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Exploring the Role of Supply Chain Ambidexterity in Enhancing Resilience and Sustainability: A Mediated Framework

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Abstract

In an era of increasing global market volatility and frequent disruptions, the strategic importance of embedding resilience and sustainability into supply chain management has become paramount. Existing literature has established the benefits of supply chain ambidexterity (SCAMB)—the concurrent pursuit of exploitative and explorative strategies—to balance efficiency with adaptability. However, the mechanisms through which SCAMB impacts sustainable performance across economic, social, and environmental dimensions remain insufficiently explored. This study addresses this gap by investigating the mediating role of supply chain resilience (SCRES) in the relationship between SCAMB and sustainable performance. A quantitative research approach was adopted, involving the distribution of structured questionnaires to managers within a diverse set of manufacturing firms in Egypt. The analysis was conducted using structural equation modelling (SEM) to examine the hypothesised relationships. The findings confirm that both exploitative and explorative dimensions of SCAMB significantly contribute to SCRES, which in turn mediates their impact on sustainable performance. While SCRES enhances environmental and social sustainability outcomes, its influence on economic sustainability appears limited, suggesting that resilience-building may entail short-term costs that challenge immediate economic gains. The results advance the theoretical discourse by elucidating the indirect role of SCRES in translating ambidextrous strategies into sustainable outcomes. For practitioners, these findings underscore the necessity of strategically balancing exploration and exploitation to develop resilience that aligns with long-term sustainability objectives. The study's implications call for further examination into sector-specific variations and the integration of digital technologies as facilitators of SCAMB and SCRES to achieve comprehensive sustainable performance.

Keywords: *Supply Chain Ambidexterity, Supply Chain Resilience, Sustainability in Supply Chains, and industrial companies in the city of Tenth of Ramadan in Egypt.*

Introduction

The importance of supply chain resilience and sustainability has never been more evident in an increasingly volatile and unpredictable global market and growing disruptions and risks (Choksy et al., 2022). Recent global events like the COVID-19 pandemic have revealed vulnerabilities in supply chains that prioritised efficiency over resilience and long-term sustainability (Ivanov & Dolgui, 2020; Sarkis et al., 2020). Moreover, evolving global challenges, such as geopolitical tensions and climate change, further stress the importance of integrating resilience and sustainability within supply chains to adapt effectively (Ibn-Mohammed et al., 2021;

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Vroegindewey & Hodbod, 2018). This has emphasised the need for supply chains to balance resilience—defined as the ability to absorb and recover from disruptions—and sustainability, which addresses environmental, social, and economic dimensions (Sarkis et al., 2020; Tukamuhabwa et al., 2015)

Supply chain ambidexterity (SCAMB), an emerging concept in supply chain management, defined as the ability to manage exploitative and explorative activities simultaneously, has emerged as a critical capability that enhances a firm's ability to respond to immediate disruptions while preparing for long-term challenges (Junni et al., 2013). Recent studies have shown that SCAMB plays a pivotal role in not just managing disruptions but in promoting sustainable, strategic practices that contribute to the long-term adaptability of supply chains (Carissimi et al., 2023; Ibn-Mohammed et al., 2021). However, the mechanisms through which ambidexterity influences sustainable performance still need to be explored, particularly in the context of global supply chains. This paper seeks to address this gap by examining how SCAMB influences supply chain resilience (SCRES) and, in turn, how resilience mediates the relationship between ambidexterity and sustainable performance.

The concept of supply chain viability has gained traction, highlighting the necessity for supply chains to withstand disruptions and adapt and thrive in a continuously changing environment (Ivanov, 2020; Sarkis, 2021). Resilience in supply chains is essential for ensuring long-term stability and adaptability. Building on the systematic literature review conducted by Tukamuhabwa et al. (2015), which analysed 91 articles, this study explores how resilience acts as a mediator that supports the long-term viability of supply chains. Tukamuhabwa et al. (2015) provided a comprehensive definition of SCRES, emphasising characteristics such as adaptive capability, recovery, and preparation, but acknowledged that existing definitions often overlook cost-effectiveness. By investigating these concepts, this paper contributes to the growing discourse on the interconnectedness of supply chain ambidexterity, resilience, and sustainability (Ponis & Koronis, 2012).

