetting efficiency gains (Aghapour et al., 2017). Generally, SCRM positively affects operational efficiency, firms must balance risk management practices with cost considerations. In the same vein, (Fernando, Tseng, et al., 2023 further findings show that supply chain risk management also has a positive and significant impact on the operational efficiency. These findings show the importance of proactive strategies in stabilizing operations among potential disruptions. The same findings are concluded with the study of (Munir et al., 2020; Rezki & Mansouri, 2024). These previous studies shown that supply chain risk management is an integral component for operational efficiency.

2.6 Mediating Effect of Supply Chain Risk Management

Previous studies indicated supply chain risk management is a significant indicator of operational efficiency. In the same vein, logistics integration also improves the operational efficiency of the organizations. These relationships were tested directly but ignored with mediated effects. Based on these relationships mediating role of SCRM between logistics integration and operational efficiency because authors argued that supply chain risk management is a significant mediator (Waqas et al., 2023), particularly in the study of (Waqas et al., 2023) suggested that supply chain risk management provides an added layer of stability to logistics integration efforts, enhancing operational efficiency. Further study by (Odimarha et al., 2024) confirms this view, showing that firms with strong logistics integration and supply chain risk management practices achieve higher efficiency through mitigating risks that would otherwise disrupt operations. Qiao & Zhao, (2023) further added the view that integrating risk management into logistics operations allows firms to handle unexpected disruptions better, therefore maintaining operational efficiency. Some studies, however, suggest that the benefits of this mediating effect are contingent on the firm's risk tolerance and resource allocation to supply chain risk management

(Tukamuhabwa et al., 2023). Moreover, extant studies focused on the direct and individual influence of information sharing, technology integration, and management information systems on operational performance, without adequately addressing the interconnectedness of these factors within a holistic logistics framework systems (Bhima et al., 2023; Kedi et al., 2024; Uddin, 2023; Zheng & Zhou, 2023). Previous studies found that supply chain risk management significantly mediates (Waqas et al., 2023). Furthermore, Uddin (2023) argued that supply chain risk management was used as a mediating effect between information sharing and operational performance but ignored by the management information system. Thus, these previous studies recommended that the effect mediator can be used in supply chain risk management.

2.7 Supply Chain Complexity as a Moderator

The association of logistics integration with operational efficiency has been tested but still relationship is still not clear. Therefore, based on the inconsistencies, authors argued that supply chain complexity helps to increase the logistics integration to increase the organization's efficiency (Al-Rawashdeh et al., 2023). The supply chain consists of different factors for the management of different interdependent components, such as multiple suppliers, distribution channels, and diverse customer requirements (Iftikhar et al., 2023). As supply chains grow more complex, the effectiveness of logistics integration efforts can vary which influences how well operational efficiency is achieved. This complexity can introduce significant challenges in communication and coordination, potentially undermining the positive impacts of logistics integration on operational efficiency (Chatha & Jalil, 2022). Therefore, the supply chain could be used as a moderating variable because Al-Rawashdeh et al, (2023) found that high supply chain complexity can hinder logistics integration efforts that could minimize operational efficiency. On the other hand, Iftikhar et al, (2023) argued that with adequate integration tools, the firms could manage complexity effectively which could increase supply chain operations. Isik, (2011) further posited that supply chain complexity requires advanced integration strategies to maintain the efficiency of the organizations. Thus, based on the previous discussion, supply chain complexities could be used as a moderating variable because the level of complexity either enhances or constrains operational efficiency depending on integration capabilities.

2.8 Conceptual Framework and Hypothesis Development

After reviewing the literature various gaps have been identified. Extant studies mainly focused on the direct and individual effect of information sharing, technology integration, and management information systems on operational performance, without adequately addressing the interconnectedness of these factors in one research framework. Furthermore, previous studies also have mainly focused on the direct effect of logistics integration while ignoring the mediating effect of supply chain risk management significantly. Therefore, to address the previous gap, research used operations logistic integration as a moderating variable. Furthermore, the connection among logistics integration and operational efficiency is not clear. Extant studies have also shown the lack of empirical evidence specifically examining the moderating effects of supply chain complexity on the logistics integration-efficiency relationship, especially in the context of manufacturing firms in Saudi Arabia. Therefore, this study

fills this gap, study used as moderator is supply chain complexity. After identifying the various gaps, the current study has formulated the current research framework in Figure 1 below,

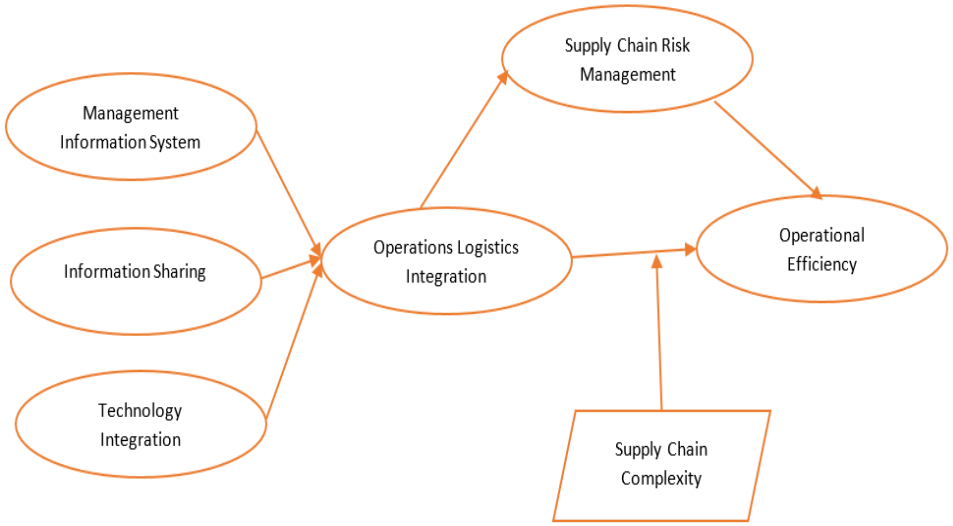

Figure 1: Research Framework

The study has the following research hypothesis below which is formulated from an extensive review of literature from both theoretical and empirical perspectives.

