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Journal of Future Sustainability

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Ambidextrous logistics in uncertain environments: A mediated moderation analysis of resilience and sustainability in domestic vs. international middle eastern firms

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CHRONICLE

Article history:
Received: October 15, 2025
Received in revised format: November 28, 2025
Accepted: January 29, 2026
Available online:
January 29, 2026

Keywords:
Supply Chain Ambidexterity
Supply Chain Resilience
Sustainable Logistics
Environmental Uncertainty
Logistics Firms
Middle East

ABSTRACT

Tribal heritage in Jharkhand holds immense potential not just as a cultural asset but as a foundation for sustainable, community-led entrepreneurship. This paper examines the major issues that can help the tribal societies transform their cultural heritage into legitimate business enterprises. Based on the domain, the study makes use of the Best-Worst Method (BWM) to rank significant enablers. It applies Interpretive Structural Modelling (ISM) and MICMAC analysis to discover the structural relationship between them. It is indicated that although the availability of natural resources, indigenous knowledge, and governmental support serve as the foundations of tribal enterprise, psychological preparedness and market access are the key factors in the long-term development. Interestingly, cultural values and education are also discovered as highly ingrained factors that determine an entrepreneurial intent and sustainability. The paper illuminates the multifaceted nature of the problems tribal entrepreneurs have to encounter, such as geographical remoteness and the changing demands of consumers, but also shows the opportunity to interfere by making specific changes. Through mapping of these enablers and their linkage, this study will provide a practical framework to be used by policymakers, NGOs, and local stakeholders to enable and expand tribal entrepreneurship in Jharkhand. Finally, it promotes the model of development in which cultural pride and economic empowerment must go hand in hand.

1. Introduction

The critical importance of supply chain resilience and sustainability has become increasingly evident within the volatile and unpredictable landscape of the global logistics industry, marked by growing disruptions and risks (Choksy et al., 2022). Recent global crises, such as the COVID-19 pandemic, have exposed significant vulnerabilities in logistics networks that historically prioritized operational efficiency over resilience and long-term sustainability (Ivanov & Dolgui, 2020; Sarkis et al., 2020). Furthermore, ongoing challenges including geopolitical tensions and climate change continue to underscore the urgent need for logistics firms to effectively integrate resilience and sustainability into their strategic frameworks to adapt and thrive (Ibn-Mohammed et al., 2021; Vroegindewey & Hodbod, 2018). This context highlights the necessity for logistics supply chains to balance resilience, defined as the capacity to absorb, adapt to, and recover from disruptions, with sustainability, which encompasses environmental, social, and economic dimensions (Sarkis et al., 2020; Tukamuhabwa et al., 2015).

Supply chain ambidexterity (SCAMB), defined as the simultaneous pursuit of exploitative (efficiency-driven) and explorative (innovation-driven) activities, has emerged as a vital capability in supply chain management. It enhances a firm's ability to respond to immediate disruptions while preparing for long-term strategic challenges (Junni et al., 2013). In the logistics sector, ambidexterity enables firms to optimize existing operations while innovating to meet evolving market and environmental demands. Recent studies suggest that SCAMB not only aids in disruption management but also promotes sustainable practices that enhance long-term adaptability (Carissimi et al., 2023; Ibn-Mohammed et al., 2021). However, the mechanisms through which ambidexterity influences sustainable performance remain underexplored, particularly within the comparative context of domestic versus international logistics operations. This study addresses this gap by investigating how SCAMB influences supply chain resilience (SCRES) and, in turn, how resilience mediates the relationship between ambidexterity and sustainable performance in logistics firms.

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ISSN 2816-8151 (Online) - ISSN 2816-8143 (Print)

doi: 10.5267/j.jfs.2026.3.003

The concept of supply chain viability has gained prominence, emphasizing the need for supply chains not only to withstand disruptions but also to adapt and prosper in a continuously changing environment (Ivanov, 2020; Sarkis, 2021). For logistics firms, especially those operating across domestic and international boundaries, resilience is essential for ensuring long-term stability and adaptability. Building upon the systematic literature review by Tukamuhabwa et al. (2015), which analyzed 91 articles, this research examines how resilience functions as a mediating mechanism that supports the long-term viability of logistics supply chains. While Tukamuhabwa et al. (2015) provided a comprehensive definition of SCRES, highlighting adaptive capability, recovery, and preparation, they also noted that cost-effectiveness is often overlooked in existing resilience frameworks. By exploring these interconnected constructs, this paper contributes to the evolving discourse on the synergy between supply chain ambidexterity, resilience, and sustainability (Ponis & Koronis, 2012), with a focused lens on the logistics industry in the Middle East.

2. Literature Review and Hypothesis Development

2.1 Supply Chain Ambidexterity in Logistics

Ambidexterity, a concept rooted in organisational theory, refers to an organisation's capacity to simultaneously balance exploration and exploitation strategies (March, 1991). Within logistics, exploration entails innovation, flexibility, and the pursuit of new opportunities, such as adopting green technologies or entering new markets, while exploitation focuses on enhancing efficiency, refining processes, and optimising existing logistical operations (Junni et al., 2013). In an era of frequent disruptions, logistics firms face the critical decision of whether to reinforce current capabilities or invest in developing new ones to navigate uncertainty (Ambulkar et al., 2023). Supply chain ambidexterity enables logistics firms to maintain operational efficiency while remaining adaptable, ensuring continuity and responsiveness amid disturbances (Kristal et al., 2010).