Literature Review and Hypothesis Development

Supply Chain Ambidexterity

Ambidexterity, initially conceptualised in organisational theory, refers to an organisation’s ability to balance exploration and exploitation strategies (March, 1991). Exploration involves innovation, flexibility, and the pursuit of new opportunities, while exploitation emphasises efficiency, refinement, and optimisation of existing processes (Junni et al., 2013). When confronted with frequent disruptions, the question for firms is whether to strengthen existing supply chain competencies or invest in developing new ones (Ambulkar et al., 2023). In supply chain contexts, ambidexterity allows firms to be both operationally efficient and adaptable, ensuring they can respond to disruptions while maintaining ongoing performance (Kristal et al., 2010)

For more than 30 years, firms have considered whether to concentrate on utilising existing competencies or creating new ones (March, 1991). In traditional ambidexterity frameworks, organisations focus on balancing internal capabilities. However, in supply chains, ambidexterity requires a broader focus on external factors, such as relationships with suppliers and stakeholders. Supply chain ambidexterity allows firms to leverage their current resources while simultaneously developing new capabilities to mitigate risks and seize opportunities in dynamic

environments (Kristal et al., 2010). Carissimi et al. (2023) emphasise the criticality of balancing exploration and exploitation, as supported by Raisch et al. (2009), who noted that achieving ambidexterity enables firms to respond effectively to environmental changes and maintain performance (Raisch et al., 2009). Despite its importance, there remains a gap in understanding how SCAMB contributes explicitly to resilience and sustainability within the supply chain.

Supply Chain Resilience

The importance of supply chain resilience has grown as disruptions become more frequent and severe. Resilience allows supply chains to withstand and recover from disturbances while maintaining operational stability in the field (Tukamuhabwa et al., 2015). Carissimi et al. (2023) draw on Pettit et al. (2010) to illustrate that resilience involves balancing vulnerabilities and capabilities within supply chains to ensure stability during disruptions (Pettit et al., 2010). In their systematic literature review of 91 studies, Tukamuhabwa et al. (2015) developed a comprehensive definition of SCRES, emphasising adaptive capability, preparation, response, connectedness, and timely recovery to a post-disruption state. However, resilience is not solely about operational recovery. According to Khan et al. (2024), resilience can be categorised into process, structure, and strategic actions, indicating that effective supply chain resilience involves recovery, strategic adaptability, and learning. This multifaceted perspective underscores that a resilient supply chain should be equipped to anticipate changes, respond efficiently, and adapt strategically over time. Ponis and Koronis (2012) expanded on this definition, highlighting connectedness and control as additional critical elements of resilience.

However, many definitions of resilience overlook cost-effectiveness, which is an important aspect of the real-world applications of SCRES. For this reason, the definition used in this paper is: "*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)

In recent literature, the link between resilience and sustainability has gained prominence. Sarkis et al. (2020) argue that resilience and sustainability are not independent but rather mutually reinforcing. Resilience ensures short-term adaptability, while sustainability addresses long-term environmental, social, and economic performance. Flexible manufacturing and supplier diversification strategies, essential for resilience, also contribute to sustainability by reducing waste and optimising resources (Klein, 2021).

Sustainability in Supply Chains

Sustainability has become a crucial focus in modern supply chain management, primarily driven by the need for long-term viability across environmental, social, and economic dimensions. This concept is often framed within the triple bottom line (TBL) framework, as Elkington (1999) proposed, which emphasises the balance between profit, environmental stewardship, and social responsibility (Elkington & Rowlands, 1999) . As global supply chains grow increasingly complex, sustainability is no longer merely a strategic option but a critical necessity for firms seeking to maintain competitive advantage (Carter & Rogers, 2008). Sustainability in supply chains refers to reducing environmental impacts, promoting social equity, and ensuring economic growth—a model often encapsulated as "people, planet, profit" (Schaltegger & Burritt, 2014).

Recent literature identifies sustainability as not only a regulatory or moral obligation but also a

significant competitive differentiator. Firms that embed sustainable practices within their supply chains tend to perform better in terms of resource utilisation, cost efficiency, and market positioning (Gold et al., 2010; Seuring & Müller, 2008). Schaltegger and Burritt (2014) argue that incorporating sustainability into supply chain performance metrics significantly boosts competitiveness. Companies that adopt sustainable supply chain management (SSCM) practices often differentiate themselves through proactive collaboration, resource optimisation, and waste minimisation (Ahi & Searcy, 2013).

