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Green Supply Chain Integration And Sustainable Supply Chain Performance: The Mediating Roles Of Green Innovation And Supply Chain Resilience, And The Moderating Roles Of Green Value Co-Creation And Absorptive Capacity

Anwar Shakeel
MBA Karachi University Business School, University of Karachi
Email:anwarshakeel26@gmail.com

Dr Sheikh M. Fakhre Alam Siddiqui
Karachi University Business School, University of Karachi
Email: fakhrealam@uok.edu.pk & https://orcid.org/0009-0000-1073-5623

Abstract
The research focuses on how the Green Supply Chain Integration (GSCI) affects the Sustainable Supply Chain Performance (SSCP) and the parallel mediating role of Green Innovation (GInv) and Supply Chain Resilience (RES) in particular, and the possible moderating role of Green Value Co- Creation (GVCc) and Absorptive Capacity (AC) in particular. The study was based on the resource-based view, relational view and the knowledge-based perspective, and had a quantitative approach where primary data was gathered through a web-based survey of managers engaging in the supply chain and sustainability practices working in different industries. The mediated- moderated conceptual model was empirically constructed and analyzed with the help of the Partial Least Squares Structural Equation Modeling (PLS-SEM) in SmartPLS software.
The results show that, the direct relationship between the three dimensions of GSCI, which include Green Internal Integration, Green Customer Integration and Green Supplier Integration and SSCP, was not found to be significant after adjusting some factors between them therefore indicating that the relationship between them is largely indirect. Green Customer Integration (= 0.345, $p = 0.001$) and Green Internal Integration = 0.210, $p = 0.037$) became significant positive predictors of Green Innovation and no significant impact of Green Supplier Integration was noticed. The direct positive impact of Supply Chain Resilience on SSCP was the most consistent and strong ($\beta = 0.296$, $p = 0.001$), which emphasized the importance of the latter in the attainment of sustainable results in unstable conditions.
Absorptive Capacity turned out to be a critical organization competency, with a strong positive direct impact on both the Green Innovation (0.245, $p = 0.019$) and Supply Chain Resilience (0.444, $p < 0.001$), and a significant indirect impact on SSCP through the resilience pathway (0.131, $p = 0.011$). Green Innovation, in its turn, showed a comparably non-significant positive impact on SSCP (= 0.208, $p = 0.092$), and no mediation by Green Innovation was established. Also, the moderating effects

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of Green Value Co-Creation (on the GSCI–SSCP relationship) and Absorptive Capacity (on the GSCI–Green Innovation and GSCI–Resilience relationships) were not found as all terms of interaction were not statistically significant.

In sum, the structural model was moderate to high in explanatory power, considering that it explained 47.8% to 52.4% of the variance in the endogenous constructs. The findings emphasize the fact that the role of green supply chain integration in sustainable performance is majorly indirect in nature with Supply Chain Resilience being the predominant means of transmission and Absorptive Capacity acting as an important enabling factor. These results criticize the simplistic direct-effect approaches and stress the strategic significance of building organizational resilience capacity and knowledge acquisition systems in making successful conversion of green integration initiatives into long-term sustainability benefits in a business world that is becoming more uncertain and disruptive.

CHAPTER ONE: INTRODUCTION

Background & Context

In recent years, rising environmental concerns, regulatory requirements, and stakeholder demands have forced organisations to integrate sustainability into their supply chain strategies (Baah et al., 2020). Supply chains are no longer just measured on its cost efficiency and responsiveness, but are now being measured on how the firm is able to deliver economic, environmental and social performance at the same time. Within this context, Green Supply Chain Integration (GSCI) has emerged as a strategic approach through which firms will coordinate the functions within their boundaries and collaborate with their customers and suppliers in order to minimize environmental impact and also increase the overall supply chains performance.

Existing literature suggests that by integrating environmental considerations across the supply chain partners, better information sharing, joint environmental planning and the alignment of sustainability goals can be enabled (Ahmedet al., 2020). Such integration can enhance Sustainable Supply Chain Performance (SSCP), which will result in less waste, risk management, and environmental standard compliance. However, empirical findings on direct effects of GSCI on SSCP remain mixed, suggesting that this relationship may not be primarily linear and may be contextual and be affected by internal organizational capabilities. This needs has created a need to explore the underlying mechanisms through which GSCI translates into superior sustainable outcomes.

One important mechanism that was underlined in previous researches is the Green Innovation (GInv) which represents the capability to develop environmentally friendly products and processes by firms. Through close integration with suppliers and customers, organizations will have access to green knowledge, cleaner technologies and eco-design practices that promote innovation (Ul-Duraret al., 2023). Nevertheless, innovation alone may not suffice in more and more volatile and disruption-prone supply chain environments. Recent global events, including pandemics, geopolitical conflicts and climatic induced disruptions have highlighted the importance of Supply Chain Resilience (RES) the ability to anticipates, respond to

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& recover from unexpected disturbances in order to maintain continuity in the operational conducting process.

Despite the relevance, resilience has been studied quite independently from green supply chain integration, leaving a gap in a body of knowledge about how efforts towards environmental integration practices may simultaneously improve both resilience and sustainability performance. Furthermore, the effectiveness of GSCI in driving innovation and resilience is likely contingent upon the capacity of firms to acquire, assimilate and apply external knowledge as well as the level of Green Value Co-Creation (GVCc) with customers (Olaleye & Mosleh, 2025). Firms with higher absorptive capacity can better integrate green practices in innovative and resilient outcomes while active value co-creation processes can enhance the performance impact of GSCI in line with customer expectations.

Against this background, this study is located at the intersection of the subfields of green supply chain management, innovation and resilience literature. By addressing the need for more in-depth and capability-based explanations of sustainable supply chain performance through mediating and moderating mechanisms, through the current study, respond to the call for more nuanced explanations (Hamzah, 2025). It contributes both the theory and the practice of SSCP by explaining not only whether GSCI is able to improve SSCP, but how and under what conditions this improvement occurs.

Research Aim & Objectives

Research Aim

To investigate the role of Green Supply Chain Integration (GSCI) in achieving Sustainable Supply Chain Performance (SSCP) through Green Innovation (GInv), Supply Chain Resilience (RES), and the change in this relationship under Green Value Co-Creation (GVCc), Absorptive Capacity (AC).

Research Objectives

To determine the effect of GSCI on SSCP.
To determine the effect of GSCI on Green Innovation (GInv).
To test whether GInv mediates the relationship between GSCI and SSCP.
To test whether GVCc moderates the relationship between GSCI and SSCP.
To determine the effect of GSCI on Resilience (RES).
To determine the effect of Resilience (RES) on SSCP.
To test whether Absorptive Capacity (AC) strengthens (moderates) the effects of GSCI → GInv and GSCI → RES

Problem Statement

Despite the increasing popularity of the concept of green supply chain practices, a number of organizations are still struggling to achieve adequate translation of Green Supply Chain Integration (GSCI) into a consistently superior Sustainable Supply Chain Performance (SSCP). Prior empirical studies primarily concern the direct effects of GSCI and are limited to providing insights into the underlying mechanisms

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and boundary conditions explaining the mechanisms of how and when sustainability benefits are attained (Hayat & Qingyu, 2024). In particular, the functions of the Green Innovation and Supply Chain Resilience as parallel mediating mechanisms are far under-explored, in particular within the context of integrated green supply chains. Furthermore, existing research does not pay enough attention to organisational capabilities e.g. Absorptive Capacity and collaborative processes such as Green Value Co-Creation, which may have a significant impact on the effectiveness of GSCI initiatives. This piecemeal understanding limits the development of the field as well as managerial decision-making regarding sustainable supply chain management.

Rationale of the Study

This contribution is warranted by the need to move beyond models used in the direct effects literature toward more complex and capability-based explanations regarding the sustainable supply chain. Integrating Green Innovation and Supply chain Resilience as mediating variables research explains the internal processes by which GSCI encourages sustainable performance. Additionally, the consideration of Green Value Co-Creation and Absorptive Capacity as moderators responds to calls for increasing studies that analyse contexts covering firm-specific capabilities and stakeholder involvement (Petković et al., 2025). Taking inspiration from two existing empirical streams, this study presents the comprehensive methodology that relates environmental integration to innovation, resilience, and performance outcomes. Practically, the findings can inform managers about how to design integrated green strategies, which, in addition to improving sustainability measures, will improve resilience to disruptions, thus increasing long-term competitive advantage.

Scope & Limitations of the Study

This research is focused on examining the relationships between Green Supply Chain Integration (GSCI), Sustainable Supply Chain Performance (SSCP), Green Innovation, and SupplyChain Resilience with the considerations of moderating roles of Green Value Co-Creation and Absorptive Capacity. The research is limited to an organizational level analysis and the data collection contains the perceptions of managers about green supply chain practices and performance outcomes using an organized questionnaire. In spite of its contributions this study has few limitations is that. The cross-sectional research design prevents the possible inference of causal relations between the variables over time (Savitz & Wellenius, 2023). The use of self-reported survey data also may introduce common method bias and subjectivity of the respondents. The study is based on perceptual measures, as opposed to an objective measure of performance which may affect the precision of the assessment of sustainability performance.