For decades, organisations have debated the focus on leveraging existing competencies versus cultivating new ones (March, 1991). Traditional ambidexterity frameworks emphasise internal balancing acts; however, in logistics supply chains, ambidexterity necessitates an external orientation, incorporating relationships with suppliers, partners, and stakeholders across often complex domestic and international networks. Logistics ambidexterity allows firms to utilise current assets while building new capabilities to mitigate risks and capitalise on opportunities in dynamic environments (Kristal et al., 2010). Carissimi et al. (2023) underscore the importance of balancing exploration and exploitation, a view supported by Raisch et al. (2009), who noted that ambidexterity equips firms to respond to environmental shifts while sustaining performance. Despite its recognised value, how logistics ambidexterity specifically fosters resilience and sustainability, particularly in comparative settings (domestic versus international), remains underexplored.

2.2 Supply Chain Resilience in Logistics

As disruptions grow in frequency and severity, the importance of supply chain resilience has become paramount. Resilience enables logistics networks to withstand, adapt to, and recover from disturbances while maintaining operational stability (Tukamuhabwa et al., 2015). Carissimi et al. (2023), drawing on Pettit et al. (2010), illustrate that resilience involves managing vulnerabilities while leveraging capabilities to ensure continuity during crises. In their review of 91 studies, Tukamuhabwa et al. (2015) formulated a comprehensive definition of supply chain resilience (SCRES), highlighting adaptive capability, preparedness, responsiveness, connectivity, and timely recovery. Yet, resilience extends beyond operational bounce-back. Khan et al. (2024) categorise resilience into process, structural, and strategic dimensions, suggesting that effective resilience encompasses recovery, adaptability, and organisational learning. This multi-layered view implies that a resilient logistics supply chain must anticipate changes, respond efficiently, and adapt strategically over time. Ponis and Koronis (2012) further emphasise connectedness and control as key components of resilience.
However, many resilience definitions neglect cost-effectiveness, a crucial consideration for logistics firms operating under competitive and budgetary pressures. Therefore, this study adopts the following definition: "The adaptive capability of a supply chain to prepare for and/or respond to disruptions, to make a timely and cost-effective recovery, and therefore progress to a post-disruption state of operations, ideally, a better state than prior to the disruption" (Tukamuhabwa et al., 2015).
Recent literature increasingly links resilience with sustainability. Sarkis et al. (2020) posit that resilience and sustainability are interdependent and mutually reinforcing. While resilience supports short-term adaptability, sustainability addresses long-term environmental, social, and economic outcomes. In logistics, strategies such as flexible routing, multi-modal transport, and supplier diversification, essential for resilience, also advance sustainability by reducing waste, optimising resource use, and lowering carbon footprints (Klein, 2021).

2.3 Sustainability in Logistics Supply Chains

Sustainability has evolved into a critical imperative within modern logistics management, driven by the necessity for long-term viability across environmental, social, and economic dimensions. This holistic approach is commonly framed through the triple bottom line (TBL) perspective, which emphasizes the equilibrium between profit generation, environmental stewardship, and social responsibility (Elkington & Rowlands, 1999). As global logistics networks grow in complexity and

reach, sustainability has transitioned from a voluntary strategic choice to an essential component for firms aiming to maintain competitive relevance (Carter & Rogers, 2008). In the logistics context, sustainability entails minimizing environmental footprints, such as through carbon-efficient transport, promoting fair labor practices and community engagement, and ensuring economic growth, collectively captured by the "people, planet, profit" paradigm (Schaltegger & Burritt, 2014).
Contemporary literature increasingly positions sustainability not only as a compliance or ethical requirement but also as a significant source of competitive differentiation. Logistics firms that integrate sustainable practices into their operations often achieve superior resource utilization, cost efficiency, and market positioning (Gold et al., 2010; Seuring & Müller, 2008). Schaltegger and Burritt (2014) contend that embedding sustainability into performance measurement systems substantially enhances a firm's competitiveness. Companies adopting sustainable logistics and supply chain management (SSCM) practices distinguish themselves through proactive partner collaboration, optimized asset use, and waste reduction across transportation, warehousing, and packaging (Ahi & Searcy, 2013).

Furthermore, the rising emphasis on resilient supply chains has strengthened the nexus between sustainability and operational efficacy. Sustainable logistics frameworks, such as lean, green, and resilient strategies, not only help firms mitigate environmental risks but also boost their agility and responsiveness to disruptions (Azevedo et al., 2011; Sharma et al., 2021). This strategic integration allows logistics providers to balance ecological and social goals with business performance, thereby better navigating the volatility inherent in global logistics environments (Seuring & Müller, 2008).

In the post-pandemic landscape, sustainability has gained heightened significance. The logistics industry, in particular, has witnessed a shift toward “glocalization”, a hybrid model blending global scale with local adaptability to bolster resilience while adhering to sustainable principles (Sarkis et al., 2020). This convergence of resilience and sustainability underscores that agile and responsible logistics networks are not only more capable of withstanding disruptions but are also better positioned for enduring success. Sustainable logistics operations can future-proof businesses against global shocks by aligning environmental accountability and social welfare with economic viability (Carter & Rogers, 2008).

