The Impact of Supply Chain Agility on Sustainable Supply Chain Performance: The Moderating Role of Supply Chain Innovation and The Mediating Role of Sustainable Supply Chain Management Practices in Sri Lankan Manufacturing Companies

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ABSTRACT

This study examines the impact of supply chain agility on sustainable supply chain performance, with sustainable supply chain management (SSCM) practices as a mediating mechanism and supply chain innovation as a moderating factor within the context of Sri Lankan manufacturing firms. Drawing on Dynamic Capabilities Theory, the Resource-Based View, and the Triple Bottom Line framework, the study develops and tests a conceptual model through a quantitative, cross-sectional survey. Data were collected from 78 people involved in supply chain operations across export-oriented manufacturing industries, and the hypotheses were tested using partial least squares structural equation modeling (PLS-SEM). The results reveal that supply chain agility has a significant positive effect on SSCM practices, while its direct effect on sustainable supply chain performance is not significant. SSCM practices, however, have a significant positive impact on performance and fully mediate the relationship between agility and performance, indicating that agility contributes to sustainability outcomes only when translated into operational practices. In contrast, the moderating effect of supply chain innovation is not supported. The model demonstrates acceptable explanatory power and predictive relevance. The study contributes to the literature by providing evidence of full mediation and highlighting the importance of operationalizing dynamic capabilities through sustainability practices to achieve performance outcomes, particularly in emerging economy contexts. The findings offer practical insights for managers and policymakers to integrate supply chain agility into SSCM practices to enhance sustainable performance.

Keywords: Supply Chain Agility, Sustainable Supply Chain Management, Sustainable Supply Chain Performance, Supply Chain Innovation, Sustainability

INTRODUCTION

The convergence of operational disruptions, sustainability pressures, and competitive pressures in the global manufacturing world has driven one of the most significant transformations in supply chain governance and strategy. These pressures are not only structurally important but also strategically naked in the case of the export-oriented emerging economies like those of Sri Lanka where the manufacturing base of the country (anchored on the production of apparel and textiles, food and beverage processing, rubber and plastic products and the assembly of light electronics) is a significant source of foreign exchange income and the formal sector of the economy. The post-COVID-19 pandemic has deepened the supply chain vulnerabilities of Sri Lankan manufacturers, revealing acute gaps in responsiveness, supplier diversification, and sustainability governance, while also driving buyer-driven and regulatory imperatives for greener, more socially responsible supply chains (Sharma et al., 2023). In this regard, determining the organizational competencies and managerial actions that enable manufacturing companies to achieve excellent, wholly sustainable supply chain performance has become a significant research agenda with theoretical and policy importance.

Supply chain agility is now among the most theorized and investigated capabilities in modern operations management literature. The ability of the supply chain to quickly track changes in the environment and act speedily, flexibly, and precisely in procurement, production, and distribution activities (Gligor et al., 2019), agility has been repeatedly associated with a competitive advantage, resiliency, and performance results in a wide range of industrial and geographic settings. Recent meta-analytic evidence confirms that supply chain agility has both a positive and significant impact on operational and financial performance indicators, and that its particular paths to sustainable performance outcomes are not adequately theorized (Alfalla-Luque et al., 2023). The difference between operational performance and sustainable supply chain performance (SSCP) i.e. the last one is based on achievement of environmental, social and economic aspects as per the Triple Bottom Line (TBL) format is of paramount significance as the operational mechanisms prompted by agility could lead to achievement rather dissimilar outcomes as compared to the operational principles that rest on the use of traditional performance measurement (Seuring & Muller, 2008; Agyabeng-Mensah et al., 2025).

Two potential pathways and two boundary conditions of the relationship between supply chain agility and sustainable performance were proposed, but have never been thoroughly studied together under two theoretical mechanisms. To begin with, theorized behavioral and organizational mediators include sustainable supply chain management practices (SSCM), including green procurement, environmental collaboration with suppliers, socially responsible sourcing, and closed-loop logistics, that have institutionalized dynamic capabilities like agility into routines to create triple-bottom-line performance (Gimenez et al., 2012; Agyabeng-Mensah et al., 2025). Regarding the Dynamic Capabilities Theory (DCT), agility is a sensing-and-seizing capability whose effectiveness is achieved through operational and managerial routines, with SSCM practices as a major vehicle for this (Teece et al., 1997; Dubey et al., 2019). Second, as has been suggested, supply chain innovation (SCI), the conscious implementation and incorporation of new technologies, processes, or business model configurations into supply chain activities, has served as a moderating contingency to enhance the productive utilization of supply chain capabilities within performance objectives (Hofmann & Rueusch, 2017; Wang & Wang, 2024). Companies that are more intensive in supply chain innovation can be more sensitive in realizing sensing and responsiveness into an enduring and quantifiable performance alteration through the provision of the technological and process infrastructure on which dynamic operations may be operationalized.

Although theoretical plausibility and growing empirical support for individual constructs bolster these mechanisms, no published study to date has empirically tested both the mediating role of SSCM practices and the moderating role of SCI in the relationship between supply chain agility and sustainable supply chain performance in an emerging-economy manufacturing setup. This divide is further established, especially in Sri Lanka, where the manufacturing industry operates under a unique set of institutional pressures, resource limitations, reliance on exports, and economic vulnerability following the crisis. In Sri Lanka, sustainability-related compliance demands on manufacturers in the export sector have been strengthened in recent years by the Sri Lankan Board of Investment and export promotion authority, as these buyers in multiple manufacturing industries such as apparel and food processing and particularly multinational buyers increasingly lay environmental and social standards as a precondition to market entry (Jayasinghe-Mudalige & Fujiwara, 2008; Sharma et al., 2023). The practical importance of the interaction between agility, sustainable practices, and supply chain innovation in generating sustainable performance outcomes is consequently of significant value to managers, policymakers, and development practitioners.

