Received: 17 July 2025 | Accepted: 12 December 2025 | Published: 20 December 2025

Sustainable Trends & Business Research

Vol. 03 | Issue 02 | Pages 118-128 |

Research Article

How Supplier Trust Enhances Environmental Sustainability: A Moderated Mediation Model of Green Supply Chain Integration and Information Sharing

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Declaration of Interests
The authors declare no competing financial or personal interests.

Abstract

Environmental sustainability has become a strategic imperative for firms operating in resource-constrained emerging markets facing increasing regulatory scrutiny, supply chain risks, and stakeholder pressure. This study examines how supplier trust influences environmental sustainability performance in Pakistan's pharmaceutical sector through a moderated mediation model, with green supply chain integration (GSCI) as a mediator and information sharing as a moderator. Drawing on signaling theory, we argue that supplier trust acts as a credible relational signal that reduces uncertainty and enables deeper green integration, thereby improving environmental sustainability outcomes. Data were collected through survey from 250 supply chain professionals and analyzed by using PROCESS Model 7 with 5,000 bootstrap resamples in SPSS. The findings show that supplier trust positively affects GSCI, which in turn enhances environmental sustainability performance. Information sharing further strengthens the indirect relationship between supplier trust and environmental sustainability through GSCI, with conditional indirect effects strongest at high levels of information sharing, providing evidence of moderated mediation. These results underscore the importance of trust-based supplier relationships and transparent information exchange in enabling effective green supply chain integration. Managerially, the study highlights fostering trustworthy partnerships and investing in information-sharing systems to support environmental initiatives. Theoretically, the research extends signaling theory by demonstrating how relational signals shape environmental sustainability performance.

Keywords: Supplier Trust; Environmental sustainability; Green supply chain integration; Information sharing; Signaling theory

How to Cite this Work:

Omair, S. & Younus, S. (2025), "How supplier trust enhances environmental sustainability: A moderated mediation model of green supply chain integration and information sharing", *Sustainable Trends and Business Research*, Vol. 03 No. 02, pp. 118-128.

1 INTRODUCTION

Environmental sustainability (ES) has become a critical strategic concern for Pakistan's pharmaceutical sector, which operates within a resource-constrained and environmentally sensitive context (Shahbaz & Malik, 2025). Pharmaceutical manufacturing generates chemical waste, effluents, packaging materials, and airborne emissions that, if unmanaged, can adversely affect public health and local ecosystems (Amir et al., 2024; Yasir et al., 2020). With rising environmental scrutiny from regulators, global buyers, and health-conscious consumers, pharmaceutical firms face increasing pressure to adopt cleaner production practices and demonstrate responsible environmental stewardship (Habib, 2024; Uddin et al., 2025). Moreover, the sector's reliance on imported raw materials and complex supply chains makes sustainability essential for long-term resilience, cost efficiency, and compliance with international quality standards. As Pakistan aims to strengthen its position in global pharmaceutical markets, integrating ES into supply chain practices is no longer optional (Zaman et al., 2024).

Environmental sustainability is not only fundamental for maintaining competitiveness, protecting community health, and ensuring the long-term viability of the industry, but it has also become a central focus for both academics and practitioners due to increasing consumer awareness and governmental pressures (Deb et al., 2023; Ding & Wang, 2025). Prior research suggests that firms that proactively address social, economic, and environmental concerns tend to achieve higher reputational benefits and improved productivity through increased sales and profitability (Lyu et al., 2022). Among these dimensions, ES has gained particular prominence, as stakeholders increasingly favor firms that demonstrate responsible and sustainable practices across their operations (Sarifud et al., 2025). Achieving ES, however, is rarely an isolated organizational effort. In supply chain–intensive industries such as pharmaceuticals, sustainability outcomes increasingly depend on how effectively firms collaborate with upstream and downstream partners. Suppliers play a pivotal role in shaping environmental performance, as they are often responsible for raw material sourcing, production processes, and logistics activities that directly influence emissions, waste generation, and resource consumption (Barhoom et al., 2025). Consequently, relational mechanisms governing buyer–supplier interactions have emerged as critical enablers of sustainable supply chain practices.