2.4 Linking Logistics Ambidexterity to Supply Chain Resilience

Supply chain ambidexterity (SCAMB) is increasingly acknowledged as a vital enhancer of supply chain resilience, particularly within logistics. The concurrent exploitation of existing capabilities and exploration of new opportunities equips firms to navigate disruptions more effectively. Aslam et al. (2020) offer empirical support for the positive influence of SCAMB on resilience, arguing that ambidextrous supply chains, characterized by a balance between adaptability and operational alignment, are better prepared to dynamically adjust to both expected and unforeseen disruptions. This dual capacity enables logistics firms to sustain operational stability and recover swiftly from setbacks, thereby cultivating a more resilient supply network. Their work highlights the importance of nurturing both exploitative and explorative strategies to manage risks in volatile settings. By pursuing exploration and exploitation simultaneously, logistics firms can adapt to changing conditions while preserving core efficiencies, leading to more robust supply chain management (Ambulkar et al., 2023).
Ambulkar et al. (2023) examine the impact of supply chain disruptions on financial performance, focusing on the moderating role of SCAMB, through exploration and exploitation, in mitigating adverse effects. In contrast, the present study investigates how logistics ambidexterity enhances supply chain resilience and supports sustainable performance across economic, environmental, and social dimensions. Additionally, it explores the interactive role of environmental uncertainty in the relationship between ambidexterity and resilience, with a specific focus on differences between domestic and international logistics firms.
Drawing from the literature, the following hypotheses are proposed:

H_1: *Supply chain ambidexterity positively influences supply chain resilience in logistics firms.*
H_{1a}: *Exploration ambidexterity positively influences supply chain resilience.*
H_{1b}: *Exploitation ambidexterity positively influences supply chain resilience.*

2.5 Linking Supply Chain Resilience to Sustainable Performance in Logistics

The integration of resilience and sustainability has become especially pertinent in light of recent global disruptions. In the logistics sector, supply chain resilience refers to the ability to maintain operational stability and continuity under stress (Ali et al., 2024), while supply chain sustainability (SCS) is evaluated through the triple bottom line (TBL) framework, balancing environmental, social, and economic performance. Resilience plays a critical role in upholding this balance across all three dimensions. For logistics firms, resilience strengthens economic outcomes by enabling rapid recovery from disruptions, such as port closures or fuel shortages, and supports environmental goals by promoting efficient resource use, such as optimized routing to reduce emissions. Moreover, resilience contributes to social sustainability by safeguarding employment, ensuring safe working conditions, and maintaining community support during crises (Sarkis et al., 2020). Logistics firms enhance resilience by developing capacities to anticipate**,** adapt, and respond to external disruptions, allowing them to manage disturbances and transition to an improved, often more sustainable, operational state (Ali et al., 2017; Carissimi et al., 2023; Christopher & Peck, 2004; Ponomarov & Holcomb, 2009). Consequently, alongside sustainability, resilience has emerged as a central paradigm in modern logistics and supply chain management.

Strategies such as flexible routing, multimodal transport options, and adaptive inventory management not only mitigate disruption risks but also align with sustainability objectives by reducing environmental impact and enhancing social equity within logistics networks (Kholaif et al., 2023). As a result, resilient logistics operations are better positioned to achieve long-term sustainability outcomes. This intersection underscores that logistics supply chains must be both adaptable and future-proof to ensure long-term viability in a rapidly changing world. Carissimi et al. (2023) reinforce this by noting that sustainable logistics chains incorporate proactive and reactive measures to simultaneously maintain resilience and sustainability. Resilient logistics structures are better equipped to realize sustainability outcomes by harmonizing environmental, social, and economic performance. SCRES ensures that firms can recover from disruptions while minimizing their environmental footprint and advancing social responsibility (Tukamuhabwa et al., 2015).
Drawing from the literature, the following hypotheses are proposed:

H_2: *Supply chain resilience positively influences sustainable performance in logistics firms.*

To offer a detailed understanding of how resilience affects each sustainability dimension, this hypothesis is divided into three sub-hypotheses:

H_{2a}: *Supply chain resilience positively influences economic sustainability by reducing disruption-related costs and ensuring operational continuity*.
H_{2b}: *Supply chain resilience positively influences social sustainability by maintaining workforce stability and protecting community welfare during disruptions.*
H_{2c}: *Supply chain resilience positively influences environmental sustainability by promoting efficient resource use and minimizing waste.*

2.6 Linking Supply Chain Ambidexterity with Sustainable Performance in Logistics

In a recent comprehensive review, Carissimi et al. (2023) analyzed 221 articles spanning 2004 to 2021, highlighting the need for organizations to develop ambidexterity while prioritizing sustainability objectives and maintaining sufficient redundancy to withstand disruptive events (Bui et al., 2021). Applied to logistics, this implies that ambidextrous capabilities enable firms not only to manage disruptions but also to drive sustainable outcomes across economic, social, and environmental fronts.