The paper bridges this gap by formulating and empirically testing an integrated theoretical framework in the supply chain agility that directly and indirectly affects sustainable supply chain performance, with SSCM practices as a proposed mediator and supply chain innovation as a proposed moderator between agility and performance.

LITERATURE REVIEW

Theoretical Foundations

The study is based on three theoretical frameworks: Dynamic Capabilities Theory (DCT), the Resource-Based View (RBV), and the Triple Bottom Line (TBL). According to the theory of Dynamic Capabilities, which underpins competitive advantage in fluctuating conditions, companies can maintain performance by detecting environmental changes, grasping new opportunities, and rearranging internal resources and processes (Teece et al., 1997). Agility is a higher-order dynamic capability in the context of the supply chain, enabling companies to integrate, create, and mobilize supply chain-level resources in response to environmental turbulence (Dubey et al., 2019; Gligor et al., 2019). Recent supply chain research on the use of DCT has pointed out that dynamic capabilities are not performance-generating concepts but are driven by operational-level routines and practices that translate sensing and seizing into actual performance (Sharma et al., 2023; Alfalla-Luque et al., 2023).

The Resource-Based View (RBV) can be viewed as a complement to DCT, as it also highlights that competitive advantage can be sustained through the ownership of valuable, rare, inimitable, and non-substitutable (VRIN) resources and capabilities (Barney, 1991). As an embedded organizational capability, supply chain agility meets the VRIN requirements and provides the resources on which sustainable performance can be established. Nevertheless, understanding of contextual modifiers has grown within RBV scholarship to explain how resources are transformed into performance outcomes, with the firm's innovation environment as one moderator, triggered by situational factors (Ataseven & Nair, 2017; Wang & Wang, 2024). A supply chain innovation, viewed through the RBV lens, is considered a complementary resource that enhances the value-generating capacity of agility resources, aligning with the moderation hypothesis established in this paper.

The Triple Bottom Line (TBL) framework is a conceptual framework that offers a normative and measurement-based perspective on the sustainable performance of the supply chain. The TBL paradigm implies that organizational performance should be measured across three interrelated aspects: economic prosperity, environmental stewardship, and social equity (Elkington, 1997, as operationalized empirically by Seuring and Muller, 2008; Zhu et al., 2008). Modern-day sustainable supply chain studies have also operationalized the multi-dimensional concept of SSCP, which includes reducing environmental impact, ensuring social conformity, and creating economic value over time throughout the supply chain (Agyabeng-Mensah et al., 2025; Bag et al., 2023).

Supply Chain Agility and Sustainable Supply Chain Performance.

In recent scholarship, supply chain agility (SCA) has been defined with incremental theoretical precision as the integrated ability of the supply chain system to respond quickly, precisely, and at low cost to uncertain environmental shifts without impacting or diminishing customer value (Gligor et al., 2019; Alfalla-Luque et al., 2023). The main areas of supply chain agility are market responsiveness, virtual responsiveness, process responsiveness, and network-based responsiveness, which lead to supply chain agility in a turbulent environment (Swafford et al., 2006; Dubey et al., 2019).

The correlation between supply chain agility and performance has attracted significant empirical scholarly interest. The meta-analytic review by Alfalla-Luque et al. (2023), which relied on 87 empirical studies across different industries and geographies, demonstrated a significant positive relationship between supply chain agility and operational performance, with the overall effect size indicating substantial economic and managerial impact. The more recent study by Wang and Wang (2024) showed that supply chain agility is a key antecedent of firm sustainability performance in the post-COVID manufacturing environment, where agile supply chains have proven more effective at mitigating disruptions without compromising environmental and social compliance commitments. Sharma et al. (2023) found that agility positively affects various aspects of sustainable performance among developing-economy export-oriented manufacturers, as it enables firms to reorganize supplier networks and logistics configurations in response to market cues and environmental sustainability requirements.

The importance of the concept of agility to sustainable performance is further enhanced by export dependency, exposure to international buyer standards, unstable global demand, and susceptibility to input availability, all of which affect the manufacturing industry in Sri Lanka. The clothing industry, which is the largest manufacturing export earner of Sri Lanka, has been subject to recurrent stabilization due to fluctuation in global retail market demand for products, inability of raw material suppliers to maintain stable prices, and the use of stricter environmental and labour regulations by the buyers of European and North American countries (Jayasinghe-Mudalige & Fujiwara, 2008). Agile supply chain skills, such as those of manufacturers in this environment, enable the redesign of procurement and production operations to meet such pressures while also meeting sustainability performance requirements. Based on DCT and the empirical evidence of the reviewed materials above, the hypothesis would be as follows:

H1: Supply Chain Agility has a significant positive impact on Sustainable Supply Chain Performance (SSCP).

Mediating Role of the Sustainable Supply Chain Management Practices.

The practices of sustainable supply chain management (SSCM) involve the intentional incorporation of environmental and social issues in decisions made by the supply chain, which include green procurement, sustainable selection and development of suppliers, green packaging, closed-loop logistics and social compliance monitoring (Gimenez & Tachizawa, 2012; Gold et al., 2010). Modern research has theorized that SSCM practices are an operationalized manifestation of a firm's sustainability orientation within its supply chain network, thereby converting strategic sustainability pledges into quantifiable process-level results (Agyabeng-Mensah et al., 2025; Bag et al., 2023).

The SSCM of mediating the relationship between supply chain agility and SSCP can be theoretically grounded in DCT's distinction between higher-order dynamic capability (e.g., agility) and operational routines that yield performance outcomes. Based on this reasoning, supply chain agility offers the sense-making and reconfiguration capability to the organization effective in enabling firms to see sustainability-relevant threats and opportunities in their environment of supply chains but must the actual sustainable performance improvement is possible only when the firm institutionalized SSCM practices that can direct agile response to environmental and social performance objectives (Teece et al., 1997; Dubey et al., 2019). Companies with well-established SSCM routines have an advantage in implementing agile capabilities that meet both operational and sustainability performance goals.