H1: *Information sharing has a significant effect on operations logistics integration.*
H2: *Technology integration has a significant effect on operations logistics integration.*
H3: *Management information system has a significant effect on operations logistics integration.*
H4: *Operations logistics integrations have a significant effect on operations efficiency.*
H5: *Supply chain risk management has a significant effect on operational efficiency.*
H6: *Operations logistics integration significantly affects operations efficiency with the mediating effect of supply chain risk monument.*
H7: *Operations logistics integration significantly affects operations with the moderating effect of supply chain complexity.*

3. Methodology

3.1 Research Strategy

Researchers often utilize surveys to gather data from organizations or individuals. Surveys are especially effective for studies that seek to measure both independent and dependent variables, allowing for the rapid collection of participant information (Amin et al., 2022). This method involves gathering data about people's knowledge, attitudes, and behaviors, making it a valuable tool for description, comparison, and explanation. Sierles, (2003) pointed out that surveys are relatively cost-effective, especially when self-administered, and they provide a unique ability to describe characteristics of large populations that few other observational methods can match.

Given the time and budget constraints for data collection, employing the survey method proves to be a practical choice for research. Therefore, the current study has used the survey to collect the data.

Survey instrument adopted from the extant literature. Logistics integration was measured by four questions (Alam et al., 2014), and technology was also measured by five items (Alam et al., 2014). Management information systems comprise three items Chapman & Kihn, (2009). Information sharing is also measured by three items (Liu et al., 2015). Further supply chain risk management was measured from 3 items which were taken from (Uddin, 2023). Supply chain complexity is measured by four items (Chand et al., 2022). Lastly, operational efficiency was measured by 8 items (Al Yami et al., 2022). The above items were measured on five-point scale items which were ranked 1 for strongly disagree and 5 for strongly agree.

3.2 Research Design

The research used the quantitative research approach for testing hypotheses through a systematic and scientific method to quantify data (Bloomfield & Fisher, 2019). The research approach was aligned with the research objectives. A cross-sectional approach was adopted where data collected in one time frame (Sekaran, 2016). This involved gathering survey data from one organization, reflecting a snapshot of the variables under study. Cross-sectional research often employs various survey techniques to obtain data, integrating multiple quantitative methods for a comprehensive analysis (Sekaran, 2016). Therefore, a study has used this research design for the current study.

3.3 Population, Sampling, and Sample Size

Study population was manufacturing company's employees in Saudi Arabia. The data was collected from these participants through the self-administered survey instrument The population was limited to employees within these manufacturing firms, ensuring that respondents had the necessary information to address study objectives (Sekaran, 2016). The goal of selecting these participants was to gain an in-depth understanding of the phenomena under investigation. A sample size greater than 30 and fewer than 500 is considered suitable for many studies (Sekaran, 2016). For this research, convenience sampling was utilized to effectively recruit participants. The convenience sampling technique was especially useful in this context, as it facilitated the collection of data from a sufficient number of employees addressing time constraints and reducing costs (Etikan et al., 2016). The total questionnaires were distributed to 450 employees of manufacturing companies in Saudi Arabia. Among those 330 were returned where 320 were useable for further analysis. The collected data were analyzed through SPSS and AMOS.

3.4 Respondents Profile

Below Table 1 shows the demographic characteristics of the respondents of manufacturing companies in Saudi Arabia. Among the respondents of the employees, there were 62.5% were male as compared to females which shows more respondents as compared to females Saudi Arabia is not a female dominant society, especially in the corporate sector. The age distribution shows a strong presence of younger

workers, with 46.9% falling within the 25-34 age group, indicating a workforce that is relatively young and potentially open to innovation and new technologies. Educational attainment is notably high, with 56.3% of employees holding a Bachelor's degree, which suggests a skilled labor force equipped to handle the demands of modern manufacturing processes. Furthermore, the years of experience data reveal that a significant portion of employees (56.3%) have 5 years or less of experience, which may imply a fresh influx of talent and perspectives within the industry. The above results are predicted in Table.1 below,

Table 1: Demographic Characteristics

Demographic Variable	Category	Frequency (N)	Percentage (%)
Gender	Male	200	62.5
	Female	120	37.5
Age Group	18-24 years	50	15.6
	25-34 years	100	31.3
	35-44 years	90	28.1
	45-54 years	50	15.6
	55 years and above	30	9.4
Education Degree	High	40	12.5
	Bachelor's	180	56.3
	Master's	70	21.9
	PHD	30	9.4
Years of Experience	0-2 years	80	25
	3-5 years	100	31.3
	6-10 years	80	25
	11 years and above	60	18.8

3.5 Model Fit and Construct Measurement

The measurement model of the study was assessed from three parameters namely absolute fit, incremental fit, and parsimonious fit. In these criteria, for absolute fitness acceptable value for RMSEA is below 0.008 and the GFI value is above 0.90 (Hair et al., 2017). The initial measurement model in this study achieved an acceptable RMSEA value of 0.066, but the GFI value was suboptimal at 0.851. Regarding incremental fit, the threshold for AGFI, CFI, TLI, and NFI is a value above 0.90 (Hair Jr et al., 2020). In this model, CFI (0.929) and TLI (0.919) met these criteria, and AGFI (0.913) and NFI (0.925) met the threshold values. Lastly, the parsimonious fit was evaluated with Chisq/df, which should be below 3.0 (Hair Jr et al., 2020). The model met this criterion, as the Chisq/df value was 1.928, indicating a satisfactory parsimonious fit. The previous values show the model's fitness of the constructs.