One such mechanism is supplier trust (ST), which reduces relational uncertainty and encourages firms to move beyond short-term, transactional exchanges toward long-term collaborative relationships (Shahbaz & Malik, 2025). When firms trust their suppliers, they are more willing to share sensitive information, jointly invest in environmental initiatives, and coordinate sustainability goals (Caliskan et al., 2025). ST fosters mutual commitment and lowers the perceived risks associated with implementing environmentally responsible practices that often require joint decision-making and resource sharing. In the absence of ST, firms may hesitate to engage suppliers in sustainability initiatives due to concerns about opportunism or non-compliance (Yavaprabhas et al., 2025). Complementing ST is information sharing (IS), which serves as the operational backbone of effective supply chain collaboration (Mehmood et al., 2025). Transparent, timely, and accurate IS enables supply chain partners to align environmental objectives, monitor performance, and identify inefficiencies across processes (Rizavi et al., 2025; Zhang et al., 2024). IS is particularly important for environmental initiatives, which often involve complex data related to emissions, waste management, energy use, and regulatory compliance. Without robust IS, even high levels of ST may fail to translate into coordinated green actions, limiting the effectiveness of sustainability efforts.

Together, ST and IS facilitate green supply chain integration (GSCI), which reflects the extent to which firms collaboratively embed environmental considerations into supply chain processes. GSCI involves coordinated activities such as cleaner production, eco-design, green logistics, and joint environmental planning across organizational boundaries (Rafique et al., 2025; Uddin et al., 2025). Through GSCI, firms can transform relational and informational resources into tangible environmental improvements, including reduced waste, improved resource efficiency, and enhanced compliance with environmental standards (Santos et al., 2025; Zhang et al., 2022). Despite growing recognition of these mechanisms, limited empirical research has examined how ST contributes to ES through GSCI, particularly under varying levels of IS in emerging-market contexts. Addressing this gap, the present study investigates how ST influences ES in Pakistan's pharmaceutical sector, with GSCI as a mediating mechanism and IS as a moderating condition. Accordingly, the study pursues the following research objectives:

i. To examine the direct role of ST on ES and GSCI.

ii. To examine the mediating role of GSCI in the ST and ES relationship.

iii. To examine the moderated mediation role of IS in the relationship of ST and ES through GSCI.

This study offers several important theoretical and practical contributions. Theoretically, it extends signaling theory into the green supply chain context by explaining how relational and informational signals jointly shape ES outcomes. By integrating ST, GSCI, and IS into a single moderated mediation framework, the study provides a nuanced understanding of sustainability mechanisms in supply chain relationships. Practically, the findings offer valuable insights for supply chain managers in the pharmaceutical sector and beyond, highlighting how trust-based supplier relationships and effective IS can enhance green collaboration and improve ES across supply chains.

The remainder of this paper is organized as follows. The next section reviews the relevant literature and develops the hypotheses grounded in signaling theory. This is followed by the research methodology, data analysis, and results, after which the discussion, implications, and conclusions are presented.

2 LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

This research is supported by the lens of signaling theory proposed by Connelly et al. (2011), which explains how actors send observable cues to reduce information asymmetry and influence counterpart beliefs and behaviors. In supply chain relationships, buyers, suppliers, and focal firms often operate under imperfect conditions, particularly regarding partners' reliability, compliance, and environmental responsibility (Mehmood et al., 2025; Uddin et al., 2025). Under such conditions, relational and informational cues become critical for guiding interorganizational decision-making. Within supply chains, ST and IS function as important signals that shape partner expectations and collaborative behavior. When supply chain actors demonstrate trustworthy behavior or share reliable and timely information, these actions serve as credible cues that encourage partners to invest in cooperative routines, including GSCI, which ultimately enhances ES outcomes (Alkaraan et al., 2025; Rashid et al., 2025). Signaling can occur through direct mechanisms, such as voluntary disclosure of environmental practices, or indirect mechanisms, such as continuous and transparent information exchange that indicates long-term commitment (Li et al., 2017). Recent sustainability research further suggests that credible signaling mechanisms are particularly important in environmentally sensitive industries, where coordination failures can result in significant environmental and reputational risks (Zhang et al., 2022; Santos et al., 2025).