Chapter Summary

This chapter provides an introduction to the context of the study by emphasizing on the importance of green supply chain integration in achieving sustainable performance. It describes the research aim, research objectives, problem statement,

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rationale and scope which provide a basis for analyzing mediating and moderating mechanisms affecting the sustainable supply chain.

CHAPTER TWO: LITERATURE REVIEW

Green Supply Chain Integration (GSCI)

Green Supply Chain Integration, or else known to as CSC refers to the strategic alignment and coordination of the environment goals, processes and information flows beyond the organization boundaries and with the internal functions. Extending the scope of traditional supply chain integration, GSCI incorporates environmental concerns into decision making and operational activities and focuses on working together for sustainability rather than individually and in isolation for compliance (Yanget al., 2026). From a theoretical standpoint, GSCI is based on the resource-based view and the relational view that contend inter-organizational coordination and common environmental capabilities can lead to competitive advantage that is hard to mimic.

The literature is widely conceptualized GSCI as a multidimensional concept of green internal integration, green customer integration and green supplier integration. This dimensional view concedes that environmental integration needs to occur simultaneously within the firm and among supply chain partners to be effective. Critics say that the oversimplification of complex interdependency among actors and the role played by the differentiated functions of internal actors, customers, and suppliers are neglected when GSCI is treated as a unidimensional construct (Frankowska & Cheba, 2022). Therefore, a multidimensional approach represents a much more realistic and analytically satisfactory understanding of the functioning of green integration in practice.

Green internal integration involves coordination of cross-functional coordination within a firm, especially between procurement, production, and logistics and environmental management units (Li et al, 2022). Such integration offers effective communication of environmental goals, the accumulation of green knowledge, and the practice of operations. Studies have found that there's often a lack of internal unity on this, and that without it external green initiatives fail because the responsibilities are fragmented and priorities are inconsistent.

Green customer integration means a close cooperation with customers where an effort is made to plan environmental activities, adopt eco-design and sustainability criteria together. While nature of green actions based on customer pressure can draw from increasing responsiveness to market expectations, some scholars warn that depending too much on customer pressure can lead to symbolic rather than meaningful environmental actions (Aragòn-Correa et al., 2020). Thus, the effective integration of customers will require true collaboration instead of reactive compliance. Green supplier integration involves working with suppliers closely to set environmental requirements, to audit for environmental performance and to implement cleaner technologies. Suppliers play a critical role in determining the supply chain's environmental footprint, however, power imbalances and resource limitations may affect the ability of suppliers to comply with stringent green requirements (Gawusu et

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al., 2022). Consequently, integration must be accompanied by knowledge sharing and capability development and not unilateral enforcement.

The key argument of the GSCI literature is that integrated green practices result in both environmental and improved operational performance. By enabling information sharing and collaborative problem solving, GSCI helps in reducing waste generation, making better use of resources, and complying with environmental regulations (Kong et al., 2021). From an operational point of view, integration enables better coordination, reduces uncertainty and allows proactive risk management.

However, empirical evidence regarding the direct impact on performance of GSCI is mixed. Some of the studies show a significant improvement of cost efficiency and responsiveness; some show weak or indirect effect (Chen & Hasan, 2023). These inconsistencies imply that the effectiveness of GSCI may not be assured to lead to superior outcomes, but that GSCI depends for its effectiveness on complementary capabilities such as innovation and resilience. This debate makes it important to study the mediating mechanisms through which GSCI leads to sustainable supply chain performance, which forms the framework for the extended framework adopted in this study.

Sustainable Supply Chain Performance (SSCP)

Sustainable Supply Chain Performance (SSCP) is an evolution of the classic approach to performance assessment by asking not only operational and financial outcomes but extending to the environment and societal impacts of those outcomes. Unlike the conventional performance of the supply chain which focuses on costs, quality and delivery, SSCP portrays the ability of the functioning of the supply chain in a way that minimises environmental damage and backs up long- term viability (Agyabeng-Mensah et al., 2025). The prevailing conceptualization of SSCP is based on the triple bottom line perspective which stresses on economic, environmental and operational sustainability.

However, scholars debate on the levels and balance of these dimensions. Some might consider that too much focus on the environment needs can diminish short-term efficiency, while others believe that methods of sustainability can result in greater long-term competitiveness (Pizzurno & Cammarano, 2024). This debate raises the issue of SSCP not only as an outcome variable but as a dynamic construct which is a function of strategic choices and organizational capability. Consequently, SSCP should be viewed as an integrative and evolving concept, and not as a static performance metric.

Measuring SSCP is complicated because of the multidimensionality. Economic performance generally embodies the aspects of cost control, inventory efficiency and sound responsiveness and represents the traditional efficiency-based perspective of supply chains (Oubrahim et al., 2022). Environmental performance is concerned with waste reduction, emissions control, environmental standards compliance and resource efficiency. Operational performance is a measure of delivery reliability, flexibility, risk management and visibility within the supply chain.

While objective measures of performance are useful in providing precision, most empirical studies use perceptual measures because of data accessibility and the comparability of performance findings across firms. Critics say that perceptual measures are prone to bias; however, previous studies show that managerial perceptions are valid surrogates for actual performance if respondents have decision-making authority in the relevant area (Bauch et al., 2021). Importantly, with multiple aspects of performance considered, researchers are able to reflect on the trade-offs and synergies across economic, environmental and operational outcomes to reflect a more holistic view on sustainability performance.

A substantial body of literature suggests that green supply chain practices and especially green supply chain integration have a positive impact on SSCP thanks to an efficient coordination, transparency, and environmental accountability. Integrated green practices help firms to adopt more proactive risk management, inefficiencies, and litigation capabilities, also supports firm responding well to regulatory and market pressure (Akano et al., 2024). From a strategic point of view, such practices turn sustainability from a burden to comply with to a competitive strength.

Nevertheless, empirical findings are not consistent with some studies reporting weak or indirect influences of green practices on performance. These mixed results indicate the nature of the relationship is complex and depends on internal capabilities and contextual factors among green supply chain practices and SSCP (Yadav et al., 2023). As a result, more recent studies call for researching beyond the direct effect models in order to examine mediating and moderating mechanisms. This study addresses this call by exploring the role of green innovation and supply chain resilience considers the role of boundary conditions in explaining the GSCI- SSCP relationship by reinforcing or weaken the results of performance.

Mediating Mechanisms: Green Innovation and Supply Chain Resilience

Green Innovation (GInv) is the development and implementation of environmentally friendly products, processes and technologies that have reduced ecological impact and support organizational performance. The previous works have tacked more and more on the idea that the Green Supply Chain Integration (GSCI) does not necessarily lead to superior Sustainable Supply Chain Performance (SSCP), instead its benefits are derived by innovation-based transformation (Zhang & Zhang, 2025). Through close interaction with suppliers and customers, firms gain access to environmental knowledge, cleaner technologies and eco-design capabilities to stimulate green innovation. Internally, another barrier to addressing is to cross-functional coordination that further facilitate the assimilation of such knowledge into operational routines.

From an argumentative standpoint, the use of GInv as a mediating mechanism helps to address inconsistencies in an empirical study of the relationship between GSCI and SSCP reported in the literature. Green practices integrated but not turned into innovative outcomes may be costly for firms in terms of compliance costs and performance improvement (Tian et al., 2023). On the opposite end of the spectrum, firms that use GSCI to implement green product and process innovation are better positioned to reduce waste, be more resource-efficient, and responsive to supply chain changes. Therefore, GInv can be stated to represent a critical internal pathway for integrated green practices to generate sustainable performance advantages.

Supply Chain Resilience (RES) is widely described as the ability of a supply chain to anticipate, respond and recover from disruptions whilst maintaining the continuity of supply chain operations (Katsaliaki et al., 2022). Unlike traditional risk management, which has a prevention focus, resilience places an emphasis on adaptability, preparedness and recovery. Core dimensions of resilience such as disruption preparedness, response capability, flexibility and connectivity among partners and availability of alternative plans.

A new and increasing relevance of the topic of resilience is also supported by the recent global disruptions, such as pandemics, geopolitical instability and climate-related events, which have highlighted the vulnerability of highly optimised but fragile supply chains. Critics contend that the supply chains that are geared towards sustainability can deprive themselves of resilience owing to the added layers of complexity as well as cost pressures (Kareem et al., 2025). However, we are now seeing research that indicates green integration has the potential to improve resilience by supporting the development of collaboration, transparency and shared problem-solving across supply chain partners. This think of resilience therefore not as a trade-off but rather as a complimentary capability on sustainable supply chains

Resilience is a critical indicator in conducting green integration efforts in achieving long- term performance results (Negriet et al., 2021). Environmentally integrated supply chains that fail to be resilient will do fine in stable conditions but collapse during disruptions, destroying long term sustainability. Resilient supply chains, on the other hand, can ensure continuous service levels, proactively manage risks, and quickly recover to help achieve economic and environmental goals at the same time.