After the constructs model fitness, the next step is to assess the model from “factor loadings, composite reliability (CR), alpha, and average variance extracted (AVE)” which are considered to be a critical indicator. Among these factor loadings represent the correlation between observed variables and their underlying latent constructs, with loadings of 0.70 or higher indicating strong item-construct alignment (Hair et al., 2017). For construct reliability, CR values should exceed 0.70 to indicate adequate internal consistency, and an acceptable value for alpha is also greater than 0.70. Table 2 predicted values show that all factors loadings and alpha values were greater than above threshold holds values which shows the construct convergent validity.

Table 2: Construct Descriptive and Reliability

Constructs	Coding's	Mean	SD	Loading	Alpha	Standardized Regression Weight
Information Sharing	IS1	3.275	0.682	0.845	0.869	0.812*
	IS2	3.312	0.734	0.853		0.821*
	IS3	3.31	0.688	0.862		0.837*
Technology Integration	TI1	4.215	0.723	0.81	0.863	0.852*
	TI2	3.325	0.689	0.812		0.870*
	TI3	3.345	0.706	0.818		0.841*
	TI4	4.275	0.73	0.84		0.832*
	TI5	3.32	0.698	0.824		0.821*
Management Information Systems	MIS1	3.345	0.742	0.855	0.870	0.846*
	MIS2	3.31	0.677	0.859		0.839*
	MIS3	3.305	0.682	0.861		0.850*
Operations Logistics Integration	OLI1	3.355	0.754	0.872	0.880	0.868*
	OLI2	4.225	0.694	0.865		0.845*
	OLI3	3.325	0.707	0.877		0.860*
	OLI4	3.21	0.722	0.864		0.850*
Supply Chain Risk Management	SCRM1	3.33	0.736	0.88	0.885	0.876*
	SCRM2	4.275	0.719	0.879		0.855*
	SCRM3	3.315	0.688	0.884		0.840*
Supply Chain Complexity	SCC1	3.350	0.688	0.860	0.870	0.834*
	SCC2	3.312	0.709	0.853		0.848*
	SCC3	4.313	0.725	0.855		0.825*
	SCC4	3.36	0.714	0.862		0.844*
Operational efficiency	OE1	3.421	0.872	0.89	0.831	0.861*
	OE2	3.453	0.725	0.867		0.849*
	OE3	3.440	0.712	0.879		0.858*
	OE4	3.473	0.72	0.87		0.845*
	OE5	3.444	0.73	0.865		0.852*
	OE6	3.482	0.715	0.878		0.860*
	OE7	3.433	0.719	0.862		0.847*
	OE8	3.464	0.724	0.874		0.855*

3.6 Discriminant Validity

The discriminant validity shows that each construct is different from another construct which is essential to ensuring the model measures unique concepts accurately. For the assessment of discriminant validity in AMOS, the Fornell-Larcker criterion is applied commonly where square square root of each construct's AVE should be greater than its correlations with other constructs (Henseler et al., 2015). Typically, an AVE of 0.50 or higher for each construct is required, indicating that over 50% of the variance is explained by the construct's indicators. When the square root of AVE values, which are on the diagonal of the Fornell-Larcker table, exceed the inter-construct correlations (off-diagonal values) then the discriminant validity is confirmed, indicating that each construct is conceptually and empirically distinguishable from others. Table 3 values shows that each construct's diagonal values are greater than from below values.

Table 3: Discriminant Validity

	IS	TI	MIS	OLI	SCRM	SSC	OE
IS	0.853						
TI	0.651	0.821					
MIS	0.621	0.663	0.853				
OLI	0.515	0.574	0.559	0.871			
SCRM	0.523	0.532	0.578	0.641	0.876		
SCC	0.512	0.564	0.556	0.508	0.654	0.854	
OC	0.231	0.313	0.341	0.132	0.232	0.452	0.892

3.7 Hypothesis Results

The next after the model fitness and assessment is to test the study hypothesis. For this purpose, researchers employed the structural model employing the SEM technique. The direct effect SEM analysis shows that information sharing has a positive and significant impact on the operations and logistics integration of manufacturing companies in Saudi Arabia and this relationship supports hypothesis 1. These results indicated that effective communication among supply chain partners enhances logistical efficiency and coordination. Similarly, hypothesis H2 results show that technology integration positively impacts operations logistics integration which demonstrates that the adoption of advanced technologies facilitates efficient logistics processes, which are essential for maintaining competitiveness in the manufacturing sector. The findings for hypothesis H3 further emphasized the importance of management information systems (MIS), which are shown to have a significant positive impact on operations logistics integration through improving data management and decision-making capabilities. In addition, hypothesis H4 results show that operations logistics integration positively and significantly enhances operational efficiency which shows its critical role in optimizing resource utilization and general performance in manufacturing firms. Furthermore, supply chain risk management (H5) is shown to have a positive impact on operational efficiency which shows its importance in mitigating disruptions and enhancing performance. On the other hand, the mediation hypothesis (H6) was rejected which indicates that the relationship between logistics integration and operational efficiency does not depend on risk management. Further moderating, effect results showed the significant positive moderating effect of supply chain complexity which confirmed hypothesis 7. This suggests that as supply chain complexity increases, the positive impact of operations logistics integration on operational efficiency is amplified, reinforcing the need for manufacturing firms to navigate their complex supply chain environments effectively. The above results are predicted in the following Table 4.