2.1 Role of Supplier Trust

Signaling theory offers a compelling explanation for how ST contributes to improved ES outcomes. Supply chains are characterized by substantial information asymmetry, as suppliers typically possess superior knowledge regarding their operational processes, environmental practices, and regulatory compliance than buyers (Connelly et al., 2011). This imbalance creates uncertainty regarding whether suppliers are genuinely committed to environmental responsibility or merely engaging in symbolic actions. ST develops when suppliers consistently emit credible and positive signals through their behaviors, disclosures, and certifications. Such signals may include transparent emissions reporting, publication of sustainability metrics, participation in environmental initiatives, and consistent adherence to environmental regulations (Mallet et al., 2022). When buyers perceive these signals as reliable, ST strengthens, leading to greater willingness to collaborate on environmental goals and coordinate sustainability-related activities (Hussain et al., 2019). In this way, ST reflects the interpretation of supplier signals and enables buyers to update expectations regarding partners' environmental commitment, thereby facilitating closer coordination (Gualandris & Kalchschmidt, 2016). Moreover, trusted suppliers are more likely to continue emitting reinforcing signals, such as engagement in eco-design, waste reduction initiatives, and circular-economy practices (Li et al., 2025; Okeke, 2025). These ongoing signals strengthen the feedback loop between ST and ES and encourage firms to invest in integrative environmental practices. Recent studies in sustainable supply chain management also confirm that relational governance mechanisms, including trust-based relationships, play a critical role in enabling environmentally responsible collaboration and performance improvement (Touboulic & Walker, 2021; Lyu et al., 2022). Accordingly, the following hypotheses are proposed:

H1: ST positively influences GSCI.

H2: ST positively influences ES.

2.2 Green Supply Chain Integration as Mediator

Although ST establishes a cooperative foundation, trust alone does not automatically translate into improved ES. Instead, ST enables firms to engage in joint investments, coordinated processes, and shared decision-making that operationalize environmental objectives across supply chain relationships. In this context, GSCI captures the extent to which environmental considerations are systematically embedded and aligned across internal functions and external partners. Through GSCI, firms move beyond isolated environmental initiatives toward coordinated supply chain-wide

practices, allowing sustainability goals to be jointly planned, implemented, and monitored. Specifically, GSCI facilitates the integration of environmental standards, shared green technologies, and collaborative routines that reduce environmental impacts through activities such as waste and rework reduction, emissions control, improved resource efficiency, and green innovation (Naz et al., 2024; Ren et al., 2024). By aligning environmental objectives across organizational boundaries, GSCI enhances process transparency and operational consistency, which are critical for achieving measurable sustainability outcomes in complex supply chains. As relational signals accumulate over time, firms become more willing to deepen green integration, invest in shared environmental capabilities, and align long-term sustainability strategies with supply chain partners (Shahzad et al., 2023). Recent empirical research provides strong support for the performance relevance of GSCI. Studies show that green integration enables firms to convert relational resources and collaborative intent into tangible environmental improvements by facilitating knowledge exchange, joint problem-solving, and coordinated environmental actions (Zhang et al., 2022). Related work also indicates that GSCI strengthens green innovation capabilities and improves environmental performance by linking internal environmental management with external supply chain coordination (Lyu et al., 2022). Furthermore, evidence from recent sustainability research confirms that GSCI acts as a critical mechanism through which relational and informational resources translate into ES outcomes, particularly in environmentally sensitive and regulation-intensive industries (Santos et al., 2025; Zhu et al., 2021; Khan et al., 2023). Therefore, building on both signaling theory and the growing empirical literature, this study examines the mediating role of GSCI in the relationship between ST and ES:

H3: GSCI positively influences ES.