Additionally, the growing demand for resilient supply chains has reinforced the connection between sustainability and operational effectiveness. Sustainable supply chain management (SSCM) frameworks, such as lean, green, and resilient strategies, not only help firms minimise environmental risks but also enhance their flexibility and responsiveness to disruptions (Azevedo et al., 2011; Sharma et al., 2021). This integration of strategies enables firms to balance ecological sustainability with business performance, positioning them to better navigate uncertainty and volatility in the global supply chain environment (Seuring & Müller, 2008).

In the post-COVID era, the importance of sustainability has gained even greater prominence. Industries have increasingly turned towards "glocalisation"—a hybrid strategy that blends global and local supply chain approaches to enhance resilience while adhering to sustainable practices (Sarkis et al., 2020). This intersection between resilience and sustainability highlights that adaptable supply chains are not only better prepared to withstand disruptions but also better equipped for long-term success. Sustainable supply chains can secure future-proof operations in the face of global disruptions (Carter & Rogers, 2008)by ensuring environmental responsibility and social welfare alongside economic viability.

Linking SC Ambidexterity to SC Resilience

Supply chain ambidexterity (SCAMB) is increasingly recognised for enhancing supply chain resilience. Simultaneously exploiting existing capabilities while exploring new opportunities enables firms to navigate disruptions effectively. Aslam et al. (2020) provide empirical evidence supporting the positive impact of SCAMB on supply chain resilience. They argue that ambidextrous supply chains, characterised by a balance between adaptability and alignment, are better equipped to adjust dynamically to both anticipated and unanticipated disruptions (Aslam et al., 2020) . This dual capacity allows firms to maintain operational stability and quickly recover from setbacks, fostering a more resilient supply chain. Their work underscores the importance of ambidexterity in building resilience, highlighting the need for firms to cultivate both exploitative and explorative strategies to manage risks in a volatile environment. By engaging in exploration and exploitation concurrently, firms practising SCAMB can adapt to changes while maintaining core efficiencies, resulting in more effective supply chain management (Ambulkar et al., 2023).

Ambulkar et al. (2023) investigates the effect of supply chain disruptions on the financial performance of companies, with a focus on the moderating role of supply chain ambidexterity in its two dimensions: exploration and exploitation. It emphasizes mitigating the adverse impacts of supply chain disruptions on financial performance by leveraging exploratory ambidexterity on one side and exploitative ambidexterity on the other. In contrast, the current study examines the influence of supply chain ambidexterity, encompassing both exploratory and exploitative dimensions, on improving supply chain resilience and various dimensions of sustainable performance, including economic (financial), environmental, and social outcomes. Furthermore,

it explores the interactive role of environmental uncertainty in the relationship between supply chain ambidexterity and resilience.

Drawing from the literature, the following hypotheses are proposed:

H1: *Supply chain ambidexterity positively influences supply chain resilience.*

H1a: *Exploration ambidexterity positively influences supply chain resilience.*

H1b: *Exploitation ambidexterity positively influences supply chain resilience.*

Linking SC Resilience to Sustainable Performance

The integration of resilience and sustainability is especially relevant in light of recent global disruptions, as Supply chain resilience refers to operation stability and continuity (Ali et al., 2024), while Supply chain sustainability (SCS), typically evaluated using the triple bottom line (TBL) framework, focuses on balancing environmental, social, and economic performance. Resilience plays a critical role in sustaining this balance across these dimensions. For instance, resilience strengthens economic performance by ensuring supply chains recover from disruptions, and it supports environmental goals by promoting the efficient use of resources. Furthermore, resilience contributes to social sustainability by safeguarding jobs and ensuring community stability during crises (Sarkis et al., 2020).

It is suggested that supply chains enhance their resilience by developing the capacity to "anticipate," "adapt," and "respond" to external disruptions, enabling them to manage disturbances and transition to an improved state (Ali et al., 2017; Carissimi et al., 2023; Christopher & Peck, 2004; Ponomarov & Holcomb, 2009). Consequently, alongside sustainability, supply chain resilience has emerged as a crucial paradigm in supply chain management (SCM).