Empirically, Mensah et al. (2025) presented recent evidence on the mediating advantage of SSCM practices in the capability-performance interrelations through a mediated moderation design in a developing-country manufacturing environment, in which sustainable practices partly mediated the connection between organizational capabilities and SSCP. Correspondingly, Bag et al. (2023) confirmed that the mediating effect of digital capabilities on environmental performance among Indian manufacturers was mediated by green supply chain management practices, providing empirical evidence of the mechanism underlying differences between capability types. The mediating pathway may, however, be limited by resource shortages, skill gaps, and ineffective regulatory enforcement, thereby constraining the institutionalization of formal SSCM practices in the Sri Lankan context. With the support of theoretical reasoning and the existing empirical data, the following hypothesis can be created:

H2: Supply Chain Agility has a significant positive impact on Sustainable Supply Chain Management (SSCM)

H3: Sustainable Supply Chain Management (SSCM) has a significant positive impact on Sustainable Supply Chain Performance (SSCP).

H4: Sustainable Supply Chain Management (SSCM) mediates the impact of Supply Chain Agility on Sustainable Supply Chain Performance (SSCP).

Supply Chain Innovation as a Moderator

Supply chain innovation (SCI) refers to the intentional creation, adoption, and deployment of new supply chain processes, technologies, or organizational forms that create new value within the supply chain system (Hofmann & Ruesch, 2017; Ataseven & Nair, 2017). In its conceptual sense, SCI addresses technological innovations, namely the implementation of digital tracking, AI-powered demand forecasting, and blockchain-supported transparency platforms, as well as process innovations, such as new supplier collaboration models, circular-economy logistics, and data-driven sustainability reporting mechanisms. The recent academic literature has highlighted the role of SCI as a strategic facilitator that boosts the effective utilization of existing capabilities to improve performance, as a complementary asset in the RBV sense (Wang & Wang, 2024; Bag et al., 2023).

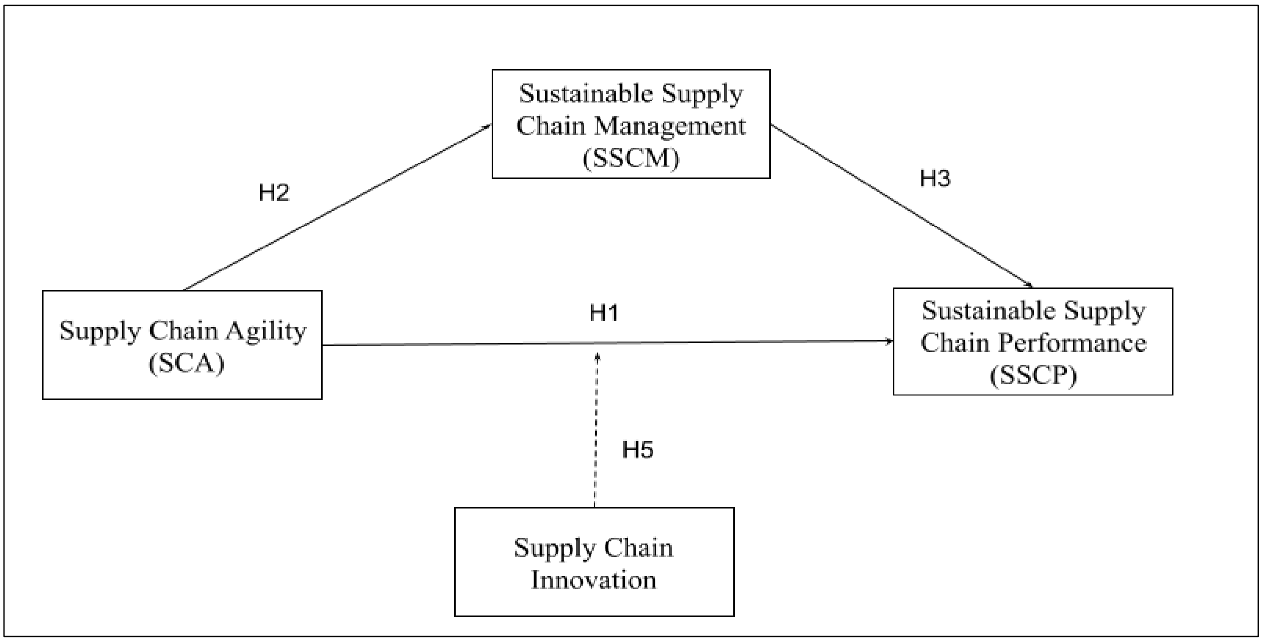
Theoretically, the moderating role of SCI in the relationship between agility and SSCP is grounded in DCT and RBV. From a DCT perspective, innovation gives the reconfiguration appropriate infrastructure where agile firms can convert their capabilities of sensing and seizing into performance-relevant behaviors, where they do not have an innovation capacity, agile responsiveness lacks the execution frameworks required to deliver sustainable performance results (Teece et al., 1997; Hofmann & Ruesch, 2017). According to RBV, SCI is a complementary resource that enhances the value-creating potential of agility-based resources, such that the agility-performance nexus is better connected the higher the portal of supply chain innovation potential of the firm (Ataseven & Nair, 2017; Wang & Wang, 2024). That is, innovation is the mechanism of amplification that transforms responsiveness of agility into quantifiable, sustainable performance accumulation.