Based on the literature, the following hypotheses are proposed:

H_3: *Supply chain ambidexterity positively influences sustainable performance in logistics firms.*
H_{3a}: *Exploration ambidexterity positively influences economic sustainability.*
H_{3b}: *Exploration ambidexterity positively influences social sustainability.*
H_{3c}: *Exploration ambidexterity positively influences environmental sustainability.*
H_{3d}: *Exploitation ambidexterity positively influences economic sustainability.*
H_{3e}: *Exploitation ambidexterity positively influences social sustainability.*
H_{3f}: *Exploitation ambidexterity positively influences environmental sustainability.*

2.7 The Mediating Role of Supply Chain Resilience

Supply chain ambidexterity (SCAMB) enhances resilience by enabling firms to concurrently refine existing operations and explore new capabilities. This strengthened resilience, in turn, reinforces sustainability outcomes by ensuring that logistics supply chains remain both adaptable and resource-efficient. Such mediation is especially critical in dynamic operating environments, where logistics firms must continuously adapt to disruptions, regulatory shifts, and evolving market expectations (Ponis & Koronis, 2012).

Given the established theoretical relationships, where SC ambidexterity fosters supply chain resilience, and resilience subsequently enhances sustainable performance, we posit that SC ambidexterity exerts a positive indirect effect on economic, social, and environmental sustainability through the mediating role of SC resilience. In practical terms, the adaptive and efficient capabilities cultivated through ambidexterity contribute to a more resilient logistics network, which ultimately drives superior and more balanced sustainable outcomes. Based on this reasoning, the following hypothesis is proposed:

H_4: *Supply chain resilience mediates the relationship between supply chain ambidexterity and sustainable performance in logistics firms.*

2.8 The Moderating Role of Environmental Uncertainty

Uncertainty becomes a significant managerial concern when an organization lacks sufficient internal or external knowledge to anticipate or respond to changes. External uncertainty, often termed environmental uncertainty, refers to unstable and

unpredictable conditions in a firm's external operating environment (Kreye, 2017). Researchers note that uncertainty primarily affects organizations when it interacts with core operational elements, undermining efficiency and strategic alignment. It is consistently emphasized that uncertainty plays a crucial role in shaping supply chain behavior and performance (Gadde & Wynstra, 2018). A well-established stream of literature on dynamic capabilities argues that such capabilities are particularly vital in turbulent and unpredictable settings (Wilhelm et al., 2015). Teece (2007) highlighted the critical importance of dynamic capabilities in enabling firms to reconfigure resources and routines in response to environmental change. By definition, dynamism requires adaptability, which compels firms to deploy dynamic capabilities such as supply chain ambidexterity. Firms operating in dynamic environments must adjust their operational and strategic routines to capitalize on shifting demand patterns, regulatory landscapes, and competitive pressures (Aslam et al., 2019). Environmental uncertainty is a key driver of such dynamism. In the context of logistics, we propose that environmental uncertainty moderates the relationship between SC ambidexterity and supply chain resilience. Specifically, under higher levels of uncertainty, such as geopolitical instability, regulatory volatility, or sudden market shifts, the positive effect of ambidexterity on resilience is expected to be stronger. Conversely, in relatively stable environments, the influence of ambidexterity on resilience may be less pronounced. Therefore, the following hypothesis is advanced:

H_5: *Environmental uncertainty moderates the relationship between supply chain ambidexterity and supply chain resilience, such that higher levels of uncertainty strengthen the positive impact of ambidexterity on resilience.*