Table 4: Study hypothesis Results

Relationships	Coefficients	S.E	T Statistics	Conclusion
IS->OLI	0.475	0.085	5.588	Not Rejected
TI->OLI	0.380	0.079	4.794	Not Rejected
MIS->OLI	0.425	0.082	5.183	Not Rejected
OPI->OE	0.541	0.09	6.001	Not Rejected
SCRM->OE.	0.392	0.078	4.999	Not Rejected
OLI->SCRM->OE	0.211	0.095	2.105	Rejected
SCC*OLI-<OE	0.263	0.086	3.023	Not Rejected

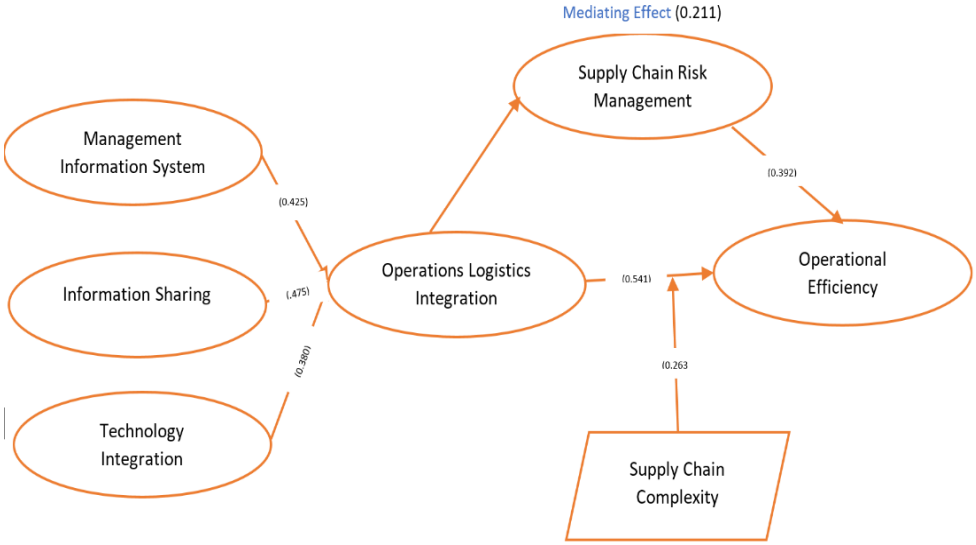

Figure 2: Beta Coefficients Values

4. Discussion

The study aimed to test the impact of information sharing, management information systems, and technology integration on logistics integration to improve operational efficiency. The study also tested the mediating effect of supply chain risk management and the moderating role of supply chain complexities in the context of Saudi Arabian manufacturing companies. For this purpose, data was collected from the employees of manufacturing companies in Saudi Arabia. The direct effect results show that information sharing has a positive and significant impact on the operations and logistics integration of manufacturing companies in Saudi Arabia. These findings show that in Saudi Arabia manufacturing company's effective communication among supply chain partners not only streamlines processes but it also enhances coordination, which is critical for achieving operational efficiency. The results are consistent with the study of (Bhima et al., 2023; Uddin, 2023) where they highlighted that transparent information exchange leads to reduced lead times and improved inventory management. In an environment where manufacturing firms face increasing competition and pressure to meet customer demands, the ability to share timely and accurate information becomes paramount. As Saudi Arabia in their industrial zone wants rapid growth as per the government's Vision 2030 which ms to diversify the economy and reduce dependence on oil revenues. Therefore, to capitalize on these opportunities, manufacturing firms must prioritize the establishment of collaborative relationships with suppliers, distributors, and other partners. This can be achieved through implementing integrated information systems that facilitate real-time data sharing and could promote collaborative planning efforts that can provide stakeholders with immediate access to critical information which can increase the economic growth of the economy.

Furthermore, technological integration also has a positive and significant impact

on the operational logistics integration of manufacturing companies in Saudi Arabia. These findings show that Saudi Arabian manufacturing companies pay greater attention to the adoption of advanced technologies, such as automation, artificial intelligence (AI), and data analytics, which significantly facilitates smoother logistics operations. This outcome is further consistent with the study of (Samad et al., 2023; Zheng & Zhou, 2023) who support this finding by noting that technology enables quicker decision-making and more agile responses to market demands. In a rapidly changing business setting, the ability to adapt to fluctuations in demand is crucial for maintaining a competitive edge. These findings emphasized that for the Saudi Arabian manufacturing companies leveraging technological advancements is essential for optimizing operations. The implementation of automated systems could lead to increased efficiency in warehousing and transportation because automated guided vehicles could streamline material handling processes which can improve operational efficiency. Furthermore, management information systems also positively and significantly affect the logistics integration of manufacturing companies in Saudi Arabia. These findings show that in Saudi Arabia manufacturing companies effective MIS plays a vital role in improving data management and supporting informed decision-making, so enhancing logistics processes. The results are similar to the study of (Adeitan et al., 2021; Tang et al., 2024) where they identify management information systems as a critical enabler for achieving operational excellence, underscoring its importance in modern manufacturing environments. In Saudi Arabia, where manufacturing firms are increasingly relying on data-driven decision-making, implementing robust MIS is essential for optimizing logistics operations. These findings enforced that Saudi Arabian manufacturing companies should focus on management information systems because a well-implemented management information system can provide real-time visibility into logistics operations. This visibility allows firms to monitor inventory levels, track shipments, and analyze performance metrics, enabling them to make proactive adjustments as needed that can enhance their ability to respond to changing market conditions and customer demands which improve the operational efficiency of the organizations.

Further results show that operations logistics integration also has a positive and significant impact on the operations efficiency of manufacturing companies in Saudi Arabia. This relation advocated that well-coordinated logistics streamline manufacturing processes by improving inventory management, and distribution efficiency where all of which are critical to reducing lead times and costs which increases the operational efficiency of the organizations. The results are consistent with the study of (Sazu & Jahan, 2022; Trakulsunti et al., 2023) where they found that efficient logistics integration has been shown to support operational efficiency. This is further supported by the study of Vafaei-Zadeh et al, (2020), who also highlighted that efficient logistics integration allows Saudi firms to respond to market demands with agility, and optimize resource utilization which helps to improve operational efficiency. In the same vein, further findings show that supply chain risk management also has a positive and significant impact on the operational efficiency of Saudi Arabia manufacturing companies. These findings show the importance of proactive strategies in stabilizing operations among potential disruptions. The findings are supported by the study (Munir et al., 2020; Rezki & Mansouri, 2024). These findings confirmed that Saudi firms should develop a strong risk management system to minimize disruptions, maintain consistent production levels, and reduce operational costs associated with sudden supply chain disruptions that can increase operational efficiency.