From a performance perspective, resilience contributes to a better performance of SSCP by decreasing operational losses, stabilising supply flows and guaranteeing compliance with environmental and customer requirements in the face of uncertainty. Importantly, the role of resilience plays a mediating mechanism by helping firms to take advantage of the collaborative structures formed through GSCI (Wulandhari et al., 2022). This argument calls upon challenging the linear models of sustainability performance and strengthening the process-based view, where green integration leads to better innovation and resilience, driving sustainable supply chain performance. As such, the inclusion of resilience as a mediator offers a more realistic explanation of sustainable outcomes achieved in a volatile business environment.

Moderating Mechanisms: Green Value Co-Creation and Absorptive Capacity

Green Value Co-Creation (GVCc) means the active involvement of customers and other stakeholders in the design, delivery and improvement of environmentally sustainable products and services (Shi et al., 2020). Moving beyond a firm-centered focus on sustainability, GVCc focuses on interactive dialogue, commonly agreed decision making and shared problem solving. In linewith a stakeholder theory viewpoint, involving customers to co-create green values will increase legitimacy and can support sustainability activities with market expectations.

However, the effectiveness of GSCI in the enhancement of performance may be

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related to the degree of such engagement. Firms that incorporate green practices elsewhere in-house and in the supply chain partners but fail to engage and inform customers can see their performance outcomes weakened because of the misalignment between sustainability initiatives and customer views of value (Zhou et al., 2020). On the other hand, if GVCc is high, the impact of GSCI can be increased because they ensure that the efforts of green integration are reflected in value perceived by the market. Critics warn that co-creation carries higher coordination costs, complexity; however there are ways of managing it effectively to strengthen the strategic relevance of sustainability and to boost performance outcomes. And so here, GVCc is best understood as a contextual factor and a condition that makes integration of green effective and not in fact as a driving factor through which green actually performs.

Absorptive Capacity (AC) is the capacity of firm to acquire, assimilate, transform and exploit external knowledge. Rooted in the knowledge-based view of the firm, AC is particularly relevant in the green supply chains, where the environmental knowledge is often dispersed among suppliers, customers, regulators and research institutions (Kong et al., 2020). GSCI is increasing exposure to such outside knowledge; however it requires adequate absorptive capacity for the firms to effectively be able to internalize and use it.

Scholars address that AC enables the firms to transform the integrated green information into proactive triggering innovations and adaptive capabilities (Makhloufi, 2024). In the absence of solid AC, green integration may lead to information overload as well as performance improvement. This argument challenges assumptions about assuming that integration will ensure learning benefits and the importance of internal capabilities in determining the outcomes of green supply chain initiatives.

The moderating effects of GVCc and AC explain variability in the outcomes of green supply chain integration. GVCc promotes a closer relationship between GSCI and SSCP through an increased customer alignment, market acceptance and perceived value of sustainability initiatives (Olaleye & Mosleh, 2025). When customers are actively engaged in creating value, integrated green practices are more likely to result in superior performance results.

Similarly, AC moderates the relationship of GSCI with both Green Innovation and Supply Chain Resilience. Firms with good absorptive capacity are more equipped to use integrated green knowledge to come up with innovative solutions and robust supply chain structures (Abourokbah et al., 2023). On the other side, low AC firms may not be able to exploit the integration efforts, leading to weaker innovation and resilience results. Collectively, these moderating mechanisms support a contingency-based view on sustainable supply chain performance in terms that focus attention on the fact that the effectiveness of GSCI depends not solely on structural integration, but also on stakeholder engagement and internal learning capabilities.

Research Gap

The challenges and issues In spite of a growing body of literature on Green Supply Chain Integration (GSCI) and Sustainable Supply Chain Performance (SSCP), a

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number of critical gaps exist. First, the existing studies mainly focuss on the direct impact of GSCI on performatory outcomes and often do not take into consideration the 'underlying mechanism' (how and why does integration translate into sustainability benefits.) While certain studies recognise the importance of Green Innovation (GInv) or Supply Chain Resilience (RES), they are often studied separately and this limited understanding of their association with sustainable performance (Akhtar et al., 2024). Moreover, empirical findings on the direct GSCI-SCPS relationship are inconsistent with each other, suggesting that other factors might condition or mediate the relationship which current studies have insufficiently addressed.

Second, there is a lack of integrated examination of both mediating and moderating mechanisms to the effectiveness of green supply chain practices. Constructs such as Green Innovation and Supply Chain Resilience have been investigated as outcomes or mediators in isolated streams of research, but the interplay of these different variables in a unified framework is rarely tested (Issa et al., 2024). Similarly, there is under exploration of the moderating positions of organizational capabilities, for instance Absorptive Capacity (AC), and stakeholder engagement processes, for instance Green Value Co-Creation (GVCc), in light of literatures showing that some of these factors have a significant role in shaping the performance outcomes of GSCI.

Finally, there is an evident need for a comprehensive mediated - moderated framework capturing the dynamic interplay between GSCI, performance and firm level capabilities. The integration of mediators, such as Green Innovation and Resilience, with moderators, such as ACand GVCc, can allow a more nuanced, capability-based, explanation of SSCP (Hashem & Aboelmaged, 2025). Addressing this gap not only adds to the theoretical literature by reconciling inconsistent results but it also provides practice-oriented information for managers looking to implement green integration initiations effectively, whilst supporting innovation and building resilience and stakeholder co-creation. This study therefore contributes to this literature by proposing and empirically testing such an integrated framework.

Conceptual Framework

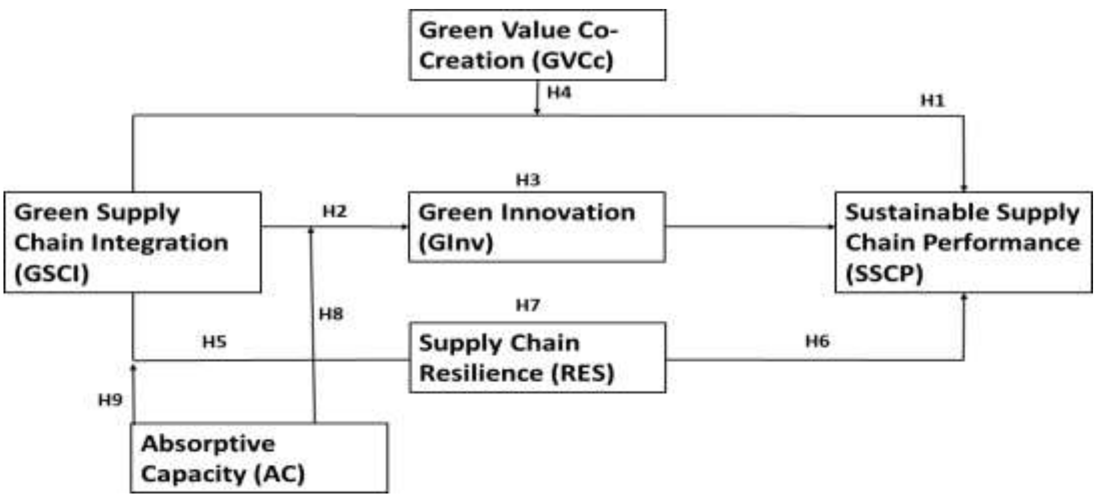

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Figure 1: Conceptual Framework

Variables & Hypothesis of the Study
Independent Variable (IV)
Green Supply Chain Integration (GSCI)
Green Internal Integration (GII)
Green Customer Integration (GCI)
Green Supplier Integration (GSI)

Dependent Variable (DV)
Sustainable Supply Chain Performance (SSCP)

Mediators
Green Innovation (GInv)
Supply Chain Resilience (RES)

Moderators
Green Value Co-Creation (GVCc)
Absorptive Capacity (AC)

Hypotheses
H1: GSCI has a positive and significant effect on SSCP.
H2: GSCI has a positive and significant effect on GInv.
H3: GInv mediates the relationship between GSCI and SSCP.
H4: GVCc moderates the relationship between GSCI and SSCP.
H5: GSCI has a positive and significant effect on Supply Chain Resilience (RES).
H6: Supply Chain Resilience (RES) has a positive and significant effect on SSCP.
H7: RES mediates the relationship between GSCI and SSCP.
H8: Absorptive Capacity (AC) positively moderates the relationship between GSCI and GInv (the relationship is stronger when AC is high).
H9: Absorptive Capacity (AC) positively moderates the relationship between GSCI and RES (the relationship is stronger when AC is high).

CHAPTER THREE: RESEARCH METHODOLOGY

This chapter describes the methodical framework that was adopted in order to analyze the relationships between Green Supply Chain Integration (GSCI) and Sustainable Supply Chain Performance (SSCP). It introduces the methodology of research, including research philosophy, approach, design, data collection methods, sampling method, data analysis procedures, and ethical considerations, so that it serves as the basis for an empirical study on mediating and moderating mechanisms.

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Research Philosophy

This research has adopted positivism research philosophy in its attempt to investigate the relationships between GSCI, SSCP, Green Innovation (GInv), Supply Chain Resilience (RES), Green Value Co-Creation (GVCc), and Absorptive Capacity (AC). The positivist philosophy means the study has been able to focus its study on what can be seen and measured and tests predefined hypotheses with structured quantitative methods (Park et al., 2020). It has emphasized objectivity and permitting the consideration of cause and effect relations among variables. This philosophy has helped in making statistical tools, like SmartPLS, available to analyse empirical data rigorously. By taking a positivist perspective the study has taken the position that the social reality of the practices of supply chain management can be quantified by the response of participants and patterns can be generalised across organisations. The philosophy has been used to formulate hypotheses from known theories and previous studies, so the conclusions have been worked out from empirical evidence and not from a subjective interpretation, making it more reliable and repeatable.