H3: GSCI mediates the relationship between ST and ES.

2.3 Information Sharing as Moderator

From a signaling perspective, IS enhances the visibility and credibility of relational cues by reducing ambiguity and improving coordination among supply chain partners (Kauffman & Mohtadi, 2009). Even when ST exists, insufficient IS can constrain integration efforts because partners lack access to timely and accurate operational and environmental data (Fatima et al., 2023; Mehak et al., 2024). In contrast, when ST is accompanied by high levels of IS, supply chain partners are better positioned to coordinate complex green practices, thereby strengthening integration. Recent research highlights IS as a critical boundary condition in sustainability-related supply chain relationships. Studies show that IS strengthens the translation of relational resources into integrative capabilities and environmental performance by enabling joint planning, monitoring, and evaluation of sustainability initiatives (Lyu et al., 2022; Santos et al., 2025). Furthermore, contemporary evidence suggests that the indirect effect of relational mechanisms on sustainability outcomes varies depending on the quality and extent of IS across supply chains (Zhu et al., 2021; Khan et al., 2023). Accordingly, the indirect pathway from ST to ES through GSCI is expected to vary across levels of IS. Higher levels of IS strengthen the ST–GSCI relationship and amplify the indirect effect on ES, while lower levels of IS weaken this mechanism. Thus, the following hypothesis is proposed:

H4: The indirect effect of ST on ES through GSCI is conditional on IS, such that the mediated effect is stronger at higher levels of IS.

Figure 1 illustrates the theoretical framework of the study, depicting the mediating role of GSCI and the moderating role of IS in the relationship between ST and ES.

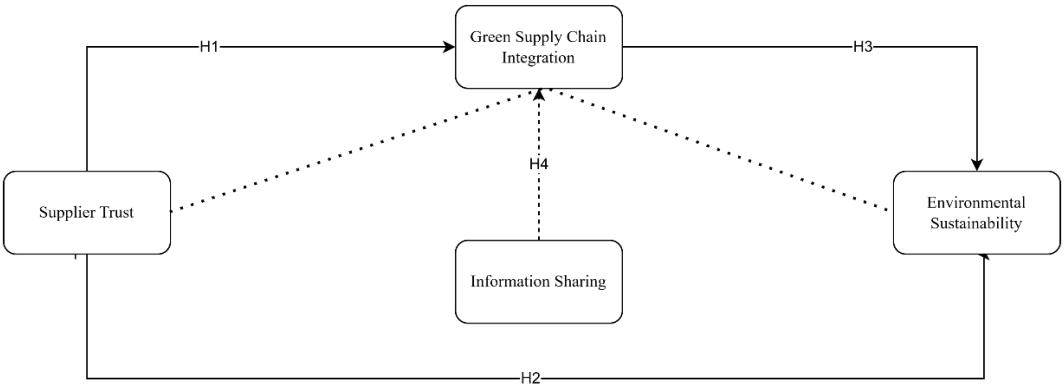

Figure 1. Framework of the study

Source(s): Authors' Own Work.

3 RESEARCH METHODOLOGY

3.1 Research Design and Context

This study employed a descriptive, cross-sectional research design to empirically examine the proposed relationships among ST, GSCI, IS, and ES. A quantitative survey approach was adopted as it is appropriate for testing theory-driven hypotheses and moderated mediation models in supply chain and sustainability research. Data were collected from pharmaceutical firms operating in the South Punjab region of Pakistan (Hair et al., 2017). The pharmaceutical sector was selected for three key reasons. First, pharmaceutical manufacturing is environmentally sensitive due to its intensive use of chemicals, energy, and packaging materials, making ES a critical managerial and regulatory concern. Second, pharmaceutical supply chains are highly dependent on upstream suppliers and information exchange, rendering relational mechanisms such as ST and IS particularly relevant. Third, the sector operates under increasing regulatory scrutiny and global quality standards, which necessitate coordinated green practices across supply chain partners. These characteristics make the pharmaceutical industry an appropriate empirical setting for testing the proposed signaling-based framework.