On the other hand, the mediating effect of supply chain risk management is not mediated between the relationship of operations logistics integration and the operational efficiency of manufacturing companies in Saudi Arabia. This relationship shows that supply chain risk management does not mediate the relationship between operations logistics integration and operational performance in Saudi Arabian manufacturing companies. The possible reason for not mediating may be because logistics integration directly influences operational performance through streamlined processes and enhanced resource utilization, minimizing delays and reducing costs independently of risk management interventions. In this context, risk management likely plays a more supportive, rather than transformative, role by stabilizing operations in the face of disruptions rather than amplifying the gains from logistics integration. Another possible reason might be that in Saudi Arabian manufacturing companies, many manufacturing companies may already have strong logistics systems in place that directly improve operational performance, with risk management functioning more as a precautionary measure than a performance enhancer. This suggests that while supply chain risk management is critical for resilience, its impact may be more direct rather than acting as a bridge between logistics integration and operational performance. These arguments are further supported by the findings of (Waqas et al., 2023).

In another context, moderating effect results show that supply chain complexity also positively and significantly moderated the relationship between operational logistics integration and the operational efficiency of manufacturing companies in Saudi Arabia. These findings indicated that when the supply chain complexity increases, the positive impact of logistics integration on operational efficiency also increases. This insight is especially relevant for manufacturing firms in Saudi Arabia, where navigating complex supply chains is essential for optimizing performance. As, moderating effect has been tested first time, therefore extant findings could not be supported. The findings are further reinforced with the study of Al-Rawashdeh et al, (2023) and they argued that supply chain complexity played an important role to increase the performance of the organization. Based on the findings, it is recommended that in Saudi Arabia manufacturing companies should invest in supply chain mapping and analysis to identify potential areas for improvement that can help firms gain insights into the interdependencies within their supply chains and develop strategies to enhance coordination and collaboration among stakeholders. Additionally, raising strong relationships with suppliers and partners could improve communication and collaboration which enables firms to improve their logistics integration that could lead to improved operational efficiency.

5. Theoretical and practical Implications

The findings with the extended model of supply chain risk management as a mediating variable and supply chain complexity as a moderating variable contributed theoretical and practical implications in the context of Saudi Arabian manufacturing companies. Theoretically, the positive and significant impact of information sharing, technology integration, management information systems, and logistics integration aligns with theories of supply chain management that highlight the importance of collaboration and technology in enhancing operational performance. Furthermore,

the study also contributed to the significant moderating effect of supply chain complexity between logistics integration and operational efficiency in the context of Saudi Arabian manufacturing companies. The study with this relationship enriches the theoretical enhancement by signifying that the effectiveness of logistics integration strategies may vary depending on the level of complexity within the supply chain, prompting researchers to explore the contextual factors influencing supply chain performance. The study with the current model could also help other researchers explore their research area in the future with the extended model of any other moderating and mediating variable. On the other hand, the study also has some practical implications in the context of Saudi Arabia manufacturing companies. Firstly, positive and significant relationships indicated that firms should prioritize raising information-sharing practices and investing in advanced technologies to streamline logistics processes. Furthermore, study findings also emphasize the need for companies to proactively manage supply chain complexities which could improve the logistics integration efforts and may yield greater benefits in more complex environments to increase the operational performance. In other words, companies should also invest the supply chain risk management strategies that could help identify weaknesses and enhance their general operational resilience. By adopting these practical strategies, manufacturing firms in Saudi Arabia can position themselves to better navigate challenges, optimize performance, and align with the national goals of economic diversification and growth under Vision 2030.

6. Conclusion and Future Directions

The study tested the operations logistics integration information system enablers' influence on operations efficiency through supply chain risk management with the moderating role of supply chain complexity of Saudi Arabian manufacturing companies. For this purpose, 320 manufacturing company employees through self-administered questionnaires which were distributed through a convenient sampling technique. Used cross-sectional research design, quantitative research approach, and structural Equation Modeling (SEM) technique. The SEM results show that information sharing, management information sharing, and technology integration positively and significantly impact operations logistics integration. Further operations logistics integration and supply chain risk management also positively and significantly impact operational efficiency. The indirect mediating effect showed that supply chain risk management is not mediated between operations logistics integration and operational efficiency. In contrast, moderating effect results also show that supply chain complexity significantly strengthens the relationship between logistics integration and operational efficiency. These findings contributed that increasing, management information systems, information sharing, and technology integration is crucial for improving operational logistics integration. Besides, organizations should consider the role of supply chain complexity in strengthening the relationship between logistics integration and operational efficiency.

The study has various limitations that could be addressed in further study. The study was limited to Saudi Arabia and results could not be employed in other countries where the culture and environment are different as compared to Saudi Arabia. Therefore, further research could be explored on other countries to changes in results. In addition, the study focused on a cross-sectional research design where data on one

time, further research could be explored on longitudinal research design to increase the variation in the results. In other words, the study is limited to a quantitative research approach, further research could be explored on mixed methods both qualitative and quantitative methods.

Acknowledgement

This work was supported through the Ambitious Funding track by the Deanship of Scientific Research, Vice Presidency for Graduate Studies and Scientific Research, King Faisal University, Saudi Arabia [KFU242396].