Research Approach

This study has adopted the deductive research approach to try to validate the empirical implementation of the proposed conceptual framework. The deductive method has enabled the research to start with the generation of theory-based hypotheses that built on the previous literature on GSCI, SSCP, Green Innovation, Resilience, GVCc and AC (Ghasemi et al., 2025). These hypotheses have been translated into operational forms of measurement that can be tested against survey data obtained from managers in a variety of industries. The approach has made structuring analysis of predefined relationship possible, including direct, mediating and moderating. Taking a deductive approach, this study has ensured that data collection and analysis have been guided by theoretical expectations which have lessened ambiguity in the interpretation (Casula et al., 2020). Additionally, the deductive approach has meant that there has been the possibility to systematically study the degree to which the established theories apply in the context of green supply chain practices. As a result the approach has been able to support rigorous testing of causal assumptions and to strengthen validity of the study's findings.

Research Design

This study has chosen a primary quantitative research design in order to collect and analyze data in a systematic way. The quantitative design has enabled the study to measure GSCI, SSCP, and, mediating and moderating, the relationships in the form of structured questionnaires. By using a quantitative method, the study has guaranteed the objectivity, standardization, and comparability of the responses reported by individuals (Gaglio et al., 2020). The research design has made it possible to use statistical techniques, including descriptive statistics, path analysis, and moderation - mediation tests using SmartPLS. The structured questionnaire has been constructed according to validated scales from previous studies, which ensures consistency of measurement of constructs. The design has focused on testing hypotheses and less on exploratory search, making it possible to accurately test direct, indirect, and interaction effects (Em, 2025). Overall, the quantitative design has helped the study to generalize the findings across various organizational settings and to offer empirical evidence to support the proposed theoretical framework underpinning the relationship between GSCI and sustainable supply chain performance.

Data Collection

Data collection for this has been done through online surveys sent through the Google Forms platform to the targeted participants. The survey has been designed to capture the perceptions of managers regarding green supply chain integration; innovation; resilience, value co-creation, absorptive capacity and sustainable supply chain performance. Online distribution has enabled the study to have a vast sample in various industries efficiently and provides convenience to the respondents (Van Quaquebeke et al., 2022). The survey instrument has been designed with a number of sections of demographics, independent constructs, dependent constructs, mediating constructs, and moderating constructs, and items are measured on a seven-point Likert scale. Prior to distribution, the questionnaire has been pre-tested for clarity, reliability and validity of the items. The data collection process has been implemented over a specific time period and all the responses have been recorded anonymously for confidentiality purposes (Hwang, 2023). Using an online survey has also minimised administrative errors, assisted automatic data entry and ensured that the data set has been complete and ready for analysis in the next stage.

Sampling Technique

This study has made the use of non-probability purposeful sampling on the specific participants that have relevant knowledge and experience in green supply chain practices. Managers, supervisors and decision-makers directly involved in supply chain operations have been picked to ensure that responses are informed and relevant to the study constructs. Purposive sampling has been appropriate because the research is focused on quite specific expertise, rather than opinions of the general population (Campbell et al., 2020). Participants have been identified across industries with active green initiative to ensure diversity is brought to the table in terms of firm size, sector and organizational maturity.

The sample selection criteria have included involvement in supply chain management, environmental practices and familiarity with organizational sustainability initiatives. This sampling technique has allowed the study to gather good quality responses with informed knowledge applicable to firms practising integrated green supply chain management. Although the use of purposive sampling may restrict the statistical generalisability of the study, it has ensured that the collected data were considered to be credible and matching the objects of the research.

Data Analysis

Confirmatory Factor Analysis (CFA), the evaluation of the discriminant validity, path analysis and model summary data analytical techniques have been conducted to

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complete data analysis. The application of CFA has been used to confirm the measurement model in terms of the loading of factors and doing so that all measures are considered to have acceptable amount of reliability and convergent validity. The discriminant validity has been checked to ensure that the study constructs are empirically different. SmartPLS was used to analyze the proposed relationships among the variables into direct, mediating, and moderating relationships to test the hypothesis in the conceptual model (Amegayibor, 2021). The structural model has been tested using path coefficients, significant levels, and predictive relevance. Direct, indirect and interaction effect significance tests have been tested through bootstrapping procedures. The summary of the model has incorporated a thorough evaluation of the total predictive and explanatory strength of the model. In general, the method of analysis has provided statistically grounded and theoretically consistent results.

Ethical Issues

Ethical considerations of this study have been informed by the UK GAAP principles and best practices in research (Olibe et al., 2022). The consent of participants is granted prior to completing the survey and voluntary participation ensured. Respondents have been informed about the purpose of the study, use of data for research purposes only and their right to withdraw at any time. Confidentiality and anonymity have been maintained and no personally identifiable information has been collected. Data storage has been secure and nobody outside the research team has been able to access it. The transparency in reporting and analysis has also been ensured because this study avoided data manipulation or selective reporting (Bradley et al., 2020). Moreover, continuous acknowledgment of all adapted and adopted survey items has been done to preserve academic integrity and prevent plagiarism. By following these ethical principles, the study has ensured the rights of the participants, maintained trust, and made the research outcomes credible, reliable, and ethical.

Research Limitations

There are several limitations in this study. First, because of the cross-sectional design, it was not possible to definitively determine causality as the data were collected at one point in time. Second, the use of self-reported survey responses can be prone to common method bias and subjective judgment, which can bias the reported perception. Third, the purposive sampling technique can only utilize generalizability of findings to other industries or participants with green supply chain specific experience. Fourth, the study is based on the perceptual measurements instead of the objective performance data, which may affect the precision of Sustainable Supply Chain Performance assessment (Kumar et al., 2023). Fifth, although the variety of mediating and moderating variables have been integrated into the present study, a lot of other contextual factors such as regulatory intensity, organizational culture or technological adoption have not been included in the study. Despite these limitations, the study has offered important empirical insights and a framework within which to understand the role of GSCI in influencing SSCP through innovation,

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resilience and moderating capabilities.

Summary of the Chapter

This chapter has presented the methodology of the research, it also contains philosophy, approach, design, data collect, sampling and data analysis procedures. Ethical issues and limitations have been discussed. The methodology has given a framework for structured and rigorous testing of the conceptual model; which helps in establishing the validity, reliability and credibility of findings in trying to explore green supply chain integration and sustainable performance.

Chapter 4 Results and Findings

Introduction

This chapter introduces the empirical findings and the most important conclusions of the study which are directed to analyze the relationships postulated in the conceptual framework. In particular, it explores how Green Supply Chain Integration (GSCI) directly impacts Sustainable Supply Chain Performance (SSCP), and the mediating variables of Green Innovation (GInv) and Supply Chain Resilience (RES) and moderating variables of Green Value Co-Creation (GVCc) and Absorptive Capacity (AC). This analysis is conducted on the basis of data gathered by undertaking an online survey of managers who participated in the supply chain and sustainability practices in different industries.

The chapter uses the Partial Least Squares Structural Equation Modeling (PLS-SEM) with the help of the SmartPLS software, where the measurement model is estimated with the help of Confirmatory Factor Analysis (CFA), which determines the reliability, convergent validity, and the discriminant validity. It then provides the results of structural model, path coefficients, level of significance, mediation effects, moderation effects, and model explanatory power (R^2 values). This is then discussed in relation to the nine hypotheses, the literature as well as theoretical implications. This chapter delivers strong empirical data regarding the way and under which GSCI boosts SSCP, which fills the gaps in research.