There is empirical evidence in favour of the moderating effect of innovation in supply chain capability-performance relationships. Wang and Wang (2024) found that the relationship between firm agility and performance was substantially mediated by digital supply chain innovation in manufacturing firms in the post-pandemic period, with the positive effect of agility on performance being substantially higher in high-innovation firms. In the same way, the moderating mechanism proposed here was shown by Agyabeng-Mensah et al. (2025) to moderate the relationship between supply chain practices and performance outcomes in a Sub-Saharan African manufacturing setting, providing an analogous developing-economy setup. SRI, as a possible moderator of the agility-SSCP relationship, is credible and has a practical value in the Sri Lankan context, where the primary export-oriented manufacturers have already initiated the digital traceability mechanisms and automated logistics services, as well as the technological innovations of the sustainable packaging sector in reaction to the requirements of the global buyers. Based on this theoretical and empirical background, the hypothesis presented below is presented:

H5: Supply Chain Innovation positively moderates the relationship between supply chain agility and sustainable supply chain performance (SSCP).

Based on prior literature, Supply Chain Agility enhances flexibility and responsiveness, supporting the development of Sustainable Supply Chain Management practices and improving Sustainable Supply Chain Performance. At the same time, Supply Chain Innovation strengthens coordination and information sharing among partners, thereby further improving performance outcomes. Sustainable Supply Chain Management also plays a direct role in improving performance through responsible operational practices. Therefore, the conceptual framework posits that Supply Chain Agility and Supply Chain Innovation affect Sustainable Supply Chain Performance, with Sustainable Supply Chain Management serving as a mediating mechanism.

Figure 1: Conceptual Framework



Source: Developed by the Author

METHODOLOGY

Research Design

The study adopts a quantitative, cross-sectional survey design, consistent with the positivist paradigm widely used in empirical supply chain management research (Hair et al., 2019). A deductive approach is employed, where hypotheses derived from theory are tested using primary data. The analysis is conducted using partial least squares structural equation modelling (PLS-SEM). The cross-sectional design is appropriate for examining relationships among latent constructs using established measurement scales. However, it is important to note that this design does not allow for strong conclusions about causality over time (Alfalla-Luque et al., 2023). PLS-SEM is selected due to several methodological reasons. The study involves a complex structural model that includes both mediation and moderation effects. It also follows an exploratory and prediction-oriented approach. Furthermore, PLS-SEM is well suited for research in manufacturing settings within emerging economies, where data may not meet strict distributional requirements (Hair et al., 2019; Ringle et al., 2020).

Population, Sampling, and Data Collection.

The target population of this study comprises manufacturing firms in Sri Lanka engaged in export-oriented industries, including apparel and textiles, food and beverage processing, rubber and plastic products, and light electronics and electrical manufacturing. These sectors represent a significant share of the country's export earnings and operate within highly competitive and dynamic supply chain environments. Firms in these industries are increasingly exposed to global sustainability requirements, supply chain disruptions, and pressures from international buyers to adopt agility and innovation (Sharma et al., 2022).

The sampling frame was developed using membership directories from the Joint Apparel Association Forum (JAAF), the Sri Lanka Food Processors' Association (SLFPA), and the Board of Investment of Sri Lanka. These sources collectively cover a substantial portion of formal-sector export manufacturing firms in the country. A stratified random sampling technique was employed to ensure proportional representation across industry sub-sectors and firm size categories. Firms were categorized into small and medium enterprises (50–249 employees) and large enterprises (250 or more employees). The selected respondents included supply chain managers, operations managers, procurement managers, and senior logistics executives who are directly involved in supply chain decision-making. These individuals were chosen due to their relevant expertise and access to information on supply chain agility, SSCM practices, innovation adoption, and performance outcomes (Agyabeng-Mensah et al., 2025). Data was collected using a structured, self-administered questionnaire over a five-month period. A combination of face-to-face distribution and secure online survey methods was used to improve response rates and ensure data reliability.

Measurement Instruments

The questionnaire employed validated measurement scales adapted from prior studies to ensure reliability and validity. Supply Chain Agility (SCA) was measured using six items adapted from Cantele et al. (2023) that capture the firm's ability, along with its suppliers, to respond quickly to changes in supply, demand, and the external environment. Sustainable Supply Chain Management (SSCM) was assessed through five items adapted from Yap and Tan (2012), Koh et al. (2007), Dubey et al. (2017), and Kot (2018), reflecting practices such as strategic supplier collaboration, environmental conservation, green product design, logistics optimization, and material reuse. Supply Chain Innovation (SCI) was measured using three items from Lee et al. (2011), focusing on process and technological innovation within supply chain operations. Sustainable Supply Chain Performance (SSCP) was evaluated using eight items adapted from Aladaileh et al. (2024), covering cost reduction, customer satisfaction, time efficiency, service improvement, responsiveness, organizational agility, collaboration, and overall firm performance. All items were measured using a five-point Likert scale ranging from strongly disagree to strongly agree.

After pre-testing the pilot study with 20 supply chain managers selected from the target group (who were not included in the final sample), the modified questionnaire was sent to 90 companies. The final usable sample, after accounting for incomplete responses, non-returns, and questionnaires not returned in systematic response patterns, stood at 78 responses, with a response rate of 86.6%. This sample size meets the minimum threshold for PLS-SEM, which is at least 10 times the number of structural directions for a given construct (Hair et al., 2019). Non-response bias was measured by the wave-analysis procedure mentioned by Armstrong and Overton (1977) by comparing the early and late respondents to the key construct means; no statistically significant differences were found ($p > .05$ in all comparisons), which implies that non-response bias is not a formidable problem to the validity of the findings.

DATA ANALYSIS AND RESULTS

Descriptive Statistics for demographics

The sample consisted of 78 respondents from manufacturing organizations in Sri Lanka. The majority of respondents were male (46), followed by female participants (32).In terms of age distribution, most respondents were between 25–34 years (33), followed by 35–44 years (21), indicating a relatively young and active workforce. A smaller proportion belonged to the age categories below 25 (13), 45–54 (8), and above 55 (3).