References

Adeitan, A. D., Aigbavboa, C., & Bamisaye, O. S. (2021). Influence of information flow on logistics management in the industry 4.0 era. *International Journal of Supply and Operations Management*, *8*(1), 29-38. https://dx.doi.org/10.22034/IJSOM.2021.1.3

Aghapour, A. H., Marthandan, G., Fie, D. Y. G., & Zailani, S. (2017). Risk management process towards operation performance in supply chain management: a survey of manufacturing SMEs. *International journal of logistics systems and management*, *27*(1), 78-114. https://doi.org/10.1504/IJLSM.2017.083224

Ajiga, D., Okeleke, P. A., Folorunsho, S. O., & Ezeigweneme, C. (2024). The role of software automation in improving industrial operations and efficiency. https://doi.org/10.53430/ijeru.2024.7.1.0031

Akinsulire, A. A., Idemudia, C., Okwandu, A. C., & Iwuanyanwu, O. (2024). Supply chain management and operational efficiency in affordable housing: An integrated review. *Magna Scientia Advanced Research and Reviews*, *11*(2), 105-118. https://doi.org/10.30574/msarr.2024.11.2.0113

Al-Dweiri, M., Ramadan, B., Rawshdeh, A., Nassoura, A., Al-Hamad, A., & Ahmad, A. (2024). The mediating role of lean operations on the relationship between supply chain integration and operational performance. *Uncertain Supply Chain Management*, *12*(2), 1163-1174. http://dx.doi.org/10.5267/j.uscm.2023.11.017

Al-Rawashdeh, O. M., Jawabreh, O., & Ali, B. (2023). Supply chain management and organizational performance: the moderating effect of supply chain complexity. *Information Sciences Letters*, *12*(3), 1673-1684. http://dx.doi.org/10.18576/isl/120351

Al Yami, M., Ajmal, M. M., & Balasubramanian, S. (2022). Does size matter? The effects of public sector organizational size'on knowledge management processes and operational efficiency. *VINE Journal of Information and Knowledge Management Systems*, *52*(5), 670-700. https://doi.org/10.1108/VJIKMS-07-2020-0123

Alam, A., K. Bagchi, P., Kim, B., Mitra, S., & Seabra, F. (2014). The mediating effect of logistics integration on supply chain performance: a multi-country study. *The International Journal of Logistics Management*, *25*(3), 553-580. https://doi.org/10.1108/IJLM-05-2013-0050

Amin, F., Majeed, A., Mateen, A., Abbasi, R., & Hwang, S. O. (2022). A systematic survey

on the recent advancements in the Social Internet of Things. *IEEE Access*, *10*, 63867-63884. https://doi.org/10.1109/ACCESS.2022.3183261

Bhima, B., Zahra, A. R. A., Nurtino, T., & Firli, M. Z. (2023). Enhancing organizational efficiency through the integration of artificial intelligence in management information systems. *APTISI Transactions on Management*, *7*(3), 282-289. https://doi.org/10.33050/atm.v7i3.2146

Bloomfield, J., & Fisher, M. J. (2019). Quantitative research design. *Journal of the Australasian Rehabilitation Nurses Association*, *22*(2), 27-30. https://doi.org/10.33235/jarna.22.2.27-30

Chand, P., Kumar, A., Thakkar, J., & Ghosh, K. K. (2022). Direct and mediation effect of supply chain complexity drivers on supply chain performance: an empirical evidence of organizational complexity theory. *International Journal of Operations & Production Management*, *42*(6), 797-825. https://doi.org/10.1108/IJOPM-11-2021-0681

Chapman, C. S., & Kihn, L.-A. (2009). Information system integration, enabling control and performance. *Accounting, organizations and society*, *34*(2), 151-169. https://doi.org/10.1016/j.aos.2008.07.003

Chatha, K. A., & Jalil, M. (2022). Complexity in three-echelon supply chain network and manufacturing firm's operational performance. *Computers & Industrial Engineering*, *169*, 108196. https://doi.org/10.1016/j.cie.2022.108196

Dexter, S., & Richardson, J. W. (2020). What does technology integration research tell us about the leadership of technology? *Journal of Research on Technology in Education*, *52*(1), 17-36. https://doi.org/10.1080/15391523.2019.1668316

Di Capua, M., Ciaramella, A., & De Prisco, A. (2023). Machine learning and computer vision for the automation of processes in advanced logistics: The integrated logistic platform (ILP) 4.0. *Procedia Computer Science*, *217*, 326-338. https://doi.org/10.1016/j.procs.2022.12.228

Diawati, P., Gadzali, S. S., Abd Aziz, M. K. N., Ausat, A. M. A., & Suherlan, S. (2023). The role of information technology in improving the efficiency and productivity of human resources in the workplace. *Jurnal Teknologi Dan Sistem Informasi Bisnis*, *5*(3), 296-302. https://doi.org/10.47233/jteksis.v5i3.872

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American journal of theoretical and applied statistics*, *5*(1), 1-4. http://dx.doi.org/10.11648/j.ajtas.20160501.11

Ewuga, S. K., Egieya, Z. E., Omotosho, A., & Adegbite, A. O. (2023). Comparative review of technology integration in SMES: a tale of two economies-the United States and Nigeria. *Engineering Science & Technology Journal*, *4*(6), 555-570. https://doi.org/10.51594/estj.v4i6.680

Fernando, Y., Tseng, M.-L., Wahyuni-Td, I. S., de Sousa Jabbour, A. B. L., Chiappetta Jabbour, C. J., & Foropon, C. (2023). Cyber supply chain risk management and performance in industry 4.0 era: information system security practices in Malaysia. *Journal of Industrial and Production Engineering*, *40*(2), 102-116. https://doi.org/10.1080/21681015.2022.2116495

Fernando, Y., Wahyuni-TD, I. S., Zainul Abideen, A., & Mergeresa, F. (2023). Traceability technology, halal logistics brand and logistics performance: religious beliefs and beyond. *Journal of Islamic Marketing*, *14*(4), 1007-1031. https://doi.org/10.1108/JIMA-06-2020-0183

Hair, J., Hollingsworth, C. L., Randolph, A. B., & Chong, A. Y. L. (2017). An updated and expanded assessment of PLS-SEM in information systems research. *Industrial management & data systems*, *117*(3), 442-458.

https://doi.org/10.1108/IMDS-04-2016-0130

Hair Jr, J. F., Howard, M. C., & Nitzl, C. (2020). Assessing measurement model quality in PLS-SEM using confirmatory composite analysis. *Journal of business research*, *109*, 101-110. https://doi.org/10.1016/j.jbusres.2019.11.069