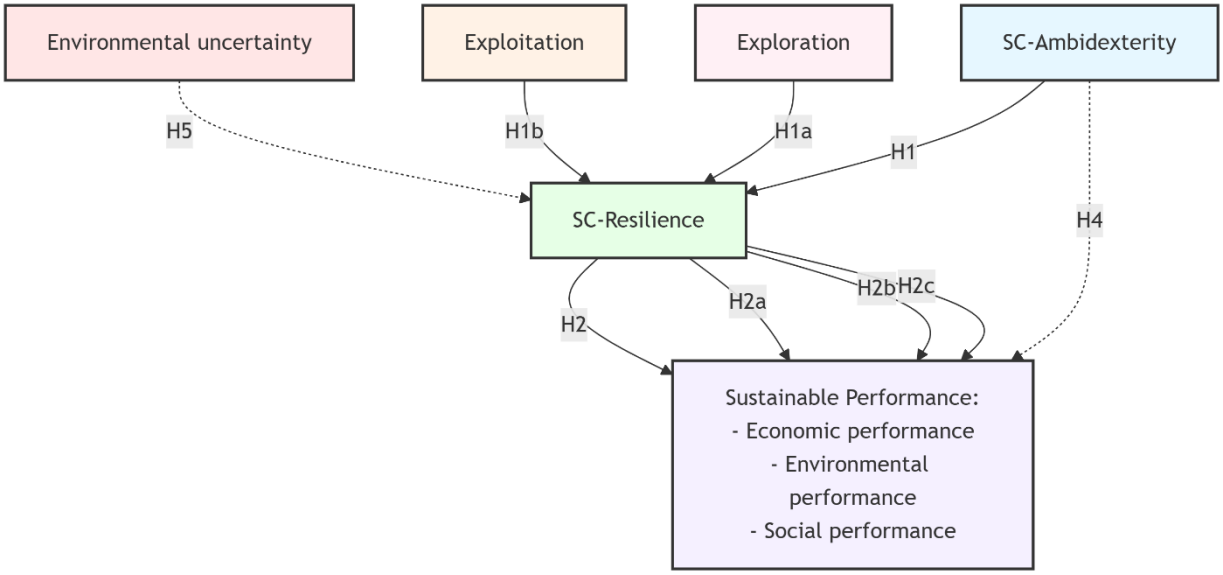

Fig. 1. Hypothesized model

3. Research Methods

3.1 Designing Questionnaire and Instrument Development

This study focuses on the managers of domestic and international logistics firms operating in the Middle East. The research model is shown in Figure 1. The sample includes both domestic and international logistics enterprises operating across various sectors. Instead of requesting respondents merely whether they approve or agree to a statement, the Likert scale items measured the degree of their agreement or disagreement on a five-point scale, ranging from 1 (strongly disagree) to 5 (strongly agree), with 3 representing a neutral response.

In line with research objectives, most of the theoretical constructs in this study were adopted from past research. The researchers followed a positive paradigm when designing the research. In addition to this, data were collected through research questionnaires. The research questionnaire in this study comprises construct items and demographic characteristics of the respondents. Construct items were developed by reviewing the literature and previously established scales. Supply chain resilience scale items were adopted from a previously developed scale by (Luo, 2024; Brandon et al., 2014) and then slightly adapted. Scale items for the construct Supply Chain Ambidexterity for two dimensions (Exploitation and Exploration) were adopted from (Khan et al., 2021; Ojha et al., 2018). Similarly, the Sustainable Performance scale for three dimensions (Economic performance, Environmental performance, and social performance) was adopted (Paulraj, 2011; Bansal, 2005; Zhu & Sarkis, 2004). Scale items for Environmental Uncertainty were adapted from Kreye (2017) and Aslam et al. (2019).

3.2 Sample and Data Collection

As mentioned, data were collected from the logistics sector across several Middle Eastern countries. The study population includes managers from both domestic and international logistics firms. The sample was stratified according to firm type (domestic/international) and operational scope. Table 1 shows the distribution of the sample size among the logistics firms under study according to firm type and size. The Research Ethics Committee at the corresponding author's institution obtained approval for data collection from participants. This document confirms that the research proposal, which includes questionnaires designed to collect data from participants, has been reviewed and formally approved. The study's approval reference number is LOG-2024-05. Informed consent was obtained from participants to take part in the research. Since the study population spans multiple countries and the research team is located across different regions, the data were collected from participants through an online form.

Table 1
The distribution of the sample size among logistics firms under study

Firm Type	Firm Size	Frequency	Percentage	Sample Size
Domestic Logistics	Small (<50 employees)	52	18.1%	52
	Medium (50–250)	74	25.8%	74
	Large (>250)	26	9.1%	26
International Logistics	Small (<50 employees)	46	16.0%	46
	Medium (50–250)	50	17.4%	50
	Large (>250)	39	13.6%	39
Total		287	100%	287

The sampling unit in this study is all managers in the companies. The sample size of the study community was determined using a sample size calculation formula for structural equation modeling, which recommended a minimum of 200 responses. A total of 312 responses were received, of which 287 were valid, i.e., a response rate of (84.6%), during the period from May to August 2024.

3.3 Data Analysis

Two stages for evaluating and measuring partial least squares structural equation modeling (PLS-SEM) were implemented. The first step involved conducting validity and reliability analyses, while the second step focused on testing the path coefficients, mediating effects, moderating effects, and the explanatory power of the structural model. The aim of these two steps was to confirm the validity and reliability of the constructs and examine the relationships between them. PLS-SEM is regarded as the optimal tool for illustrating causal interactions among construct variables, as it can simultaneously address model constructs and measurement items. Additionally, PLS-SEM is advantageous due to its more straightforward requirements for variable normality and randomness, making it suitable for analysing relationships among variables with irregular result distributions. Previous studies have indicated that each construct consists of a set of measurement items and have explored the causal effects of supply chain ambidexterity and supply chain resilience. Therefore, PLS-SEM was deemed more appropriate for this research than other structural equation modelling (SEM) approaches, as it effectively evaluates variable relationships, mitigates measurement errors, and avoids collinearity. The analysis was performed using SmartPLS 4.0 software with a bootstrapping procedure of 5,000 resamples to test the significance of the paths. Multi-group analysis (MGA) was also conducted to compare domestic versus international logistics firms.