Regarding educational qualifications, the majority held a bachelor's degree (33), followed by master's degree holders (23) and diploma holders (20), while only a few respondents reported other qualifications (1) or doctoral-level education (1). Work experience was fairly evenly distributed, with most respondents having 2–5 years (25), followed by 6–10 years (19), more than 10 years (18), and less than 2 years (16).

In terms of industry representation, the largest group was from the apparel and textile sector (29), followed by food and beverage (18), rubber and plastic (13), engineering and metal (10), and other industries (8). Concerning organizational position, most respondents were in managerial roles (31), followed by supervisory positions (29), and top management (18). Overall, the sample reflects a balanced representation of employees across different levels and sectors within the Sri Lankan manufacturing industry.

Model Analysis

Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed as the primary analytical technique in this study. PLS-SEM is widely used in contemporary empirical research, particularly for studies that rely on survey data to examine hypothesized relationships grounded in theory. This method was considered appropriate as the present study focuses on both theory testing and predictive analysis. In line with recommended procedures, the analysis was conducted in two stages. First, the measurement model was evaluated to ensure the reliability and validity of the constructs. Second, the structural model was assessed to test the proposed relationships among variables (Hair et al., 2021).

Measurement Model Assessment

The measurement model assessment was conducted to evaluate the adequacy of the constructs used in the study. A reflective measurement model was applied to assess reliability and validity. Indicator reliability was examined through outer loadings, while internal consistency reliability was assessed using Cronbach's alpha and composite reliability. Convergent validity was evaluated based on the Average Variance Extracted (AVE). Discriminant validity was assessed using the Fornell–Larcker criterion and the Heterotrait–Monotrait (HTMT) ratio, as recommended by Hair et al. (2021).

The measurement model was assessed to evaluate the reliability and validity of the constructs used in the study. The results indicate that all constructs demonstrate satisfactory internal consistency. Cronbach's alpha values range from 0.767 to 0.916, exceeding the recommended threshold of 0.70, thus confirming acceptable reliability. Similarly, composite reliability values (rho_c) range between 0.845 and 0.932, further supporting the consistency of the measurement scales.

Convergent validity was evaluated using the Average Variance Extracted (AVE), and all constructs reported AVE values above the threshold of 0.50, ranging from 0.524 to 0.682. This indicates that the constructs explain more than half of the variance of their respective indicators. In addition, the rho_a values also fall within acceptable ranges, reinforcing the reliability of the constructs. Overall, the results confirm that the measurement

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model satisfies the criteria for reliability and convergent validity, and is therefore suitable for subsequent structural model analysis.

Table 1: Reliability Measures and Validity Measures

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
SCA	0.844	0.869	0.883	0.558
SCI	0.767	0.773	0.865	0.682
SSCM	0.774	0.796	0.845	0.524
SSCP	0.916	0.927	0.932	0.631

Source: Survey Data, 2026

Discriminant validity was assessed using three approaches: the cross-loading criterion, the Fornell–Larcker criterion, and the Heterotrait–Monotrait (HTMT) ratio. The results of the cross-loading analysis indicate that each indicator loads highest on its respective construct compared to other constructs. For instance, all SCA indicators (SCA1–SCA6) exhibit higher loadings on AG than on SCI, SSCM, or SSCP, while SCI, SSCM, and SSCP indicators similarly demonstrate stronger loadings on their own constructs. This confirms item-level distinctiveness among constructs.

The Fornell–Larcker criterion further supports discriminant validity. The square root of the Average Variance Extracted (AVE) for each construct (SCA = 0.747, SCI = 0.826, SSCM = 0.724, SSCP = 0.794) exceeds the corresponding inter-construct correlations. This indicates that each construct shares more variance with its indicators than with those of other constructs, thereby meeting the recommended threshold. Additionally, the HTMT ratios for all construct pairs are below the conservative threshold of 0.90. The highest HTMT value observed is 0.587, with other values such as 0.573, 0.516, 0.331, and 0.174 also remaining well within acceptable limits. These results provide further evidence of adequate discriminant validity.

Collinearity was also examined using the Variance Inflation Factor (VIF) values. The VIF values for all indicators range between 1.295 and 3.367. Although one indicator (SSCP1) slightly exceeds the stricter threshold of 3.0, it remains below the commonly accepted upper limit of 5.0, indicating no serious multicollinearity concerns. Overall, the results confirm that the model satisfies the requirements for discriminant validity and does not exhibit significant collinearity.

Table 2: Validity Measures (Fornell–Larcker)

	SCA	SCI	SSCM	SSCP
SCA	0.747			
SCI	0.051	0.826		
SSCM	0.497	0.272	0.724	
SSCP	0.284	0.494	0.466	0.794

Source: Survey Data, 2026

Table 3: Validity Measures (HTMT)