Strategies such as flexible manufacturing and adaptive procurement processes not only mitigate the risks posed by disruptions but also align with sustainability goals by reducing environmental impact and enhancing social equity (Kholaif et al., 2023). As a result, resilient supply chains are better positioned to achieve long-term sustainability outcomes. This intersection between resilience and sustainability underscores that supply chains need to be both adaptable and future-proof, ensuring long-term viability in a rapidly changing world. Carissimi et al. (2023) support this by referencing the work of Seuring (Seuring & Müller, 2008), which highlighted that sustainable supply chains incorporate both proactive and reactive measures to maintain resilience and sustainability simultaneously. Resilient supply chains are better structured to achieve sustainability outcomes by balancing the environmental, social, and economic dimensions of performance. SCRES ensures that firms can recover from disruptions while minimising their environmental footprint and supporting the field of social responsibility(Tukamuhabwa et al., 2015).

Drawing from the literature, the following hypotheses are proposed:

H2: *Supply chain resilience positively influences sustainable performance. To provide a more detailed understanding of how resilience impacts the dimensions of sustainability, this hypothesis is divided into three sub-hypotheses:*

H2a*: Supply chain resilience positively influences economic sustainability by reducing the financial impact of disruptions and ensuring cost efficiency.*

***H2b**: Supply chain resilience positively influences social sustainability by maintaining workforce stability and protecting community welfare during disruptions.*

***H2c**: Supply chain resilience positively influences environmental sustainability by promoting efficient resource use and minimising waste.*

Linking SC Ambidexterity with Sustainable Performance

In their recent study (Carissimi et al., 2023), authors analysed 221 articles spanning a time horizon from 2004 to 2021. Their findings highlight organisations' need to develop ambidexterity by prioritising sustainability objectives while maintaining sufficient redundancy to withstand disruptive events (Bui et al., 2021). Drawing from the literature, the following hypotheses are proposed:

***H3:** Supply chain ambidexterity positively influences sustainable performance.*

***H3a:** Exploration ambidexterity positively influences economic sustainability*

***H3b:** Exploration ambidexterity positively influences social sustainability.*

***H3c:** Exploration ambidexterity positively influences environmental sustainability.*

***H3d:** Exploitation ambidexterity positively influences economic sustainability.*

***H3e:** Exploitation ambidexterity positively influences social sustainability.*

***H3f:** Exploitation ambidexterity positively influences environmental sustainability.*

The mediating role of Supply Chain Resilience

SCAMB enhances resilience, which in turn reinforces sustainability outcomes by ensuring that supply chains are both adaptable and resource-efficient. This mediation is critical in environments where firms must continuously adapt to disruptions and challenges (Ponis & Koronis, 2012).

Given the established relationships where SC-ambidexterity contributes to supply chain resilience and resilience, in turn, 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. This means the adaptive and efficient capabilities developed through ambidexterity help build resilience, ultimately driving better sustainable outcomes. Drawing from the literature and based on the hypothesis above, the following hypotheses are proposed:

***H4:** Supply chain resilience mediates the relationship between Supply Chain ambidexterity and sustainable performance.*

The moderating role of uncertainty

Uncertainty becomes a major concern when an organisation lacks adequate internal or external knowledge. External uncertainty, also known as environmental uncertainty, relates to the unstable conditions in a firm’s external environment (Kreye, 2017). Some researchers suggest that uncertainty, seen as an unexpected or unpredictable environment, only becomes an issue when it interacts with critical elements of firms, affecting their efficiency. They also stress that uncertainty consistently plays a crucial role in influencing supply chains (Gadde and Finn, 2018).

A prominent body of literature on dynamic capabilities highlights that these capabilities are particularly important in dynamic environments (Wilhelm et al., 2015). Teece (2007) underscored the critical importance of dynamic capabilities in such contexts. By definition, dynamism in a firm's environment requires adaptability and change, which drives the necessity of applying dynamic capabilities. Firms in dynamic environments must seize opportunities by adjusting their operational routines in response to shifting demand patterns (Aslam et al., 2019). This is facilitated through dynamic capabilities like supply chain ambidexterity (SC-Ambidexterity). Environmental uncertainty is a key factor in market dynamism. Therefore, we propose that the impact of SC-Ambidexterity on supply chain resilience (SC-Resilience) will be greater under higher levels of market uncertainty, and the reverse may also hold true. The following hypothesis is proposed:

H5. Uncertainty moderates the relationship between supply chain ambidexterity and supply chain resilience in a way that a higher level of uncertainty enhances the positive impact of supply chain ambidexterity on supply chain resilience (see Figure 1).