3.2 Population and Sampling

The target population consisted of employees working in registered pharmaceutical firms across South Punjab, Pakistan. This region hosts a significant concentration of pharmaceutical manufacturing and distribution activities, providing a suitable context for studying supply chain integration and sustainability practices. Operational- and supervisory-level employees were selected as respondents because they are directly involved in supply chain operations, supplier coordination, and environmental initiatives, and therefore possess relevant knowledge about the study constructs. A purposive sampling technique was employed to ensure that responses were obtained from individuals with adequate exposure to supply chain and environmental practices (Ghauri & Grønhaug, 2010). To determine an appropriate sample size, statistical power considerations were taken into account. Based on common guidelines for moderated mediation analysis and using G*Power principles (power = 0.80, $\alpha = 0.05$, medium effect size), a minimum sample size of approximately 200 respondents was deemed sufficient. Accordingly, a total of 250 usable responses were collected, which exceeds the recommended threshold and enhances the robustness and generalizability of the findings.

3.3 Measurement of Variables

Data were collected using a structured questionnaire comprising two sections. The first section captured demographic information, while the second section measured the four latent constructs included in the research framework. All items were assessed using a 5-point Likert scale ranging from 1 = strongly agree to 5 = strongly disagree. ST was measured using four items adapted from Qian et al. (2023). GSCI was measured using eight items adapted from Zhou et al. (2020), capturing both internal and external green integration practices. ES was measured using six items adapted from Hussain et al. (2019), reflecting improvements in resource efficiency and environmental impact reduction. IS was measured using five items adapted from Lyu et al. (2022), capturing the extent of environmental and operational information exchange among supply chain partners. All measurement scales have been validated in prior studies and are widely used in sustainability and supply chain research.

3.4 Data Collection, Ethical Considerations and Analysis

Data were collected over a six-week period using a paper-based survey. Management of the selected pharmaceutical firms was first contacted to obtain organizational consent and facilitate access to respondents. Questionnaires were distributed to eligible employees during working hours and collected upon completion. Participation in the study was voluntary, and respondents were assured of anonymity and confidentiality. Informed consent was obtained prior to data collection, and respondents were informed that the data would be used solely for academic research purposes. Ethical approval was obtained to ensure compliance with established research ethics guidelines. Data analysis was conducted in two stages. In the first stage, SPSS was used for data screening, demographic analysis, descriptive statistics, and reliability assessment. In the second stage, hypotheses were tested using the PROCESS Macro technique. Consistent with the proposed theoretical framework, PROCESS Model 7 was employed to examine the moderated mediation effect, with GSCI as the mediator and IS as the moderator. Bootstrapping procedures were used to assess indirect and conditional effects, providing robust estimates of mediation and moderated mediation relationships.

4 DATA ANALYSIS

4.1 Demographic Profile

The demographic profile of the respondents were examined in terms of gender, age, and education level. As shown in Table 1, the sample consisted of 250 respondents, of whom 35% were female (n = 88) and 65% were male (n = 162). With respect to age, the majority of respondents were between 20 and 30 years old (48%), followed by those aged 30–40 years (34%), while 18% were above 40 years of age. The educational profile indicates that the sample was relatively well educated, with 65% holding a bachelor's degree and 20% holding a master's degree. This demographic composition suggests that respondents possessed adequate educational background and professional exposure to provide informed responses regarding supply chain and environmental practices.