	SCA	**SCI**	**SSCM**	**SSCP**
SCA				
SCI	0.174			
SSCM	0.587	0.331		
SSCP	0.301	0.573	0.516	

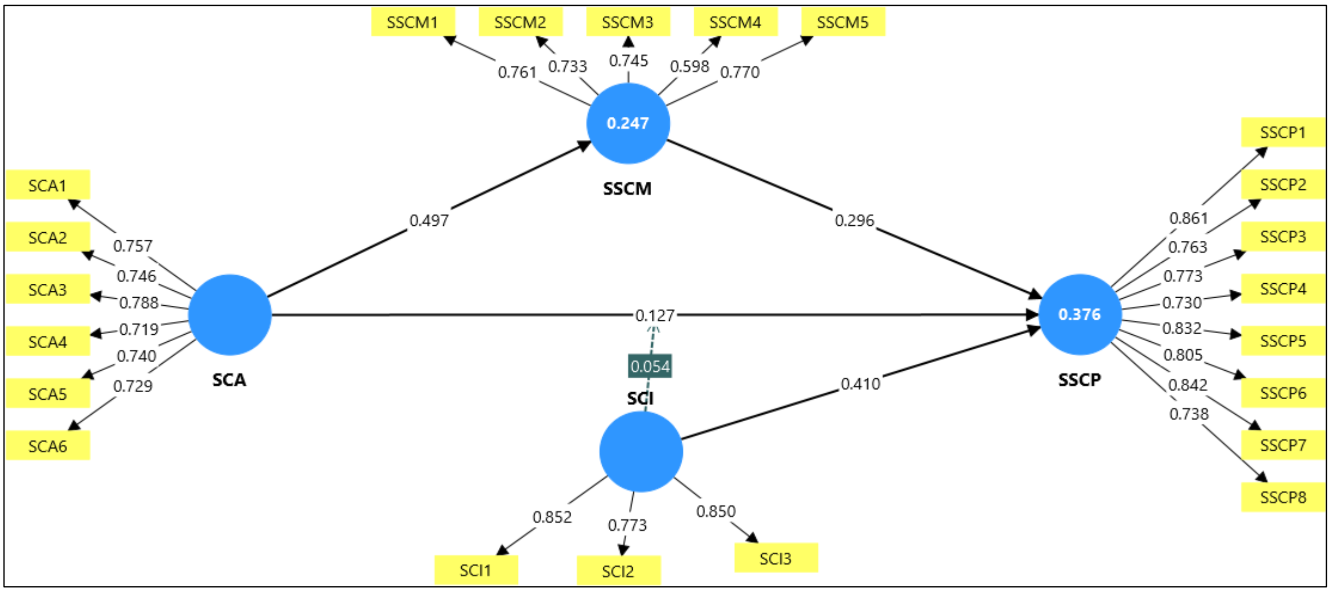
Source: Survey Data, 2026

Table 4: Validity Measures – Discriminant Validity - Cross Loadings

	SCA	SCI	SSCM	SSCP
SCA1	**0.757**	0.199	0.361	0.191
SCA2	**0.746**	-0.090	0.389	0.110
SCA3	**0.788**	0.140	0.473	0.372
SCA4	**0.719**	-0.062	0.315	0.097
SCA5	**0.740**	-0.026	0.341	0.256
SCA6	**0.729**	-0.015	0.282	0.133
SCI1	0.061	**0.852**	0.233	0.452
SCI2	0.066	**0.773**	0.224	0.410
SCI3	-0.012	**0.850**	0.213	0.346
SSCM1	0.325	0.178	**0.761**	0.350
SSCM2	0.381	0.226	**0.733**	0.324
SSCM3	0.407	0.235	**0.745**	0.223
SSCM4	0.262	0.025	**0.598**	0.205
SSCM5	0.401	0.259	**0.770**	0.503
SSCP1	0.280	0.498	0.505	**0.861**
SSCP2	0.320	0.322	0.377	**0.763**
SSCP3	0.269	0.327	0.359	**0.773**
SSCP4	0.203	0.349	0.231	**0.730**
SSCP5	0.163	0.447	0.362	**0.832**
SSCP6	0.265	0.338	0.360	**0.805**
SSCP7	0.173	0.472	0.364	**0.842**
SSCP8	0.127	0.337	0.349	**0.738**

Source: Survey Data, 2026

Figure 2. Measurement Model



Source: Survey Data, 2026

Structural Model Assessment

The structural model was evaluated using model fit indices, coefficient of determination (R^2), effect size (f^2), and predictive relevance (Q^2). The results are presented in Table X. The model fit assessment indicates an acceptable fit. The standardized root mean square residual (SRMR) of the estimated model is 0.094, slightly above the recommended threshold of 0.08 but still within an acceptable range for PLS-SEM. The normed fit index (NFI) value of 0.706 suggests a moderate model fit. Additionally, the discrepancy measures (d_ULS and d_G) do not indicate serious model misspecification, supporting the model's adequacy.

The explanatory power of the model was assessed using R^2 values. The results show that SSCM has an R^2 of 0.247, indicating weak to moderate explanatory power, while SSCP has an R^2 of 0.373, indicating moderate explanatory power. These values indicate that the independent variables explain a reasonable proportion of variance in the endogenous constructs. The effect size (f^2) results reveal that supply chain agility (SCA) has a large effect on SSCM ($f^2 = 0.328$), while its effect on SSCP is negligible ($f^2 = 0.016$). Supply chain innovation (SCI) demonstrates a moderate effect on SSCP ($f^2 = 0.242$), whereas SSCM has a small to moderate effect on SSCP ($f^2 = 0.098$). These findings highlight the relative importance of the predictors in influencing the endogenous constructs.

Furthermore, the predictive relevance of the model was assessed using Q^2 values obtained through PLSpredict. The Q^2 values for SSCM (0.200) and SSCP (0.233) are positive, indicating that the model has satisfactory predictive relevance. The RMSE and MAE values are also within acceptable ranges, further supporting the model’s predictive capability. Overall, the results confirm that the structural model demonstrates acceptable fit, moderate explanatory power, and adequate predictive relevance. Therefore, the model is suitable for further analysis, and bootstrapping was subsequently performed to assess the significance of the hypothesized relationships.

The structural model was assessed to examine the hypothesized relationships among the constructs, and the results are presented in Table X. The findings indicate that supply chain agility (SCA) has a significant positive effect on sustainable supply chain management (SSCM) ($\beta = 0.497$, $t = 5.758$, $p < 0.001$), suggesting that organizations with higher agility are more capable of adopting sustainable supply chain practices. However, the direct relationship between supply chain agility and sustainable supply chain performance (SSCP) is not statistically significant ($\beta = 0.127$, $t = 1.251$, $p = 0.211$), indicating that agility alone does not directly enhance sustainability performance.