3.4 Validity and Reliability Testing

The survey participants' responses were examined to ensure data quality, and reliable responses were identified to achieve the study's objectives. Additionally, the researchers conducted validity and reliability tests using Cronbach's alpha (α), composite reliability (CR), and average variance extracted (AVE). The results in Table 2 indicated that the values of both composite reliability (CR) and Cronbach's alpha for the Supply Chain Ambidexterity (Exploitation and Exploration), Supply chain resilience, and Sustainable Performance (Economic performance, Environmental performance, and social performance) were all greater than 0.7. This confirms the scale's reliability for each dimension of the study variables. Furthermore, the standardized coefficients for the measurement items of each dimension exceeded 0.6 and were all significant at the 1% level. The AVE values for each of these dimensions also exceeded 0.5, affirming the validity of the survey instrument concerning these dimensions. Additionally, the results showed that the AVE for the scale of the Supply Chain Ambidexterity (Exploitation and Exploration), Supply chain resilience and Sustainable Performance (Economic performance, Environmental performance, and social performance) was more significant than 0.5, indicating the validity of the scale for these dimensions as significant and acceptable. Moreover, Cronbach's alpha values for the study variables were above 0.7, indicating the scale's reliability for each studied dimension. This is clearly illustrated in Table 2, which shows the validity and reliability indicators of the survey instrument.

Table 2
Validity and Reliability Indicators

Variable	Item	St. Coe.	(α) coefficients	(CR) coefficients	(AVE) coefficients
SC-Ambidexterity					
Exploitation	Am11	0.820	0.846	0.918	0.736
	Am12	0.807			
	Am13	0.782			
	Am14	0.657			
Exploration	Am21	0.731	0.870	0.929	0.767
	Am22	0.858			
	Am23	0.807			
SC-Resilience	RE1	0.729	0.834	0.871	0.795
	RE2	0.632			
	RE3	0.768			
	RE4	0.812			
	RE5	0.718			
Environmental Uncertainty	EU1	0.752	0.894	0.918	0.790
	EU2	0.831			
	EU3	0.824			
	EU4	0.821			
	EU5	0.922			
	EU6	0.740			
	EU7	0.844			
Sustainable Performance					
Economic performance	ECO1	0.836	0.844	0.869	0.648
	ECO2	0.882			
	ECO3	0.693			
	ECO4	0.892			
	ECO5	0.682			
Environmental performance	ENP1	0.767	0.826	0.835	0.720
	ENP2	0.741			
	ENP3	0.754			
	ENP4	0.740			
	ENP5	0.656			
Social performance	SOP1	0.877	0.874	0.802	0.895
	SOP2	0.766			
	SOP3	0.742			
	SOP4	0.761			
	SOP5	0.729			

Source: Statistics analysis results.

3.5 Model Validity Indicators

The results of the significance analysis of the measurement model showed that the average path coefficient (APC) is 0.51, the average R-squared (ARS) is 0.75, and the average adjusted R-squared (AARS) is 0.80, all of which are significant at the 1% level. The results also indicated that the average variance inflation factor (AVIF) is 1.92, the average full collinearity VIF (AFVIF) is 2.52, and the R-squared contribution ratio (RSCR) equals 1. Both the Simpson's paradox ratio (SPR) and the statistical clarity ratio (SSR) equal 1, while the nonlinear bivariate causality direction ratio (NLBCDR) is 0.901. Considering the significance of the APC, ARS, and AARS indicators, the values of AVIF and AFVIF being below 5, and the RSCR being above 0.9, along with the SPR, SSR, and NLBCDR indicators exceeding 0.7, these indicators suggest the significance of the measurement model.

4. Model and Hypotheses Testing Result

4.1 Direct and Indirect Coefficients

Correlation coefficients between the variables were determined using the matrix of square roots of AVEs to test the study hypotheses. The results indicate that all correlation coefficients for each dimension or variable with itself are more significant than their correlation with the other study variables.

Table 3
Correlation Coefficient

Var.	Exploi	Explor	SCR	Eco-Per	Env-Per	So-Per	EnvUnc
Exploi	**(0.774)**						
Explor	0.683	**(0.813)**					
SCR	0.742	0.682	**(0.773)**				
Eco-Per	-0.064	0.056	0.026	**(0.800)**			
Env-Per	0.753	0.564	0.727	0.043	**(0.850)**		
So-Per	0.440	0.454	0.555	0.100	0.560	**(0.792)**	
EnvUnc	0.776	0.713	0.814	0.038	0.744	0.560	**(0.764)**

Source: Statistics analysis results.

Table 3 illustrates a positive and significant correlation between the following: Supply Chain Ambidexterity (Exploitation and Exploration), Supply chain Resilience, and Sustainable Performance (Economic performance, Environmental performance, and social performance). On the other hand, the direct and indirect relationships between the study variables were identified by testing the validity of the first four hypotheses of the study. The following table presents the results of testing the proposed model for the relationships among the study variables:

Table 4
Direct and Indirect Coefficients

Inde. V.	De. V.	Direct Coe.	Indirect Coe.	Total Coe.	R^2	Coe
Exploi	SCR	0.43	--	0.43		71%
Explor	SCR	0.40	--	0.40		
Exploi	Eco-Per	0.12	0.01	0.13		
Explor	Eco-Per	0.14	0.01	0.15		3%
SCR	Eco-Per	0.03	--	0.03		
Explor	Env-Per	0.01	0.15	0.16		
Exploi	Env-Per	0.47	0.16	0.64		64%
SCR	Env-Per	0.38	--	0.38		
Exploi	So-Per	0.06	0.13	0.19		
Explor	So-Per	0.28	0.12	0.40		36%
SCR	So-Per	0.30	--	0.30		

Source: Statistics analysis results.