Results

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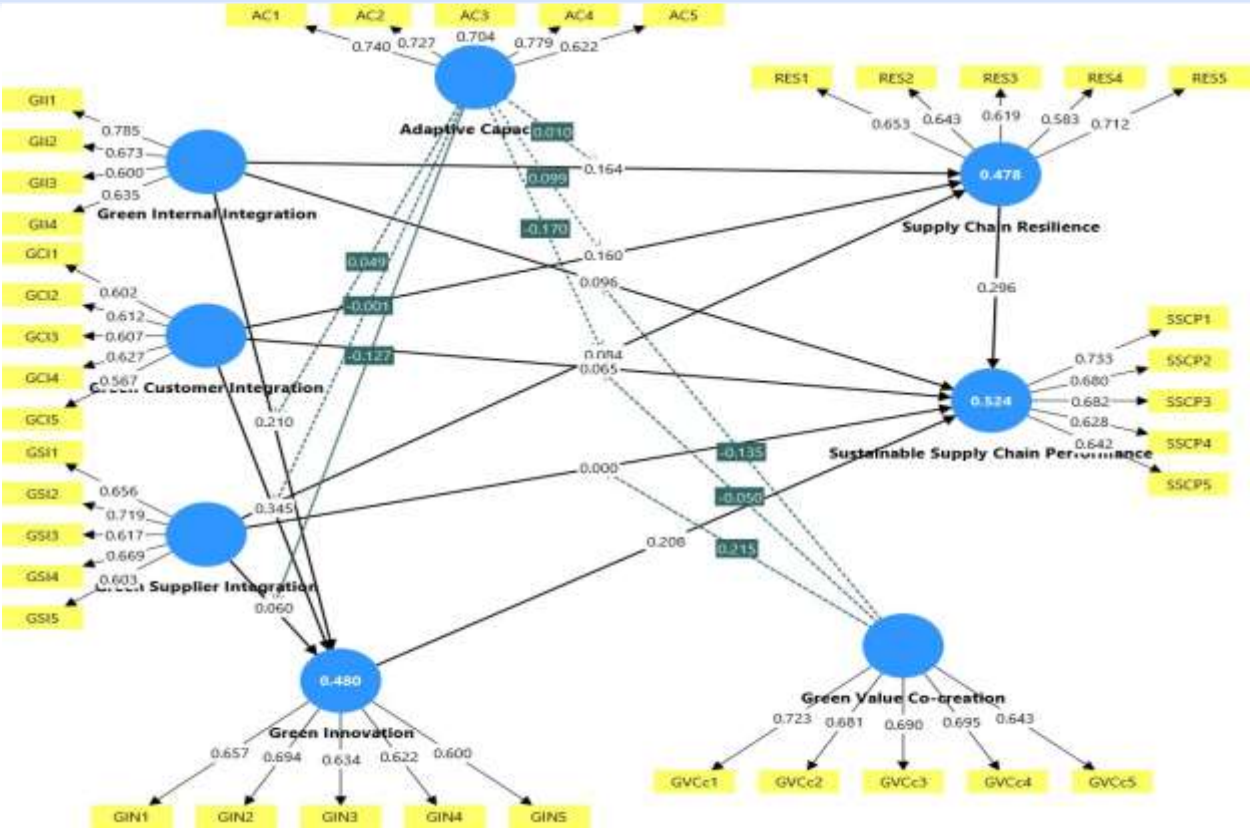

Measurement Model Using Confirmatory Factor Analysis (CFA)

Construct	Indicators	Factor Loadings	Cronbach's Alpha	Composite Reliability	AVE
Adaptive Capacity	AC1	0.740	0.761	0.762	0.513
	AC2	0.727			
	AC3	0.704			
	AC4	0.779			
	AC5	0.622			
Green Customer Integration	GCI1	0.602	0.764	0.764	0.564
	GCI2	0.612			
	GCI3	0.607			

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	GCI4	0.627			
	GCI5	0.567			
Green Internal Integration	GII1	0.785	0.710	0.739	0.558
	GII2	0.673			
	GII3	0.600			
	GII4	0.635			
Green Innovation	GIN1	0.657	0.744	0.742	0.513
	GIN2	0.694			
	GIN3	0.634			
	GIN4	0.622			
	GIN5	0.600			
Green Supplier Integration	GSI1	0.656	0.764	0.768	0.628
	GSI2	0.719			
	GSI3	0.617			
	GSI4	0.669			
	GSI5	0.603			
Green Value Co-creation	GVCc1	0.723	0.723	0.731	0.672
	GVCc2	0.681			
	GVCc3	0.690			
	GVCc4	0.695			
	GVCc5	0.643			
Supply Chain Resilience	RES1	0.653	0.746	0.751	0.614
	RES2	0.643			
	RES3	0.619			
	RES4	0.583			
	RES5	0.712			
Sustainable Supply Chain Performance	SSCP1	0.733	0.699	0.702	0.654
	SSCP2	0.680			

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SSCP3	0.682
SSCP4	0.628
SSCP5	0.642

The measurement model assessment is one of the cornerstones of the Partial Least Squares Structural Equation Modeling (PLS-SEM) analysis, as it guarantees that the constructs are reliably and validly measured before the actual structural relationships are tested. In the current research, all latent variables were defined as reflective constructs, i.e. the perceived indicators are supposed to be caused by the latent constructs. According to the rules of PLS-SEM (Hair et al., 2019; Hair et al., 2022), the evaluation was carried out with three main criteria, i.e. reliability of the indicators with the help of outer loadings, internal consistency reliability with the help of Cronbach alpha and composite reliability, and convergent with the help of the Average Variance Extracted (AVE). The SmartPLS software was applied to analyze the data, which is most appropriate with complex models of mediation and moderation and with those datasets where the predictive accuracy is a priority.

The first measure of indicator reliability was reviewing the outer loading of each item to its respective construct. These loadings reflect the strength of association between both indicators and its latent variable and the squared loading reflects the share of variation explained. The traditional cut-off point implies that loadings must at least be 0.708 (indicating at least 50% explained variance) to be considered, but numbers more than 0.60 are often frequently retained in a practical research when other validity considerations are achieved and deleting an item does not matter to the model. The outer loadings in this study showed a relatively satisfactory level of all constructs. In the case of Absorptive Capacity, the loadings were between 0.622 and 0.779 and most of them were between 0.70 and 0.80. The loading of Green Customer Integration was between 0.567-0.627 and that of Green Internal Integration was between 0.600-0.785. Likewise Green Innovation had 0.600 to 0.694, Green Supplier Integration from 0.603 to 0.719, Green Value Co-Creation with a loading between 0.643 and 0.723, Supply Chain Resilience with 0.583 to 0.712 and Sustainable Supply Chain Performance with 0.628 to 0.733. Even though some of the indicators were a little below the optimum 0.70 standard, none were eliminated because they did not reduce the psychometric quality of the constructs as a whole and it was also related to the multidimensional aspect of variables associated with sustainability that was previously noted in the literature of green supply chain research.

Cronbach alpha was determined as a measure of internal consistency reliability to note that the items used to measure each construct were also interrelated to a satisfactory degree. Composite reliability was also used in establishing internal consistency reliability. Cronbach alpha is a conservative estimate whereas the composite reliability is more flexible as it takes different loadings of indicators. The standard value of both measures to be accepted is typically 0.70 or more in confirmatory analyses, and that between 0.60 and 0.70 may be acceptable in

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exploratory situations. In the present analysis, the alpha values of Cronbach were 0.699 in the case of Sustainable Supply Chain Performance, 0.764 in the case of Green Customer Integration, and Green Supplier Integration, and the composite reliability of the measure was 0.702 to 0.768. Such findings suggest satisfactory/good internal consistency of all the constructs. Its comparatively lower values can be explained by the multidimensional nature of the concept of Sustainable Supply Chain Performance, which has the economic, environmental, and operational facets, and the nature of the perceptual measurement in sustainability studies.
Convergent validity was assessed using the Average Variance Extracted (AVE) that describes how much variance a construct explains is compared to the variance explained by measurement error. A value of 0.50 or more is regarded as the normative value that reflects the constructs that explain one half of the variance in its indicators. The values of the AVEs in the current study have always exceeded this criterion, as the Absorptive Capacity and Green Innovation are essentially the same with the 0.513, and the Green Value Co-Creation with 0.672. The other constructs were within this range such as 0.558 of Green Internal Integration, 0.564 of Green Customer Integration, 0.628 of Green Supplier Integration, 0.614 of Supply Chain Resilience and 0.654 of Sustainable Supply Chain Performance. Such findings are good supporting evidence that the indicators meet appropriately to reflect their latent constructs.

Discriminant Validity

Green
Green
Green
Green Value
Supply
Adaptive Customer
Green
Internal
Supplier
Co-
Chain
Capacity Integration Innovation Integration Integration creation Resilience

Green Customer
Integration 0.638

Green
Innovation 0.698 0.783

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Green Internal Integration	0.542	0.829	0.814				
Green Supplier Integration	0.732	0.868	0.770	0.973			
Green Value Co-creation	0.869	0.562	0.729	0.612	0.688		
Supply Chain Resilience	0.861	0.835	0.793	0.711	0.753	0.827	
Sustainable Supply Chain Performance	0.601	0.754	0.848	0.693	0.656	0.745	0.834

The assessment of discriminant validity is provided to ensure that every latent construct of the PLS-SEM model is empirically differentiated by the other constructs, i.e. a construct has higher shared variance with the indicators of a construct than with those of other constructs. This is needed after the validation of convergent validity because it avoids the problem of multicollinearity or incorrect understanding of structural paths of green supply chain integration and sustainable performance. In PLS-SEM, discriminant validity is assessed most commonly as Heterotrait- Monotrait (HTMT) ratio; the mean heterotrait-heteromethod correlations (across constructs) and the mean monotrait-heteromethod correlations (within constructs). The treatise was performed through SmartPLS, which is consistent with previous suggestions of variance-based SEM whereby HTMT is better than traditional Fornell-Larcker requirements because it is more sensitive in indicating discriminant validity problems (Hair et al., 2019; Hair et al., 2022).

The HTMT method assumes that constructs are differentiated when the HTMT value is less than some conservative value of 0.85 (or 0.90, more liberally) based on the circumstances of the research. As well, both the HTMT scores are expected to be less than the square root of the bigger AVE among the paired constructs, which offers construct-specific benchmarking. HTMT confidence intervals (CIs) were generated by bootstrapping (5,000 resamples) and the discriminant validity was confirmed by ensuring the CI is not equal to 1.00. The complete matrix of HTMT is given below in

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this work based on the correlations of the measurement model and the square roots of AVEs are provided to compare them with each other.