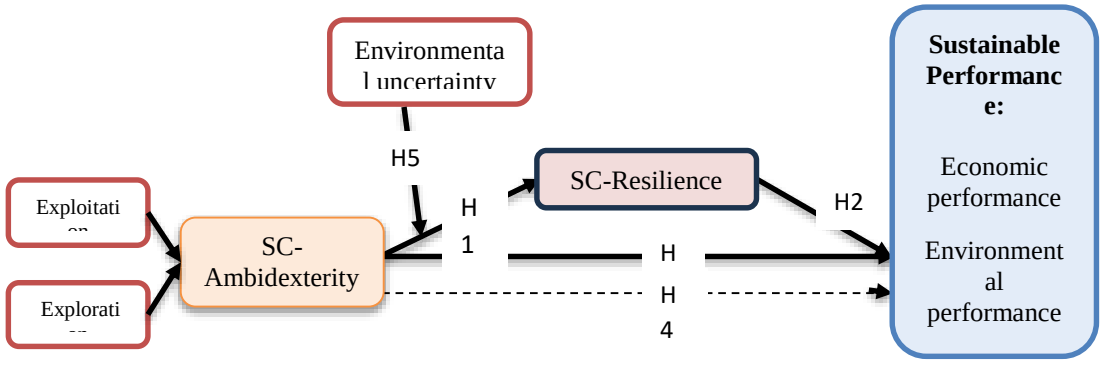

Figure 1: Hypothesized model

Research Methods

Designing Questionnaire and Instrument Development

This study focuses on the Managers of different manufacturing companies located in Egypt. The research model is shown in Figure 1—a total of 9 manufacturing industries. The industries were divided into clusters based on industry type. Manufacturing industries in the industrial companies in the city of Tenth of Ramadan in Egypt were selected. The sample contained small and medium manufacturing enterprises operating in different 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, Fuhong, 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, A. 2011; Bansal, 2005; Zhu & Sarkis 2004).

Sample and Data Collection

As mentioned, data were collected from the Egyptian industrial sector. The study population size is 1731 Sample Units from managers in industrial companies in the city of Tenth of Ramadan in Egypt. The Tenth of Ramadan consists of nine main industrial sectors, according to the periodic reports of the General Authority for Investment and Free Zones for 2023. Table (1) shows a statement of the sample size distribution among the industrial companies under study according to industrial activity.

The Research Ethics Committee at CBA in Yanbu at Taibah University 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 by the [Research Ethics Committee]. The study's approval reference number is CBA-2024-34. Verbal consent was obtained from participants to take part in the research. Since the study population is based in Egypt and the research team is located in Saudi Arabia, the data were collected from participants through an online form.

Table 1: The distribution of the sample size among the industrial companies under study according to industrial activity

	Industrial Sector	P.	%	Sample Size
1	Textile and clothing industries	309	0.179	57
2	Plastic industries	241	0.139	44
3	Food industries	236	0.136	43
4	Electrical and engineering industries	216	0.125	39
5	Furniture industry	106	0.061	19
6	Building materials industry	99	0.057	18
7	Metal and mechanical industries	248	0.143	45
8	Pharmaceutical and chemical industries	163	0.095	30
9	Paper industries	113	0.065	20
Total		1731	1	315

Source: The periodic reports of the General Authority for Investment and Free Zones for 2023.

The sampling unit in this study is all managers in the companies. The sample size of the study community was determined using the Sample Size Calculator Application, which is 315, and 257 lists were obtained, i.e. a response rate of (81.5%), and among them were 249 valid lists during the period from March to July 2023.

Data Analysis

Two methods for evaluating and measuring partial least squares (PLS) were implemented. The first step involved conducting validity and reliability analyses, while the second step focused on testing the path coefficients 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 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 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 management resilience. Therefore, PLS 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.

Validity and Reliability Testing

The surveys 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 standardised 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			
		Am24	0.791			
SC-Resilience		RE1	0.729	0.834	0.871	0.795
		RE2	0.632			
		RE3	0.768			

Variable	Item	St. Coe.	(α) coefficients	(CR) coefficients	)AVE(coefficients
	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			
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.

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.

Model and Hypotheses Testing Result

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 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).

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.