Furthermore, supply chain innovation (SCI) has a strong, significant positive effect on SSCP ($\beta = 0.410$, $t = 4.891$, $p < 0.001$), underscoring the critical role of innovation in enhancing sustainable performance outcomes. Similarly, SSCM has a significant positive effect on SSCP ($\beta = 0.296$, $t = 2.851$, $p = 0.004$), confirming that implementing sustainable supply chain management practices improve organizational performance. The mediation analysis results, as shown in Table X, reveal that SSCM significantly mediates the relationship between SCA and SSCP ($\beta = 0.147$, $t = 2.556$, $p = 0.011$). Since the indirect effect is significant while the direct effect is not, this indicates full mediation, implying that supply chain agility influences sustainable supply chain performance primarily through sustainable supply chain management practices.

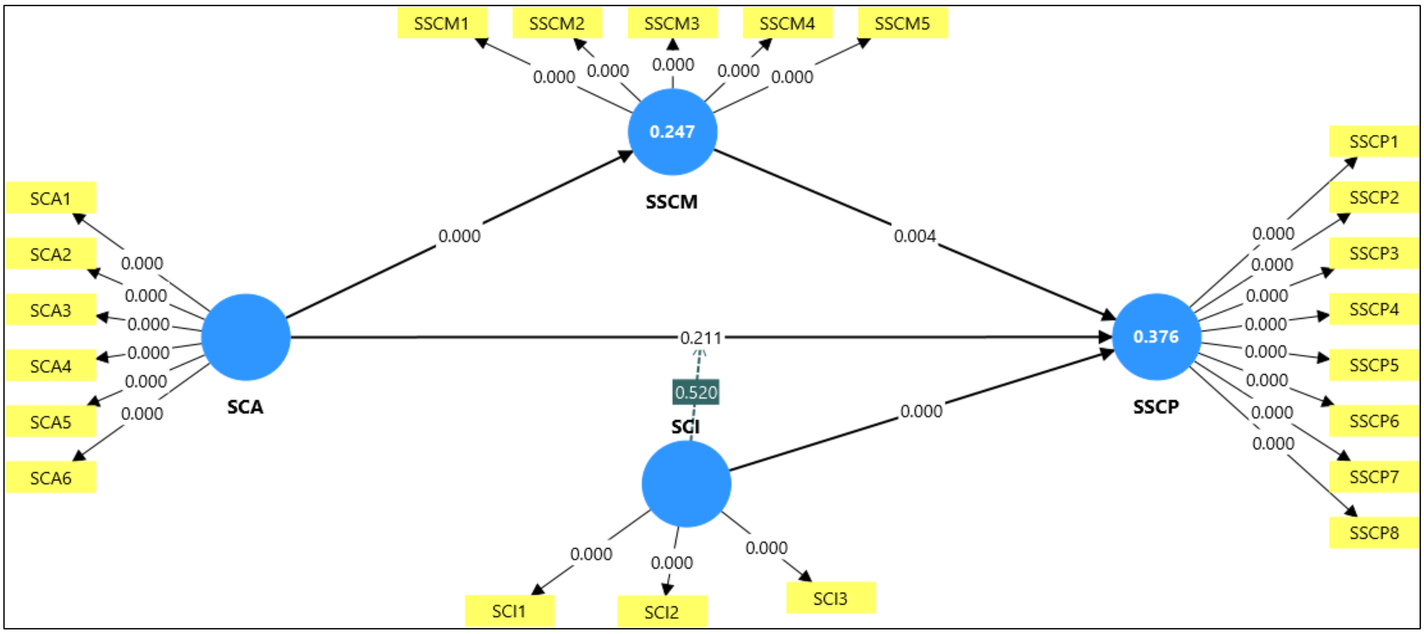
Regarding moderation, the results in Table 5 indicate that supply chain innovation does not significantly moderate the relationship between supply chain agility and SSCP. The conditional effects of SCA on SSCP at high ($\beta = 0.182$, $p = 0.159$), low ($\beta = 0.073$, $p = 0.591$), and mean ($\beta = 0.127$, $p = 0.211$) levels of SCI are all statistically insignificant. Therefore, the moderating effect of supply chain innovation is not supported. Overall, the structural model results suggest that while supply chain agility enhances sustainable management practices, its effect on sustainable performance is indirect. The findings emphasize the importance of sustainable supply chain management and innovation in driving sustainable supply chain performance.

Table 5. Hypothesis Testing

Hypothesis	Path	Path Coefficient (β)	T Statistics	P Values	Decision
H1	SCA → SSCP	0.127	1.251	0.211	Not Supported
H2	SCA → SSCM	0.497	5.758	0.000	Supported
H3	SSCM → SSCP	0.296	2.851	0.004	Supported
H4	SCA → SSCM → SSCP	0.147	2.556	0.011	Supported
H5	SCI × SCA→ SSCP	0.054	0.644	0.520	Not Supported

Source: Survey Data, 2026

Figure 3. Structural Model



Source: Survey Data, 2026

FINDINGS AND DISCUSSION

The results of the structural model provide important insights into the relationships among supply chain agility (SCA), sustainable supply chain management (SSCM), supply chain innovation (SCI), and sustainable supply chain performance (SSCP).

The findings indicate that supply chain agility has a significant positive effect on SSCM ($\beta = 0.497$, $p < 0.001$). This suggests that agile organizations are better positioned to adopt and implement sustainable supply chain practices. Agility enables firms to respond quickly to environmental changes, align internal and external processes, and enhance coordination across the supply chain (Gligor et al., 2013). Such capabilities are essential for integrating sustainability into supply chain operations. Further, the results show that SSCM significantly influences sustainable supply chain performance ($\beta = 0.296$, $p = 0.004$). This finding supports prior studies highlighting the role of sustainable practices in improving environmental, social, and economic performance outcomes (Das, 2017). Similarly, empirical evidence confirms that SSCM enhances organizational performance by improving efficiency, competitiveness, and stakeholder value (Das & Hassan, 2022) . Therefore, SSCM emerges as a key determinant of sustainable performance.