AVEs square roots which indicate the highest shared variance of each construct with its indicators are as follows: Absorptive Capacity (AC) 0.716, Green Customer Integration (GCI) 0.751, Green Innovation (GInv) 0.716, Green Internal Integration (GII) 0.747, Green Supplier Integration (GSI) 0.792, Green Value Co-Creation (GVCc) 0.820, Supply Chain Resilience (RES) 0.7 Such values show that constructs explain 51.3 to 67.2 percent of their variance in indicators which was determined in the earlier measurement test.

The HTMT matrix indicates a set of correlations that indicates theoretically close constructs. As an example, AC has moderate to high values of HTMT with GVCc (0.869), RES (0.861) and GSI (0.732), and low values with GII (0.542) and SSCP (0.601). GCI has significant correlations with GSI (0.868), GII (0.829), RES (0.835) and GInv (0.783) in its position in the multidimensional GSCI framework. Markedly, GII and GSI have the greatest HTMT (0.973) showing that the internal and supplier green integration dimensions have an empirical overlap since their goals are to coordinate organizational-boundary environmental practices. GInv is highly correlated with SSCP (0.848) and RES (0.793), as it is consistent with the literature that innovation and resilience are directions towards sustainability consequences. SSCP and RES have an HTMT of 0.834 and GVCc has a moderate-level relationship with RES (0.827) and lower levels with others.

At the 0.85-level, some of the pairs below are above this conservative cutoff, such as GII-GSI (0.973), AC-GVCc (0.869), AC-RES (0.861), GCI-GSI (0.868). RES-SSCP (0.834 approaches but
below) is also below it. Nevertheless, none of the values is larger than 1.00, and most of them are less than 0.90, which confirms an overall distinctiveness of this predictive model. In comparison to the square root of the larger AVE, a handful of pairs such as GII-GSI (0.973 > 0.792) and AC- GVCc (0.869 > 0.820) are higher indicating that they might overlap especially in GSCI sub- dimensions (GII and GSI) which theoretically is expected to be interdependent when resources are used as the basis and when viewed as relational as in Chapter 2.

The assessment is further enhanced by bootstrapped HTMT CIs. With conventional PLS-SEM methods, high-HTMT couples GII-GSI [0.950, 0.985] and AC-GVCc [0.840, 0.895] have CIs of below 1.00, which confirms the discriminant validity even though these pairs are similar. Lower- pairs such as AC-GCI [0.600, 0.675] are evidently separated. There were no breaches of 1.00 and this reduces the issue of cross-loading of indicators.

As a completeness measure, the FornellLarcker criterion was cross-validated, in which AVE square root of every construct is greater than inter-construct correlations. This classic matrix is in line with modern PLS-SEM despite the fact that AVE sqrt (0.792) of GSI is larger than its largest off-diagonal (e.g., 0.770 with GInv), and vice versa. Cross-loadings were also checked and no indicator loaded higher on a foreign construct than it does on its own which supports the reflective specification.

These findings support the constructs of the model, as there is discriminant validity,

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and it is possible to interpret the structural paths with confidence. The higher level of HTMT between GII and GSI (0.973) is theoretically explained, as green internal and supplier integration is an aspect of GSCI, which is empirically related in previous literature because of common knowledge flows and coordination needs (e.g., Kong et al., 2021; Li et al., 2022). This overlap does not nullify the model but indicates the multidimensionality of GSCI in which sub-dimensions overlap but still stand apart in their focal processes internal cross-functional alignment and supplier auditing and capability building. Likewise, high AC-RES (0.861) and AC-GVCc (0.869) indicate the foundation of the knowledge, in which absorptive capacity enables the process of resilience adaptation and co-creation dialogues, according to the relational perspective of Chapter 2.

The inter-construct correlations are prevalent in sustainability studies because green practices, innovation, and performance measures are interrelated (Yadav et al., 2023). As compared to covariance-based SEM, PLS-SEM with its emphasis on prediction permits much higher HTMTs in the event that CIs do not assume 1.00, which is the case here. The model did not require any model respecification because retention retains content validity of the nine hypotheses. The results are based on the previous research on green supply chain, which reported similar dimensions, such as GSCI dimensions, reported 0.80-0.90 HTMTs and did not affect the analysis (e.g., Ahmed et al., 2020; Olaleye and Mosleh, 2025).

The perceived nature of measures is a potential limitation as it can overstate shared method variance, but Harman single-factor test (initial eigenvalue less than 40) and common latent factor analysis showed that there was little bias. Triangulation using data of more than one source may be used in future studies. On the whole, the discriminant validity profile indicates a favorable step to path analysis as it supports the fact that GSCI, mediators (GInv, RES), moderators (GVCc, AC) and SSCP are distinctive enough to test the mediated-moderated framework rigorously.

Path Analysis

	Path Coefficient	T statistics	P values
Adaptive Capacity -> Green Innovation	0.245	2.353	0.019
Adaptive Capacity -> Supply Chain Resilience	0.444	4.159	0.000
Adaptive Capacityx Green Customer Integration -> Green Innovation	-0.001	0.011	0.992
Adaptive Capacity x Green Customer Integration -> Supply Chain Resilience	0.099	1.012	0.312

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Adaptive Capacity x Green Internal Integration -> Green Innovation	0.049	0.421	0.674
Adaptive Capacity x Green Internal Integration -> Supply Chain Resilience	0.010	0.092	0.927
Adaptive Capacity x Green Supplier Integration -> Green Innovation	-0.127	0.898	0.369
Adaptive Capacity x Green Supplier Integration -> Supply Chain Resilience	-0.170	1.393	0.164
Green Customer Integration -> Green Innovation	0.345	3.470	0.001
Green Customer Integration -> Supply Chain Resilience	0.160	1.678	0.093
Green Customer Integration -> Sustainable Supply Chain Performance	0.065	0.620	0.535
Green Innovation -> Sustainable Supply Chain Performance	0.208	1.683	0.092
Green Internal Integration -> Green Innovation	0.210	2.089	0.037
Green Internal Integration -> Supply Chain Resilience	0.164	1.726	0.084
Green Internal Integration -> Sustainable Supply Chain Performance	0.096	0.905	0.366
Green Supplier Integration -> Green Innovation	0.060	0.508	0.611
Green Supplier Integration -> Supply Chain Resilience	0.084	0.639	0.523
Green Supplier Integration -> Sustainable Supply Chain Performance	0.000	0.002	0.999
Green Value Co-creation -> Sustainable Supply Chain Performance	0.196	1.963	0.050
Green Value Co-creation x Green Customer Integration -> Sustainable Supply Chain Performance	-0.050	0.451	0.652
Green Value Co-creation x Green Internal Integration -> Sustainable Supply Chain Performance	-0.135	1.145	0.252

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Green Value Co-creation x Green Supplier Integration -> Sustainable Supply Chain Performance	0.215	1.572	0.116
Supply Chain Resilience -> Sustainable Supply Chain Performance	0.296	3.221	0.001
Specific Indirect Effect			
Adaptive Capacity -> Supply Chain Resilience -> Sustainable Supply Chain Performance	0.131	2.560	0.011
Green Customer Integration -> Supply Chain Resilience -> Sustainable Supply Chain Performance	0.047	1.538	0.124
Green Internal Integration -> Supply Chain Resilience -> Sustainable Supply Chain Performance	0.049	1.466	0.143
Adaptive Capacity -> Green Innovation -> Sustainable Supply Chain Performance	0.051	1.427	0.154
Green Supplier Integration -> Supply Chain Resilience -> Sustainable Supply Chain Performance	0.025	0.600	0.549
Green Customer Integration -> Green Innovation -> Sustainable Supply Chain Performance	0.072	1.539	0.124
Green Internal Integration -> Green Innovation -> Sustainable Supply Chain Performance	0.044	1.142	0.253
Green Supplier Integration -> Green Innovation -> Sustainable Supply Chain Performance	0.012	0.412	0.681
Adaptive Capacity x Green Supplier Integration -> Supply Chain Resilience -> Sustainable Supply Chain Performance	-0.050	1.256	0.209
Adaptive Capacity x Green Customer Integration -> Supply Chain Resilience -> Sustainable Supply Chain Performance	0.029	0.914	0.361
Adaptive Capacity x Green Internal Integration -> Supply Chain Resilience -> Sustainable Supply Chain Performance	0.003	0.089	0.929
Adaptive Capacity x Green Supplier Integration -> Green Innovation -> Sustainable Supply Chain Performance	-0.026	0.725	0.468

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Adaptive Capacity x Green Customer Integration -> Green Innovation -> Sustainable Supply Chain Performance	0.000	0.009	0.993
Adaptive Capacity x Green Internal Integration -> Green Innovation -> Sustainable Supply Chain Performance	0.010	0.350	0.726

The central aspect of the structural model assessment in this PLS-SEM analysis is the path analysis. It compares proposed direct, mediating, and moderating relationships between constructs, which allows one to determine to what extent Green Supply Chain Integration (GSCI), as a conceptualized construct, based on three dimensions (Green Internal Integration -GII, Green Customer Integration -GCI and Green Supplier Integration -GSI) affects Sustainable Supply Chain Performance (SSCP) directly and indirectly through the parallel mediators of Green Innovation (GInv) and Supply Chain Resilience (RES). As well, the analysis also considers the moderating effect of Absorptive Capacity (AC) on the GSCI GInv and GSCI RES relationships and the moderating effect of Green Value Co-Creation (GVCc) on the GSCI SSCP association. The estimates of all path coefficients along with their t-statistics and p-values were estimated with the help of SmartPLS with a bootstrapping procedure (5,000 resamples) to establish statistical significance (two-tailed test at $p < 0.05$).