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the academy of marketing science*, *43*, 115-135. https://doi.org/10.1007/s11747-014-0403-8

Iftikhar, A., Purvis, L., Giannoccaro, I., & Wang, Y. (2023). The impact of supply chain complexities on supply chain resilience: The mediating effect of big data analytics. *Production Planning & Control*, *34*(16), 1562-1582. https://doi.org/10.1080/09537287.2022.2032450

Isik, F. (2011). Complexity in supply chains: a new approach to quantitative measurement of the supply-chain-complexity. *Supply chain management*, *21*(4), 417-432. http://dx.doi.org/10.5772/15005

Judijanto, L., Asniar, N., Kushariyadi, K., Utami, E. Y., & Telaumbanua, E. (2024). Application of Integrated Logistics Networks in Improving the Efficiency of Distribution and Delivery of Goods in Indonesia a Literature Review. *Sciences du Nord Economics and Business*, *1*(01), 01-10. https://doi.org/10.58812/09cy0n26

Kauppi, K., Longoni, A., Caniato, F., & Kuula, M. (2016). Managing country disruption risks and improving operational performance: risk management along integrated supply chains. *International Journal of Production Economics*, *182*, 484-495. https://doi.org/10.1016/j.ijpe.2016.10.006

Kedi, W. E., Ejimuda, C., Idemudia, C., & Ijomah, T. I. (2024). AI Chatbot integration in SME marketing platforms: Improving customer interaction and service efficiency. *International Journal of Management & Entrepreneurship Research*, *6*(7), 2332-2341. http://dx.doi.org/10.51594/ijmer.v6i7.1327

Liu, C., Huo, B., Liu, S., & Zhao, X. (2015). Effect of information sharing and process coordination on logistics outsourcing. *Industrial management & data systems*, *115*(1), 41-63. https://doi.org/10.1108/IMDS-08-2014-0233

lo Storto, C., & Evangelista, P. (2023). Infrastructure efficiency, logistics quality and environmental impact of land logistics systems in the EU: A DEA-based dynamic mapping. *Research in Transportation Business & Management*, *46*, 100814. https://doi.org/10.1016/j.rtbm.2022.100814

Ma, X., & Zhang, J. (2024). Integrated information management of supply chain in logistics parks based on the IoT. *Internet Technology Letters*, *7*(2), e469. https://doi.org/10.1002/itl2.469

Mpuon, J. A., Odigbo, B. E., Etim, G. S., Etuk, I. U., & Usoro, A. A. (2023). Impact of system integration of automation and autonomation supply chain strategies in operational performance of manufacturing firms. *International Journal of Value Chain Management*, *14*(2), 195-219. https://doi.org/10.1504/IJVCM.2023.130988

Mugoni, E., Nyagadza, B., & Hove, P. K. (2023). Green reverse logistics technology impact on agricultural entrepreneurial marketing firms' operational efficiency and sustainable competitive advantage. *Sustainable Technology and Entrepreneurship*, *2*(2), 100034. https://doi.org/10.1016/j.stae.2022.100034

Munir, M., Jajja, M. S. S., Chatha, K. A., & Farooq, S. (2020). Supply chain risk management and operational performance: The enabling role of supply chain integration. *International Journal of Production Economics*, *227*, 107667. https://doi.org/10.1016/j.ijpe.2020.107667

Nguyen, T., Tripe, D., & Ngo, T. (2018). Operational efficiency of bank loans and deposits: A case study of Vietnamese banking system. *International Journal of Financial Studies*, *6*(1), 14. https://doi.org/10.3390/ijfs6010014

Odimarha, A. C., Ayodeji, S. A., & Abaku, E. A. (2024). The role of technology in supply chain risk management: Innovations and challenges in logistics. *Magna Scientia Advanced Research and Reviews*, *10*(2), 138-145. https://doi.org/10.30574/msarr.2024.10.2.0052

Okolo, C. A., Ijeh, S., Arowoogun, J. O., Adeniyi, A. O., & Omotayo, O. (2024). Reviewing the impact of health information technology on healthcare management efficiency. *International Medical Science Research Journal*, *4*(4), 420-440. https://doi.org/10.51594/imsrj.v4i4.1000

Purnomo, A., Firdaus, M., Asitah, N., Madjatmadja, E. D., Karmagatri, M., & Azzahri, E. F. (2023). The Research Journey Retrospective on Management Information Systems in Indonesia. 2023 International Conference on Information Management and Technology (ICIMTech), 453-458. https://doi.org/10.1109/ICIMTech59029.2023.10277992

Qiao, R., & Zhao, L. (2023). Highlight risk management in supply chain finance: effects of supply chain risk management capabilities on financing performance of small-medium enterprises. *Supply Chain Management: An International Journal*, *28*(5), 843-858. https://doi.org/10.1108/SCM-06-2022-0219

Rachmad, Y. E., Bakri, A. A., Irdiana, S., Waromi, J., & Sinlae, A. A. J. (2024). Analysis of The Influence of Financial Information Systems, Internal Control Systems, and Information Technology on Quality of Financial Reports. *Jurnal Informasi Dan Teknologi*, 266-271. https://doi.org/10.60083/jidt.v6i1.513

Ragazou, K., Passas, I., Garefalakis, A., Galariotis, E., & Zopounidis, C. (2023). Big data analytics applications in information management driving operational efficiencies and decision-making: mapping the field of knowledge with bibliometric analysis using R. *Big Data and Cognitive Computing*, *7*(1), 13. https://doi.org/10.3390/bdcc7010013

Rejeb, A., Rejeb, K., Simske, S., & Treiblmaier, H. (2021). Blockchain technologies in logistics and supply chain management: a bibliometric review. *Logistics*, *5*(4), 72. https://doi.org/10.3390/logistics5040072

Rezki, N., & Mansouri, M. (2024). Machine Learning for Proactive Supply Chain Risk Management: Predicting Delays and Enhancing Operational Efficiency. *Management Systems in Production Engineering*, *32*(3), 345-356. http://dx.doi.org/10.2478/mspe-2024-0033

Samad, T. A., Sharma, R., Ganguly, K. K., Wamba, S. F., & Jain, G. (2023). Enablers to the adoption of blockchain technology in logistics supply chains: evidence from an emerging economy. *Annals of Operations Research*, *327*(1), 251-291.