The statistical analysis results in Table 4 indicate a significant impact of exploitation Ambidexterity on supply chain resilience ($\beta = 0.429$; $p < 0.001$), as well as a significant effect of exploration Ambidexterity on supply chain resilience ($\beta = 0.397$; $p < 0.001$). Additionally, exploitation Ambidexterity has a significant effect on both sustainable economic performance ($\beta = 0.118$; $p < 0.043$) and sustainable environmental performance ($\beta = 0.474$; $p < 0.001$). However, no significant effect of exploitation Ambidexterity was found on sustainable social performance ($\beta = 0.064$; $p = 0.179$). Moreover, exploration Ambidexterity showed a significant impact on both sustainable economic performance ($\beta = 0.138$; $p < 0.022$) and sustainable social performance ($\beta = 0.010$; $p < 0.001$), while no significant effect was observed on sustainable environmental performance ($\beta = 0.064$; $p = 0.441$). Finally, the analysis revealed a significant impact of supply chain resilience on both sustainable environmental performance ($\beta = 0.381$; $p < 0.001$) and sustainable social performance ($\beta = 0.304$; $p < 0.001$), but no significant effect on sustainable economic performance ($\beta = 0.031$; $p = 0.327$). The results of the statistical analysis are shown in Fig. 2.

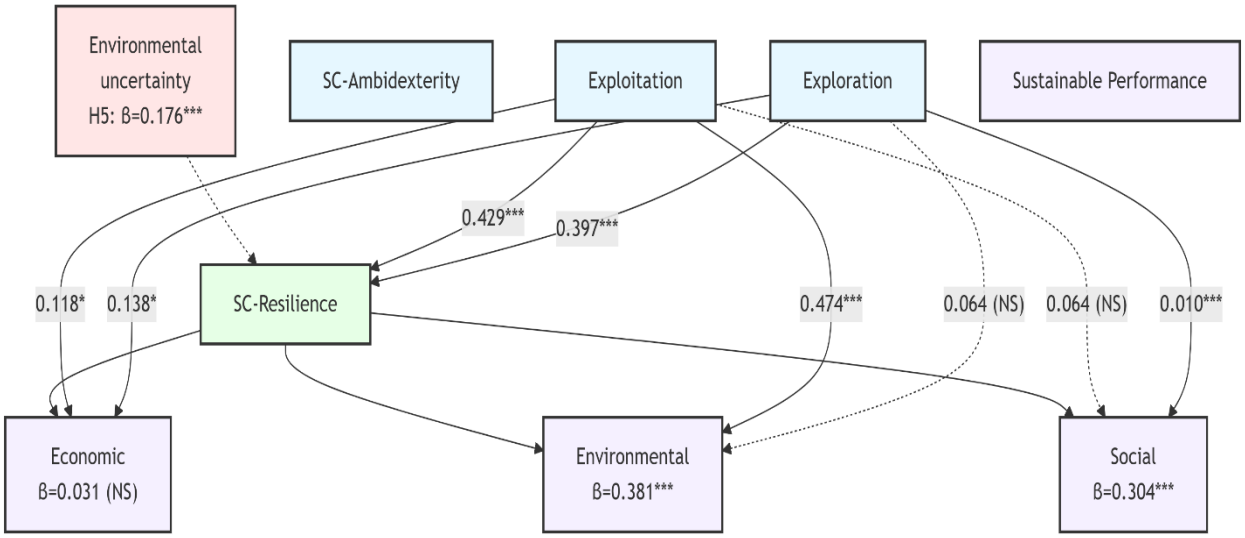

Fig. 2. Model results

4.2 Moderation Test

This research hypothesised that Environmental uncertainty would have a moderate influence on the relationship between supply chain ambidexterity and supply chain resilience. Moderation analysis was evaluated using the PLS product-indicator approach. As Chin, Marcolin, and Newsted (2003) mentioned, PLS can provide more precise estimates of moderator effects by reporting an error that attenuates approximated relationships and enhances the validation of theories (Henseler, J., & Fassott, G., 2010). To test the potential moderating effect, supply chain ambidexterity (predictor) and environmental uncertainty (moderator) were used to predict the firm's supply chain resilience.

The statistical analysis results show that the moderation effect of environmental uncertainty in the relationship between exploitation ambidexterity and supply chain resilience is significant, with ($\beta = 0.176$; $p < 0.001$). This indicates that environmental uncertainty reduces the impact of exploitation ambidexterity on supply chain resilience. On the other hand, the moderation effect of environmental uncertainty in the relationship between exploration ambidexterity and supply chain resilience was found to be non-significant, with ($\beta = 0.029$; $p = 0.441$). This suggests that environmental uncertainty does not affect the impact of exploration ambidexterity on supply chain resilience. Therefore, H5 is partially supported – it holds for exploitation but not for exploration.

5. Discussion and Implications

The findings from this study contribute to the broader discourse on supply chain ambidexterity (SCAMB), resilience, and sustainability by offering empirical evidence that underscores the critical nature of balancing exploitation and exploration activities within logistics supply chains. The significance of supply chain ambidexterity has been well-articulated in the literature, highlighting its role in equipping firms to respond effectively to immediate disruptions while preparing for long-term challenges (Junni et al., 2013; Kristal et al., 2010). Our research aligns with these theoretical perspectives, demonstrating that both exploitative and explorative capabilities significantly bolster supply chain resilience (SCRES), which, in turn, influences sustainable performance across environmental and social dimensions.