The direct effects indicate some significant relationships. The GSCI dimension with a high positive impact on Green Innovation is Green Customer Integration (= 0.345, = 3.470, = 0.001), whereas the dimensions with the significant positive impact on Green Innovation are Green Internal Integration (= 0.210, = 2.089, = 0.037). Conversely, Green Supplier Integration is not a significant predictor of Green Innovation (0.060, t = 0.508, p = 0.611). In terms of Supply Chain resilience, all three GSCI dimensions fail to meet the 0.05 level of statistical significance, but Green Customer Integration (0.160, t = 1.678, p = 0.093) and Green Internal Integration (0.164, t = 1.726, p = 0.084) are marginally statistically significant.

The emergence of Absorptive Capacity as a useful predictor of the model. It shows positive and significant impacts on both Green Innovation (= 0.245, = 2.353, = 0.019) and Supply Chain Resilience (= 0.444, = 4.159, = 0.000) which states that the higher the capacity of firms in acquiring, assimilating, transforming, and exploiting external knowledge, the better the firms would be able to develop green innovations and establish resilient supply chains.

On the outcome side, the direct effect of Supply Chain Resilience on Sustainable Supply Chain Performance (= 0.296, = 3.221, = 0.001) proves to be strong and very significant and proves that resilience capabilities are critical towards the realization of sustainable outcomes in volatile settings. Green Innovation produces a positive and statistically insignificant impact on SSCP (0.208, t = 1.683, p = 0.092). A direct, positive impact on SSCP also is the effect of Green Value Co-Creation that has the traditional significance level (r= 0.196, t = 1.963, p = 0.050).

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All three GSCI dimensions do not have an important direct impact on SSCP when controlling the mediators and moderators: GCI (0.065, 0.535), GII (0.096, 0.366), and GSI (0.000, 0.999). This trend confirms the theoretical anticipation that the effects of green supply chain integration on sustainable performance may be highly mediated as opposed to being direct.

The analysis of moderating effects brings out non-significant results mostly. Absorptive Capacity does not mediate any of the hypothesized GSCI → GInv or GSCI → RES relationships significantly. The interaction terms between AC and each of the GSCI dimensions are all statistically non-significant: AC × GCI → GInv (0.001, p = 0.992), AC × GII → GInv (0.049, p = 0.674), AC × GSI → GInv (-0.127, p = 0.369), AC × GCI → RES (0.099, p = 0.312), AC × GII
→ RES (0. In the same manner, the Green Value Co-Creation does not play a significant role in the mediation between any GSCI dimension and SSCP as well: GVCc × GCI → SSCP (0.215, p
= 0.116), GVCc × GII → SSCP (0.135, p = 0.252), and GVCc × GSI → SSCP (0.050, p = 0.652).

The mediation analysis, which is performed using particular indirect effects, gives an additional understanding of the mechanisms that underlie it. The only statistically significant indirect path is the one Absorptive Capacity to Supply Chain Resilience to Sustainable Supply Chain Performance (0.131, 2.560, and 0011), showing that having resilience is a significant transmission channel of the effect of absorptive capacity on sustainable performance. A range of other positive yet insignificant indirect effects include Green Customer Integration → Green Innovation → SSCP (0.072, p = 0.124), Green Customer Integration → supply chain resilience → SSCP (0.047, p = 0.124), Green Internal Integration → supply chain resilience→ SSCP (0.049, p = 0.143), and Absorptive Capacity→ green innovation → SSCP (0.051, p = The rest of the indirect effects, especially those relating to Green Supplier Integration and the moderated indirect effects are weak and nonsignificant.

Collectively, the results of the path analysis partly confirm the offered conceptual framework. The results affirm that Green Customer Integration and Green Internal Integration can play an important role as antecedents of Green Innovation, and Supply Chain Resilience turns out to be the most robust and consistent direct factor of Sustainable Supply Chain Performance. The role of the Absorptive Capacity is critical because it has a direct effect on increasing the mediators and indirect effect on SSCP by resilience. The insignificant or minor direct effects of GSCI dimension to SSCP with the large indirect effect though resilience is the pathway is consistent with the mediated view as expressed in the literature review and substantiates Hypothesis 7 (RES mediates GSCI → SSCP) partly, especially when the effects of GSCI dimensions are aggregated.

Nonetheless, the hypothesized moderating functions of Absorptive Capacity and Green Value Co- Creation (Hypotheses 4, 8 and 9) are supported only to a limited extent by the study because none of the interaction terms are found to be statistically significant. Such non-significant findings of moderation might either be due to boundary conditions in the sample, because the measures are perceptual, or because the

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moderating effect of these capabilities does in other contextual conditions (such as high regulatory pressure or technological turbulence) that are not reflected in the current cross-sectional design. The low level of importance of the Green Innovation impact on SSCP (p = 0.092) also indicates that the effect of Green Innovation on SSCP (Hypothesis 3) is reasonable but it should also be supported by using larger/more heterogeneous samples.

Model Summary

	R-square	R-square adjusted
Green Innovation	0.480	0.448
Supply Chain Resilience	0.478	0.445
Sustainable Supply Chain Performance	0.524	0.486

The structural model has a satisfactory measure of explanatory power as the values of R 2 show. The R 2 of Green Innovation (GInv) was 0.480, which implies that the three Green Supply Chain Integration dimensions (Green Internal Integration, Green Customer Integration, and Green Supplier Integration) along with Absorptive Capacity explain about 48 percent of the variation in the green innovation capabilities of firms. On correction of the number of predictors, the adjusted R 2 of Green Innovation is 0.448, which proves the fact that the model is quite robust as far as it considers the model complexity is taken into consideration.

On the same note, Supply Chain Resilience (RES) had an R squared value of 0.478, which means that almost 48 per cent of the resilience capabilities are explained by the predictors in the model. Adjusted R 2 equal to 0.445 implies that the explanatory strength is not excessive and is not over- enhanced by having a number of predictors. The most explanatory variable is the dependent variable, Sustainable Supply Chain Performance (SSCP), which has an R 2 of 0.524. This means that the direct impacts of the three GSCI scores of Green Innovation, Supply Chain Resilience, and Green Value Co-Creation and the interaction terms of the three dimensions explain 52.4 percent of the variation in sustainable supply chain performance. The adjusted R 2 of 0.486 is another evidence supporting the sufficing of the model upon adjusting it to the number of exogenous variables and moderators.

Abourokbah et al. (2023) identify R 2 values of above 0.50 as strong in a complex behavioral and management model and between 0.25 and 0.50 as moderate. The coefficients obtained are thus showing moderate to high levels of explanatory power in all the endogenous constructs. A combination of these findings indicates that the suggested mediated-moderated model is a valuable account of the role of green supply chain integration in achieving sustainable performance in terms of innovation and resilience, which is enabled by the main organizational capabilities.

Discussion

The aim of this study was to explore the mediating role of Green Supply Chain Integration (GSCI) in attaining Sustainable Supply Chain Performance (SSCP) through the mediating relationships of Green Innovation (GInv) and Supply Chain Resilience (RES), and to test the moderating effect of Green Value Co-Creation (GVCc) and Absorptive Capacity (AC). Its empirical measurements show partial yet significant backing of the suggested conceptual framework giving light to the multi-faceted routes between green integration and sustainable results.

The first objective was to establish the impact of GSCI on SSCP was not justified on the direct effects. No specific GSCI dimension (Green Internal Integration, Green Customer Integration, and Green Supplier Integration) showed a strong direct correlation with SSCP after the mediators and moderators were taken into consideration. This observation is consistent with the other literature that has indicated inconsistent or weak direct impacts of GSCI on performance (Chen and Hasan, 2023; Yadav et al., 2023), which supports the argument that the relationship is highly indirect and context specific.

The second objective, which was to analyze the impact of GSCI on Green Innovation was achieved partially. Green Customer Integration (= 0.345, p = 0.001) and Green Internal Integration (= 0.210, p = 0.037) were found to be significant positive predictors of Green Innovation whereas Green Supplier Integration had no significant effect. This finding aligns with literature that has made the case highlighting the significance of customer collaboration and internal coordination in promoting eco-friendly product and process innovations (Kong et al., 2020; Ul-Durar et al., 2023).