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	3%
Explor	Eco-Per	0.14	0.01	0.15	
SCR	Eco-Per	0.03	--	0.03	
Explor	Env-Per	0.01	0.15	0.16	64%
Exploi	Env-Per	0.47	0.16	0.64	
SCR	Env-Per	0.38	--	0.38	
Exploi	So-Per	0.06	0.13	0.19	36%
Explor	So-Per	0.28	0.12	0.40	
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 (β-0.429; $p < 0.001$), as well as a significant effect of exploration Ambidexterity on supply chain resilience (β-0.397; $p < 0.001$). Additionally, exploitation Ambidexterity has a significant effect on both sustainable economic performance (β-0.118; $p < 0.043$) and sustainable environmental performance (β-0.474; $p < 0.001$). However, no significant effect of exploitation Ambidexterity was found on sustainable social performance (β-0.064; $p = 0.179$). Moreover, exploration Ambidexterity showed a significant impact on both sustainable economic performance (β-0.138; $p < 0.022$) and sustainable social performance (β-0.010; $p < 0.001$), while no significant effect was observed on sustainable environmental performance (β-0.064; $p = 0.441$).

Finally, the analysis revealed a significant impact of supply chain resilience on both sustainable environmental performance (β = -0.381; p < 0.001) and sustainable social performance (β-0.304; p < 0.001), but no significant effect on sustainable economic performance (β-0.031; p = 0.327). The results of the statistical analysis are shown in Figure 2.

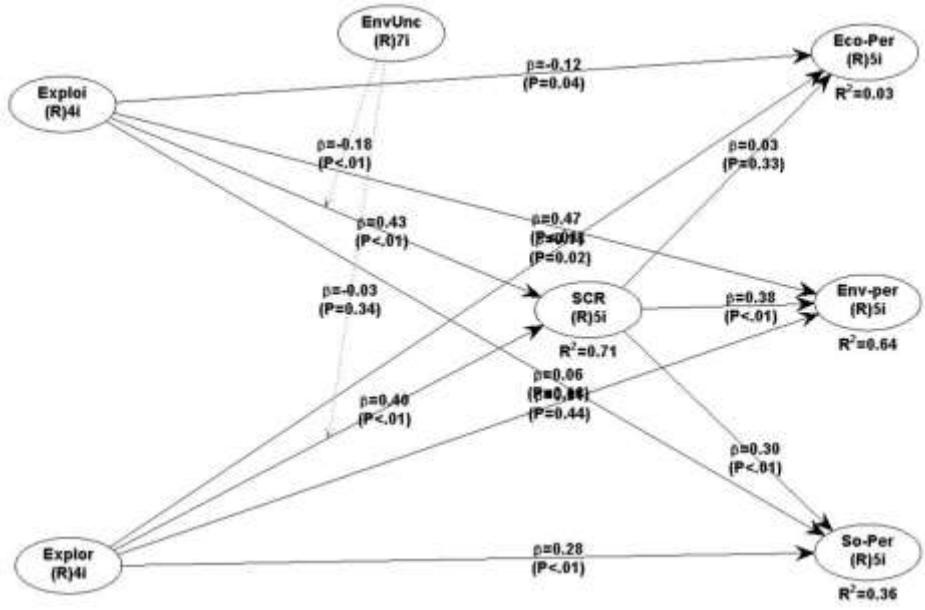

Figure 2: Model results

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 is 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 of a moderating effect, the supply chain ambidexterity (predictor) and the Environmental uncertainty (moderator) are 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 (β-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 (β-0.029; p < 0.001). This suggests that environmental uncertainty does not affect the impact of exploration ambidexterity on supply chain resilience. Therefore, H4 is not supported.

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 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.

SC Ambidexterity and SC Resilience

Consistent with prior studies, our findings indicate that SCAMB is a pivotal enabler of supply chain resilience. 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 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.

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 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.

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 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 only limited by 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.

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).

Implications and Future Research

The study’s findings have significant implications for both practitioners and researchers. For practitioners, 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 of 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. 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.

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

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An author contributions statement formatted according to the CrediT (Contributor Roles Taxonomy) guidelines, All authors have approved the final manuscript:

Conceptualization: [Ahmad A. Alharbi]

Methodology: [Ibrahim H. Sheta and Ibrahim G. Mahgoub]

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Data Availability Statement

The study population consists of managers of industrial companies in the 10th of Ramadan City, Egypt. Since the research team members are based in Saudi Arabia, data were collected from participants through an online form. The authors confirm that no data has been used that cannot be shared due to ethical, privacy, or security concerns. The data that support the findings of this study are available from the corresponding author, [Ibrahim G. Mahgoub], upon reasonable request.