Sazu, M. H., & Jahan, S. A. (2022). How analytics can improve logistics and supply chain in multinational companies: perspectives from europe and america. *Business Excellence & Management*, *12*(3). https://doi.org/10.24818/beman/2022.12.3-07

Sekaran, U. (2016). Research methods for business: A skill building approach. In: John Wiley & Sons. https://search.worldcat.org/title/1003355379

Sierles, F. S. (2003). How to do research with self-administered surveys. *Academic*

Psychiatry, *27*(2), 104-113. https://doi.org/10.1176/appi.ap.27.2.104

Sriboonlue, U., CHAIPRASIT, K., & Onputtha, S. (2024). Enhancing Operational Efficiency: Investigating Technology Readiness, Acceptance, and Utilization of Thailand National Single Window in Import, Export, and Logistics Businesses. *Asian Administration & Management Review*, *7*(2). https://ssrn.com/abstract=4874287

Sun, X., Yu, H., Solvang, W. D., Wang, Y., & Wang, K. (2022). The application of Industry 4.0 technologies in sustainable logistics: a systematic literature review (2012–2020) to explore future research opportunities. *Environmental Science and Pollution Research*, 1-32. https://doi.org/10.1007/s11356-021-17693-y

Sundram, V. P. K., Chhetri, P., & Bahrin, A. S. (2020). The consequences of information technology, information sharing and supply chain integration, towards supply chain performance and firm performance. *Journal of International Logistics and Trade*, *18*(1), 15-31. https://doi.org/10.24006/jilt.2020.18.1.015

Tang, Y. M., Chau, K. Y., Kuo, W. T., & Liu, X. X. (2024). IoT-based information system on cold-chain logistics service quality (ICCLSQ) management in logistics 4.0. *Information Systems Frontiers*, *26*(2), 689-708. https://doi.org/10.1007/s10796-023-10393-7

Tongzon, J. L., & Nguyen, H.-O. (2021). Effects of port-shipping logistics integration on technical and allocative efficiency. *The Asian Journal of Shipping and Logistics*, *37*(2), 109-116. https://doi.org/10.1016/j.ajsl.2021.01.001

Trakulsunti, Y., Antony, J., Jayaraman, R., & Tortorella, G. (2023). The application of operational excellence methodologies in logistics: a systematic review and directions for future research. *Total Quality Management & Business Excellence*, *34*(5-6), 538-557. https://doi.org/10.1080/14783363.2022.2071695

Tukamuhabwa, B., Mutebi, H., & Isabirye, D. (2023). Supplier performance in the public healthcare: internal social capital, logistics capabilities and supply chain risk management capabilities as antecedents in a developing economy. *Journal of Business and Socio-economic Development*, *3*(1), 50-68. https://doi.org/10.1108/JBSED-04-2021-0046

Uddin, A. R. (2023). The Effect of Information Enabled Logistics Integration on Operational Performance of an FMCG Manufacturing Firm in Karachi: The Mediating Role of Supply Chain Risk Management. *International" Journal of Academic Research for Humanities"*, *3*(1), 138-149. https://jar.bwo-researches.com/index.php/jarh/article/view/162

Vafaei-Zadeh, A., Ramayah, T., Hanifah, H., Kurnia, S., & Mahmud, I. (2020). Supply chain information integration and its impact on the operational performance of manufacturing firms in Malaysia. *Information & Management*, *57*(8), 103386. https://doi.org/10.1016/j.im.2020.103386

Valashiya, M. C., & Luke, R. (2023). Enhancing supply chain information sharing with third party logistics service providers. *The International Journal of Logistics Management*, *34*(6), 1523-1542. https://doi.org/10.1108/IJLM-11-2021-0522

Waqas, U., Abd Rahman, A., Ismail, N. W., Kamal Basha, N., & Umair, S. (2023). Influence of supply chain risk management and its mediating role on supply chain performance: perspectives from an agri-fresh produce. *Annals of Operations Research*, *324*(1), 1399-1427. https://doi.org/10.1007/s10479-022-04702-7

Wong, L.-W., Tan, G. W.-H., Ooi, K.-B., Lin, B., & Dwivedi, Y. K. (2024). Artificial intelligence-driven risk management for enhancing supply chain agility: A deep-learning-based dual-stage PLS-SEM-ANN analysis. *International Journal of Production Research*, *62*(15), 5535-5555. https://doi.org/10.1080/00207543.2022.2063089

Xu, X., & He, Y. (2024). Blockchain application in modern logistics information sharing: A review and case study analysis. *Production Planning & Control*, *35*(9), 886-900. https://doi.org/10.1080/09537287.2022.2058997

Zacharias, J., & Boopathy, S. (2022). The impact of Logistics Integration on Supply Chain Operational Excellence in the Service Sector. *Journal of Positive School Psychology*, *6*(2), 4834-4850. https://journalppw.com/index.php/jpsp/article/view/2939

Zhan, X., Ling, Z., Xu, Z., Guo, L., & Zhuang, S. (2024). Driving efficiency and risk management in finance through AI and RPA. http://dx.doi.org/10.20944/preprints202407.0083.v1

Zheng, F., & Zhou, X. (2023). Sustainable model of agricultural product logistics integration based on intelligent blockchain technology. *Sustainable Energy Technologies and Assessments*, *57*, 103258. https://doi.org/10.1016/j.seta.2023.103258