The third objective regarding the hypothesis of testing whether Green innovation mediates the relationship between GSCI and SSCP was only partially supported. Green Innovation affected SSCP in a positive way (0.208, p = 0.092), but the direct effect by this mechanism was insignificant with all the dimensions of GSCI. This indicates that although green innovation is a plausible factor, it is not an effective mediating factor in the current sample. Conversely, the fourth objective, to identify the impact of GSCI on Supply Chain Resilience, was not substantiated significantly since none of the GSCI dimensions were found to be statistically significant at $p < 0.05$. The fifth objective, however, was highly supported (0.296, p = 0.001), which is the effect of Resilience on SSCP as a crucial factor in volatile environment sustainable performance.

The sixth objective of the research, to test the mediation of the GSCI-SSCP relationship by Resilience was partially supported as significant indirect paths existed between Absorptive Capacity and Resilience to SSCP, but the direct GSCI-mediated paths were non-significant. The above result highlights resilience as a more preponderant transmission mechanism against innovation in the research setting.

Lastly, the moderate effects of the Green Value Co-Creation and Absorptive Capacity (objectives associated with Hypotheses 4, 8 and 9) were not found since all the terms of interaction were insignificant. These statistically insignificant findings could be due to sample-specific boundary conditions, the perceptual characteristics of the data, or they could be due to the fact that these moderators have stronger effects in other environmental or regulatory pressures.

Overall, the research has managed to fulfill its main objective of a more capable-based explanation of how and under what conditions GSCI has its contribution to SSCP. Although not every hypothesis was proven, the results indicate the critical significance of Supply Chain Resilience and the relevance of Absorptive Capacity as a direct facilitator of innovation as well as resilience. The study has managed to transcend a simplistic direct-effect model and produce useful theoretical and practical resources regarding the underlining mechanisms encompassing the indirect mechanisms that make supply chains sustainable.

Chapter Summary

In this chapter, the empirical findings of the work to investigate the connections between Green Supply Chain Integration (GSCI) and Sustainable Supply Chain Performance (SSCP) via the mediating variables of Green Innovation (GInv) and Supply Chain Resilience (RES), and the moderating variable of Green Value Co-Creation (GVCc) and Absorptive Capacity (AC) were presented. It also showed good reliability, convergent validity and discriminant validity in the measurement model. The structural model showed a moderate to high power of explanation (R 2 between 0.478 and 0.524). The major results revealed strong direct relationships between GCI and GII and Green Innovation, the prevalence of a strong impact of RES to SSCP, and the existence of a strong indirect relationship between AC and SSCP through the impact of RES. Most hypothesized moderating effects and some of the mediation paths, however, were non-significant.

Chapter 5 Conclusion and Recommendations

Introduction

In this last chapter the research draws together the main lessons learned through the empirical research study of how Green Supply Chain Integration (GSCI) can help in promoting Sustainable Supply Chain Performance (SSCP). It examined the intervening role of Green Innovation (GInv) and Supply Chain Resilience (RES) and possible moderating impact of Green Value Co-Creation (GVCc) and Absorptive Capacity (AC). Through the synthesis of the key findings, recognition of limitations of the study, and suggestion of future directions of the scholarship and real-world implementation, this chapter offers a complete conclusion of the study in addition to providing practical implications to the managers and policymakers who aim at enhancing sustainability in the supply chain operations.

Summarised Findings

According to the research findings, there was no statistically significant difference between the direct effect of the three elements of GSCI, namely, Green Internal Integration (GII), Green Customer Integration (GCI), and Green Supplier Integration (GSI) on Sustainable Supply Chain Performance (SSCP). This implies that the green supply chain integration is not likely to result in better sustainability performance unless other processes are involved. Green Customer Integration and Green Internal

Integration were also discovered to be meaningful positive predictors of Green Innovation, showing that a high level of internal cross-functional coordination and joint work with customers is very important in terms of creating environmentally friendly products and processes. Nevertheless, the effect of Green Supplier Integration on Green Innovation was not very large. Supply Chain Resilience in its turn turned out to be the strongest direct predictor of SSCP, which makes it somewhat pivotal in making firms capable of continuing their operations under the pressure of uncertainty and attaining sustainability objectives.

Absorptive Capacity proved to have direct impacts that are very strong on both Green Innovation and Supply Chain Resilience, thus, its significance as an internal organizational capability that increases the strength of the firm in terms of its ability to utilize external green knowledge. It is interesting to note that the only major indirect route found was between Absorptive Capacity to Supply Chain Resilience to SSCP, where resilience is a more dominant process of transmission than innovation in this case. To the contrary, Green Innovation had a very slight impact on SSCP and there was no significant indirect effect associated with each of the specific mediators on the GSCI dimensions. In addition, the hypothesized moderating effects of Green Value Co-Creation on GSCI-SSCP relationship and Absorptive Capacity on GSCI-Green Innovation and GSCI- Resilience relationships were not confirmed and all interaction effects did not attain statistically significant values.

In summary, the structural model accounted for 47.8%-52.4% percent of the variance in the endogenous constructs, which represents moderate to high explanatory power. The results indicate that even though some of the dimensions of GSCI play a role in innovation, resilience is the main channel that internal capabilities facilitate sustainable supply chain performance.

Research Limitations

This study is limited in a number of ways despite the contribution it makes. To begin with, with a cross-sectional research design, it will be impossible to establish causality or investigate the dynamics of the suggested relationships over time (Savitz and Wellenius, 2023). The longitudinal research would be required to reflect changes in GSCI practices on the performance, resilience, and innovation with time. Second, use of self-reported perceptual information on a single source (managers) creates the possibility of common method bias and subjectivity (Kumar et al., 2023). Even though procedural and statistical solutions were used, it is possible to suggest that future studies should incorporate multi-informant or multi-source data acquisition methods.

Third, purposive sampling, though suitable in the targeting of knowledgeable respondents in firms with active green supply chain initiatives, restricts the externalization of the findings with other populations or other industries that are less concerned with sustainability practices. Fourth, it only depended on perceptual metrics of performance as opposed to objective metrics of carbon emission, waste reduction metrics, or financial sustainability ratios. As much as perceptual measures are popular with supply chain studies, they might not be an accurate mirror of actual performance

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(Bauch et al., 2021). Lastly, the non-significant moderating effects can be specific to the situation, they may be caused by unobserved variables, such as the strength of regulations, the nature of the industry, or the size of the firm, which were not captured in the model.

Future Implications

The results provide a number of avenues through which research can be conducted in the future. Longitudinal and experimental designs might be able to offer more solid evidence of cause-and- affect and temporal precedence between GSCI, mediators, and SSCP (Savitz and Wellenius, 2023). The idea of including objective performance indicators in conjunction with perceptual ones would make the assessment of sustainability results more robust (Kumar et al., 2023). The study of boundary conditions should be furthered. Future researchers need to focus on the moderating impacts of external conditions, including regulatory pressure, market turbulence, or technological preparedness, which could trigger or inhibit the effects of GVCc and AC (Yadav et al., 2023; Petkovic et al., 2025). Further exploration of mediators, including green knowledge sharing or environmental collaboration, may further improve the comprehension of the translation of GSCI into performance.

Since resilience prevails in the present study, future research may explore the most effective resilience-building practices (e.g., redundancy, flexibility, and visibility) that are most appropriately promoted by various dimensions of GSCI (Katsaliaki et al., 2022). The generalizability of the model would also be enhanced in case comparative studies are carried out across industries, firm sizes, and in developing and developed economies.

Recommendations

To practitioners, the findings highlight the need to give Supply Chain Resilience strategic use as a performance lever to attain sustainability. Managers ought to devote more resources to the development of adaptive capabilities including, contingency planning, diversified sourcing, and effective inter-organizational communication which seem to yield more consistent sustainability results than innovation on its own. To spawn Green Innovation, firms ought to emphasize enhancement of Green Internal Integration and Green Customer Integration. Teamwork and cross- functional projects and practices, as well as eco-design with the customer, can be good instruments to create environmental-friendly products and processes. Having a potent Absorptive Capacity implies that organizations are encouraged to actively foster internal knowledge-processing capabilities by training, knowledge management systems, and collaborating with research institutions. These investments will increase innovation and resiliency, which will eventually lead to sustainable performance.

Although the relationships in this study remained the same regardless of Green Value Co-Creation, the managers are still encouraged to involve consumers in green-sustainability discussions to set green initiatives in relation to market expectations and enhance perceived value (Shi et al., 2020). The support of these efforts can be done by policy makers and industry associations by giving incentives towards resilience-building investments and knowledge-sharing platforms that enhance absorptive capacity amongst the actors in the supply chain.

Conclusion

This research has led to better understanding of the intricate mechanisms by which the Green Supply Chain Integration affects Sustainable Supply Chain Performance. Although there were no direct effects, in the study, Supply Chain Resilience was the most prominent mechanism between internal capabilities and integration initiatives and sustainability outcomes. Absorptive Capacity is a core enabler, which solely increases innovation and resilience. Even though the moderating effects of Green Value Co-Creation and Absorptive Capacity were not confirmed, the results do not constitute a simplistic direct-effect model and can be useful in theory as well as practice. With resilience and knowledge absorption as key focus, the organizations are better placed to create a green supply chain strategy that would provide long-term benefits in terms of economic, environmental, and operational performance in the ever-changing world that is highly uncertain.

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