5.1 SC Ambidexterity and SC Resilience

Consistent with prior studies, our findings indicate that SCAMB is a pivotal enabler of supply chain resilience in logistics firms. The literature suggests that ambidextrous strategies, which balance the refinement of existing processes (exploitation) with the pursuit of innovative practices (exploration), enable firms to navigate disruptions and sustain operations (Aslam et al., 2020; Ambulkar et al., 2023). This study corroborates such assertions by confirming that both dimensions of ambidexterity, exploitation and exploration, positively impact SCRES. These findings are further enriched by the insights from Khan (2024), who conceptualised resilience as encompassing process, structure, and strategic actions. This multidimensional framing highlights that the resilience achieved through SCAMB is not limited to immediate operational recovery but also includes strategic adaptability and long-term learning capabilities, positioning logistics supply chains to better anticipate, respond to, and adapt to disruptions. This result reinforces the work of Aslam et al. (2020), who posited that ambidextrous supply chains achieve greater resilience by maintaining operational stability while adapting to new challenges.

5.2 SC Resilience as a Mediator to Sustainability

The role of SCRES as a mediator between SCAMB and sustainability outcomes was also highlighted. Previous literature establishes that resilience is not only a reactive capability but a strategic enabler that supports long-term sustainability (Tukamuhabwa et al., 2015; Sarkis et al., 2020). Our study extends this knowledge by showing that resilient logistics supply chains contribute to sustainability, particularly in terms of environmental and social performance. This aligns with Tukamuhabwa et al. (2015), who suggested that adaptive capabilities in supply chains facilitate timely and effective recovery while contributing to broader sustainability goals. However, the results also present a nuanced view that challenges some existing theoretical expectations. While SCRES significantly impacts environmental and social sustainability, its influence on economic sustainability was not found to be substantial. This finding may reflect the cost-intensive nature of resilience-building measures, which can limit short-term economic gains. Such insights resonate with the discussions by Klein (2021), who noted that the integration of resilience and sustainability often requires balancing immediate costs with long-term benefits.

5.3 SC Ambidexterity and Direct Impacts on Sustainability

The relationship between SCAMB and sustainability has been a topic of growing interest, as noted by Carissimi et al. (2023). Our study confirms that exploration within logistics supply chains has a significant positive impact on social sustainability. This result aligns with the idea that innovative practices encourage fair labour standards and community welfare (Carissimi et al., 2023). On the other hand, the study found no significant impact of exploitation on social sustainability, suggesting that while efficiency and optimisation are critical for operational stability, they may not directly translate into social benefits. This finding extends the work of Ambulkar et al. (2023), who noted that while exploitative strategies enhance resilience, their contribution to social outcomes may be limited without concurrent explorative efforts.

The environmental sustainability dimension revealed a complex interplay between ambidexterity and resilience. Although exploration was expected to foster environmental performance through innovative, resource-efficient practices, the findings did not show a significant direct effect. This contrasts with Azevedo et al.'s (2011) claim that sustainable supply chain management practices involving exploration can enhance ecological outcomes. This discrepancy may suggest that the benefits of explorative activities on environmental sustainability are realised over a longer term or require integration with broader strategic initiatives.

5.4 The Moderating Role of Environmental Uncertainty

This study also explored how environmental uncertainty influences the relationship between SCAMB and SCRES. The results suggest that while uncertainty moderates the impact of exploitation on resilience, it does not significantly affect the exploration-resilience linkage. This finding supports Kreye's (2017) argument that environmental uncertainty mainly affects exploitative strategies due to their dependence on stable conditions. In contrast, explorative strategies, being inherently adaptable and flexible, may remain effective under varying levels of uncertainty (Wilhelm et al., 2015).

6. Implications and Future Research

The study's findings have significant implications for both practitioners and researchers. For practitioners in the logistics sector, the results emphasise the need for balanced ambidexterity to foster resilience and achieve sustainable supply chain performance. The limited impact of exploitation on social sustainability suggests that firms should complement efficiency-driven strategies with explorative practices that align with broader social goals. For researchers, this study underscores the importance of investigating the temporal dynamics of SCAMB's effects on sustainability, particularly the delayed benefits of exploration on environmental outcomes.

Ambulkar et al. (2023) explores the impact of supply chain disruptions on companies' financial performance, focusing on the moderating role of supply chain ambidexterity in its exploration and exploitation dimensions to mitigate negative effects. In contrast, the current study examines how supply chain ambidexterity enhances resilience and supports sustainable performance across economic, environmental, and social dimensions in the logistics sector. Additionally, it investigates the role of environmental uncertainty as a moderating factor in the relationship between ambidexterity and resilience.

Future research could explore sector-specific factors influencing the relationships studied here and the role of digital technologies in enhancing SCAMB and SCRES. The interaction between technological advancements and supply chain strategies presents an avenue for understanding how digital tools can mitigate the cost implications of resilience-building while enhancing sustainable outcomes.

Disclosure of Interest

There is no conflict of interest among the authors, and none of the authors seek to achieve any personal gains.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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