References

Ahi, P., & Searcy, C. (2013). A comparative literature analysis of definitions for green and sustainable supply chain management. Journal of cleaner production, 52, 329-341.

Ali, A., Labib, A., Afonso, P., & Mahfouz, A. (2024). Developing dynamic supply chain resilience capabilities: a study of Irish firms' response to the COVID-19 pandemic. Production, 34, e20230076.

Ali, A., Mahfouz, A., & Arisha, A. (2017). Analysing supply chain resilience: integrating the constructs in a concept mapping framework via a systematic literature review. Supply chain management: an international journal, 22(1), 16-39.

Ambulkar, S., Ralston, P. M., Polyviou, M., & Sanders, N. (2023). Frequent supply chain disruptions and firm performance: the moderating role of exploitation, exploration and supply chain ambidexterity. International Journal of Physical Distribution & Logistics Management, 53(10), 1261-1285.

Aslam, H., Khan, A. Q., Rashid, K., & Rehman, S.-u. (2020). Achieving supply chain resilience: the role of supply chain ambidexterity and supply chain agility. Journal of Manufacturing Technology Management, 31(6), 1185-1204.

Azevedo, S. G., Carvalho, H., & Machado, V. C. (2011). The influence of green practices on supply chain performance: A case study approach. Transportation research part E: logistics and transportation review, 47(6), 850-871.

Bui, T.-D., Tsai, F. M., Tseng, M.-L., Tan, R. R., Yu, K. D. S., & Lim, M. K. (2021). Sustainable supply chain management towards disruption and organizational ambidexterity: A data driven analysis. Sustainable production and consumption, 26, 373-410.

Carissimi, M. C., Creazza, A., & Colicchia, C. (2023). Crossing the chasm: Investigating the relationship between sustainability and resilience in supply chain management. Cleaner Logistics and Supply Chain, 7, 100098.

Carter, C. R., & Rogers, D. S. (2008). A framework of sustainable supply chain management: moving toward new theory. International journal of physical distribution & logistics management, 38(5), 360-387.

Choksy, U. S., Ayaz, M., Al-Tabbaa, O., & Parast, M. (2022). Supplier resilience under the COVID-19 crisis in apparel global value chain (GVC): The role of GVC governance and supplier's upgrading. Journal of Business Research, 150, 249-267.

Christopher, M., & Peck, H. (2004). Building the resilient supply chain.

Elkington, J., & Rowlands, I. H. (1999). Cannibals with forks: The triple bottom line of 21st century business. Alternatives Journal, 25(4), 42.

Gadde, L. E., & Wynstra, F. (2018). Purchasing management and the role of uncertainty. Imp Journal, 12(1), 127-147.

Gold, S., Seuring, S., & Beske, P. (2010). Sustainable supply chain management and inter-organizational resources: a literature review. Corporate social responsibility and environmental management, 17(4), 230-245.

Ivanov, D., & Dolgui, A. (2020). Viability of intertwined supply networks: extending the supply chain resilience angles towards survivability. A position paper motivated by COVID-19 outbreak. International journal of production research, 58(10), 2904-2915.

Junni, P., Sarala, R. M., Taras, V., & Tarba, S. Y. (2013). Organizational ambidexterity and performance: A meta-analysis. Academy of Management Perspectives, 27(4), 299-312.

Khan, M. (2024). Enhancing supply chain resilience: The role of SC-ambidexterity and SC-agility. Journal of Future Sustainability, 4(4), 189-214.

Kholaif, M. M. N. H. K., Ming, X., & Getele, G. K. (2023). Post COVID-19's opportunities for customer-centric green supply chain management and customers' resilience; the moderate effect of corporate social responsibility. International Journal of Emerging Markets, 18(6), 1397-1424.

Klein, C. (2021). Companies must focus on resiliency, profitability and sustainability. URL www. weforum. org.

Kristal, M. M., Huang, X., & Roth, A. V. (2010). The effect of an ambidextrous supply chain strategy on combinative competitive capabilities and business performance. Journal of operations management, 28(5), 415-429.