Table 1. Demographic Profile of Respondents (N = 250)

Variable	Category	Frequency	Percentage
Gender	Female	88	35%
	Male	162	65%
Age	20–30 years	120	48%
	30–40 years	85	34%
	40+ years	45	18%
Education	Bachelor's	163	65%
	Master's	50	20%
	Others	38	15%

Source: *Field survey.*

4.2 Descriptive Statistics and Reliability Analysis

Table 2 presents the descriptive statistics, including means, standard deviations, skewness, kurtosis, variance inflation factors (VIF), and Cronbach's alpha values. The mean values for all constructs were above the scale midpoint, indicating generally favorable perceptions among respondents. Skewness and kurtosis values fell within the acceptable range of ±3, suggesting that the data approximated normal distribution. Multicollinearity diagnostics revealed that all VIF values were below the conservative threshold of 5, indicating no multicollinearity concerns. Reliability analysis showed that Cronbach's alpha values for all constructs exceeded the recommended threshold of 0.70, demonstrating satisfactory internal consistency.

Table 2. Descriptive Statistics, Reliability, and Multicollinearity

Variable	Mean	SD	Skewness	Kurtosis	VIF	Cronbach's α
ST	4.08	0.42	0.18	–0.35	2.10	0.717
IS	3.97	0.38	–0.12	0.49	1.85	0.871
GSCI	4.12	0.44	0.25	0.62	2.55	0.803
ES	4.05	0.40	–0.08	–0.28	1.98	0.946

Note. *VIF = Variance Inflation Factor. Source. Authors' calculations using SPSS.*

4.3 Correlation and Regression Analysis

Table 3 presents the Pearson correlation matrix along with regression results used to test the direct hypotheses. As shown, all study variables are positively and significantly correlated, providing preliminary support for the proposed relationships. The strongest correlation is observed between GSCI and ES ($r = .676$, $p < .001$), suggesting that higher levels of green supply chain integration are strongly associated with improved environmental sustainability outcomes.

Regression analysis was conducted to formally test the hypotheses. The results indicate that ST has a significant positive effect on GSCI ($\beta = .515$, $t = 9.470$, $p < .001$), supporting H1. This finding suggests that higher levels of supplier trust are associated with stronger green supply chain integration. Furthermore, ST also exhibits a significant positive relationship with ES ($\beta = .370$, $t = 6.268$, $p < .001$), providing support for H2 and indicating that trust-based supplier relationships contribute directly to environmental sustainability outcomes. Similarly, GSCI has positive impact in ES, which support the H3 of the study. In addition, GSCI shows a strong and significant positive effect on ES ($\beta = .676$, $t = 14.441$, $p < .001$), supporting H4. This result highlights the central role of green supply chain integration in translating relational resources into tangible environmental performance improvements. Overall, the correlation and regression

result jointly suggest that while ST directly enhances ES, its influence is substantially strengthened through the development of integrated green supply chain practices.

Table 3. Correlation Matrix and Regression Results

Variables	1	2	3	4	Hypothesized Path	β	t-value	p-value
1. ST	1				ST → GSCI	.515	9.470	< .001
2. GSCI	.515***	1			ST → ES	.370	6.268	< .001
3. IS	.334***	.531***	1		GSCI → ES	.676	14.441	< .001
4. ES	.370***	.676***	.501***	1	IS → GSCI	.531	9.863	< .001

Note. ****p < .001. Pearson correlation coefficients are reported below the diagonal. Standardized regression coefficients (β) are reported. Source. Authors' calculations using SPSS.*

4.4 Moderated Mediation Analysis

Moderated mediation analysis was conducted using PROCESS Model 7 with 5,000 bootstrap samples to test H4. Table 4 presents the results in two panels. Panel A reports the effects of ST, IS, and their interaction on GSCI, while Panel B reports the conditional indirect effects of ST on ES through GSCI at different levels of IS. The results in Panel A indicate that ST (β = .6047, p < .001) and IS (β = .5671, p < .001) both have significant positive effects on GSCI. The interaction term between ST and IS is positive and marginally significant (β = .0875, p = .071), suggesting that IS strengthens the relationship between ST and GSCI. Panel B shows that the indirect effect of ST on ES via GSCI is significant at low, medium, and high levels of IS, with the magnitude of the indirect effect increasing as IS increases. Moreover, the index of moderated mediation is significant, confirming that the indirect effect varies systematically across levels of IS. These findings provide support for the proposed moderated mediation hypothesis H5.