However, the direct effect of supply chain agility on SSCP is not significant ($\beta = 0.127$, $p = 0.211$). This result is inconsistent with previous research that generally reports a positive relationship between agility and performance (Alfalla-Luque et al., 2023). The insignificant relationship suggests that agility alone may not directly translate into sustainable performance outcomes. Instead, its effect appears to depend on how effectively it is utilized through sustainability-oriented practices. The mediation analysis further confirms that SSCM significantly mediates the relationship between agility and SSCP ($\beta = 0.147$, $p = 0.011$). This indicates that agility enhances performance indirectly by enabling the adoption of SSCM practices. This finding aligns with prior studies that emphasize that operational practices serve as mechanisms through which organizational capabilities influence performance outcomes (Tondolo et al., 2021). Thus, SSCM serves as a critical link connecting agility and sustainable performance.

In contrast, the moderation analysis reveals that supply chain innovation does not significantly moderate the relationship between agility and SSCP ($\beta = 0.054$, $p = 0.520$). Although prior studies suggest that supply chain innovation contributes positively to organizational performance (Lee et al., 2011), the present findings indicate that innovation does not strengthen the impact of agility on sustainable performance. This may be due to contextual constraints such as resource limitations or the lack of effective integration of innovation within sustainability strategies. Overall, the findings suggest that while supply chain agility is an important capability, its impact on sustainable supply chain performance is largely indirect, mediated by SSCM practices. Organizations should therefore focus on leveraging agility to enhance sustainability initiatives rather than expecting direct performance improvements from agility alone.

CONCLUSION

This study examined the relationships among supply chain agility (SCA), sustainable supply chain management (SSCM), supply chain innovation (SCI), and sustainable supply chain performance (SSCP) within manufacturing organizations. The findings demonstrate that supply chain agility significantly enhances SSCM, which in turn improves sustainable supply chain performance. However, agility does not directly influence SSCP, indicating that its impact is primarily indirect, operating through the effective implementation of SSCM practices. The mediation analysis confirms that SSCM serves as a critical mechanism linking agility to performance. In contrast, supply chain innovation does not significantly moderate the relationship between agility and SSCP, suggesting that innovation alone is insufficient to strengthen this linkage in the studied context. Overall, the study highlights the importance of integrating agility with sustainability practices to achieve superior performance outcomes.

Theoretical Implications

This study contributes to the supply chain and sustainability literature in several important ways. First, it

advances the understanding of supply chain agility by showing that its effect on performance is indirect rather than direct. This finding challenges the common assumption of a direct agility–performance link and supports the view that organizational capabilities influence outcomes through operational practices. Second, the study highlights the critical role of sustainable supply chain management (SSCM) as a mediating mechanism, offering empirical evidence for the integration of sustainability practices within supply chain frameworks. This reinforces the need to connect dynamic capabilities with sustainability-oriented actions to achieve long-term performance outcomes. Third, the non-significant moderating effect of supply chain innovation suggests that its role is not universally applicable and may depend on contextual conditions, particularly in developing economies, thereby calling for further theoretical refinement. Importantly, the study provides theoretical novelty by identifying a full mediation effect, where SSCM practices fully transmit the impact of supply chain agility on sustainable supply chain performance. This indicates that agility alone is insufficient to enhance performance unless it is effectively translated into sustainability-oriented practices.

Managerial Implications

The findings of this study have important managerial implications, highlighting how supply chain agility can be effectively operationalized through sustainable supply chain management (SSCM) practices to enhance performance. Managers should not treat agility as an isolated capability, but rather as an enabler that supports the implementation of structured sustainability initiatives across the supply chain. In practice, this involves adopting flexible sourcing strategies, integrating sustainability criteria into supplier selection and evaluation, and collaborating with suppliers to improve environmental and social standards. Organizations can further leverage digital technologies such as real-time tracking systems and data analytics to enhance visibility and responsiveness while monitoring sustainability performance. In addition, firms should align innovation efforts with sustainability objectives by focusing on eco-friendly product design, resource efficiency, and circular practices. Building internal capabilities through employee training and embedding sustainability into organizational culture are also critical for long-term success. For export-oriented manufacturing firms, particularly in emerging economies, the ability to combine agility with SSCM practices enables faster adaptation to global sustainability requirements and market uncertainties, thereby strengthening sustainable supply chain performance and competitive positioning.

Limitations and Future Research Directions

Despite its contributions, this study has several limitations. First, the study is based on cross-sectional data, which limits the ability to establish causal relationships. Future research could adopt longitudinal designs to better capture the dynamic nature of supply chain relationships. Second, the sample is limited to manufacturing organizations within a specific context, which may affect the generalizability of the findings. Future studies could examine different industries or conduct cross-country comparisons to validate the results. Third, the study focuses on a limited set of variables. Other potential factors such as organizational culture, digital transformation, or environmental orientation could be incorporated in future research to provide a more comprehensive understanding. Fourth, the non-significant moderating effect of supply chain innovation suggests the need for further investigation. Future studies could explore different types of innovation or alternative moderating variables to better understand boundary conditions. Overall, future research should continue to explore the complex relationships between dynamic capabilities, sustainability practices, and performance outcomes in diverse contexts.

The study finds that supply chain agility improves sustainable supply chain performance indirectly through sustainable supply chain management practices, while supply chain innovation does not significantly strengthen this relationship in the Sri Lankan manufacturing context.

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