March, J. G. (1991). Exploration and exploitation in organizational learning. Organization science, 2(1), 71-87.

Pettit, T. J., Fiksel, J., & Croxton, K. L. (2010). Ensuring supply chain resilience: development of a conceptual framework. Journal of business logistics, 31(1), 1-21.

Ponis, S. T., & Koronis, E. (2012). Supply Chain Resilience? Definition of concept and its formative elements. The journal of applied business research, 28(5), 921-935.

Ponomarov, S. Y., & Holcomb, M. C. (2009). Understanding the concept of supply chain resilience. The international journal of logistics management, 20(1), 124-143.

Raisch, S., Birkinshaw, J., Probst, G., & Tushman, M. L. (2009). Organizational ambidexterity: Balancing exploitation and exploration for sustained performance. Organization science, 20(4), 685-695.

Sarkis, J., Cohen, M. J., Dewick, P., & Schröder, P. (2020). A brave new world: Lessons from the COVID-19 pandemic for transitioning to sustainable supply and production. Resources, Conservation and Recycling, 159, 104894.

Schaltegger, S., & Burritt, R. (2014). Measuring and managing sustainability performance of supply chains: Review and sustainability supply chain management framework. Supply Chain Management: An International Journal, 19(3), 232-241.

Seuring, S., & Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. Journal of cleaner production, 16(15), 1699-1710.

Sharma, V., Raut, R. D., Mangla, S. K., Narkhede, B. E., Luthra, S., & Gokhale, R. (2021). A systematic literature review to integrate lean, agile, resilient, green and sustainable paradigms in the supply chain management. Business Strategy and the Environment, 30(2), 1191-1212.

Teece, D. J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. Strategic management journal, 28(13), 1319-1350.

Tukamuhabwa, B. R., Stevenson, M., Busby, J., & Zorzini, M. (2015). Supply chain resilience: definition, review and theoretical foundations for further study. International journal of production research, 53(18), 5592-5623.

Luo, Fuhong (2024). Study on the Impact Mechanism of Supply Chain Integration on Supply Chain Resilience. Transactions on Economics, Business and Management Research, (8), 398-407.

Khan, A., Chen, C. C., Lu, K. H., Wibowo, A., Chen, S. C., & Ruangkanjanases, A. (2021). Supply chain ambidexterity and green SCM: moderating role of network capabilities. Sustainability, 13(11), 5974.

Paulraj, A. (2011). Understanding the relationships between internal resources and capabilities, sustainable supply management and organizational sustainability. Journal of Supply Chain Management, 47(1), 19-37.

Bansal, P. (2005). Evolving sustainably: A longitudinal study of corporate sustainable development. Strategic management journal, 26(3), 197-218.

Zhu, Q., & Sarkis, J. (2004). Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. Journal of operations management, 22(3), 265-289.

Brandon-Jones, E., Squire, B., Autry, C. W., & Petersen, K. J. (2014). A contingent resource-based perspective of supply chain resilience and robustness. Journal of Supply Chain Management, 50(3), 55-73.

Ojha, D., Acharya, C., & Cooper, D. (2018). Transformational leadership and supply chain ambidexterity: Mediating role of supply chain organizational learning and moderating role of uncertainty. International Journal of Production Economics, 197, 215-231.

Henseler, J., & Fassott, G. (2010). Testing moderating effects in PLS path models: An illustration of available procedures. Handbook of partial least squares: Concepts, methods and applications, 713-735.

Chin, W. W., Marcolin, B. L., & Newsted, P. R. (2003). A partial least squares latent variable modeling approach for measuring interaction effects: Results from a Monte Carlo simulation study and an

electronic-mail emotion/adoption study. Information systems research, 14(2), 189-217.

Aslam, H., Khan, A. Q., Rashid, K., & Rehman, S. U. (2020). Achieving supply chain resilience: the role of supply chain ambidexterity and supply chain agility. Journal of Manufacturing Technology Management, 31(6), 1185-1204.

Kreye, M. E. (2017). Can you put too much on your plate? Uncertainty exposure in servitized triads. International Journal of Operations & Production Management, 37(12), 1722-1740.

Wilhelm, H., Schl€ omer, M. and Maurer, I. (2015),"How dynamic capabilities affect the effectiveness and efficiency of operating routines under high and low levels of environmental dynamism", British Journal of Management, Vol. 26 No. 2, pp. 327-345.