Table 4. Moderated Mediation Results (PROCESS Model 7)

Panel A: Effects on GSCI (Mediator Model)				Panel B: Conditional Indirect Effects (ST → GSCI → ES)		
Predictor	Coefficient	SE	p-value	IS Level	Indirect Effect	95% CI
ST	.6047	.1511	< .001	Low (2.37)	0.2353	[0.1032, 0.3682]
IS	.5671	.1570	< .001	Medium (3.21)	0.3050	[0.2106, 0.4101]
ST × IS	.0875	.0482	.071	High (4.06)	0.3748	[0.2709, 0.4855]

Note. *Bootstrap sample = 5,000; CI = 95%.* ***Source****. Authors' calculations using PROCESS Macro.*

Figure 2 visually illustrates the moderated mediation effect, showing that the indirect effect of ST on ES through GSCI increases progressively from low to high levels of IS. This pattern indicates that higher levels of information sharing strengthen the mediating role of GSCI, consistent with the proposed theoretical framework.

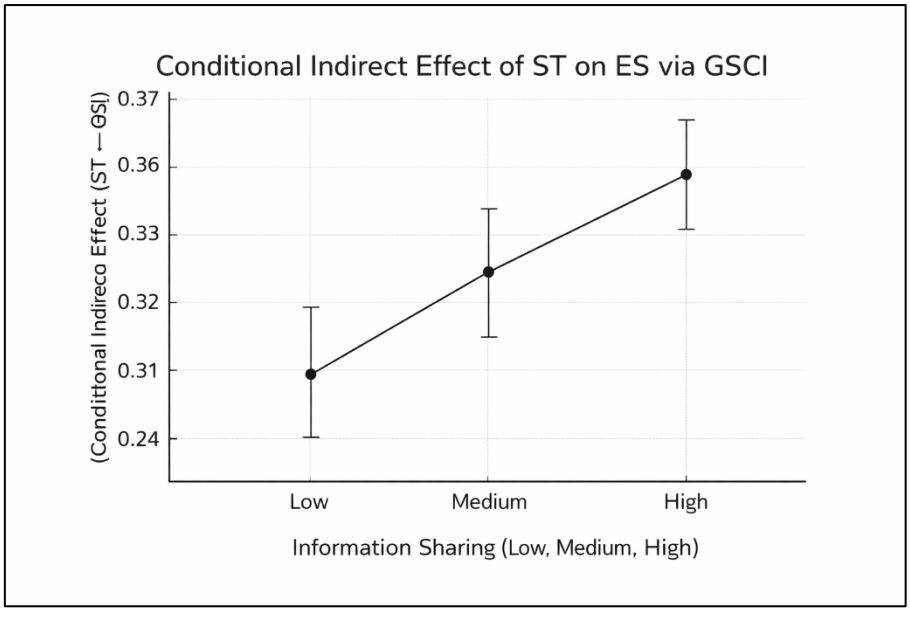

Figure 2. *Interaction plot showing the conditional indirect effect of ST on ES via GSCI across levels of IS.*
Note. *The figure illustrates that the indirect effect increases steadily as IS moves from low to high levels, indicating stronger mediation at higher levels of information sharing.*

5 DISCUSSION AND IMPLICATIONS

5.1 Discussion of Results

The primary objective of this study was to examine how supplier trust influences firms' ES outcomes through GSCI, and whether information sharing conditions the strength of this indirect relationship under the lens of signaling theory. To address these objectives, cross-sectional data were collected from 250 employees working in pharmaceutical firms using a purposive sampling approach, and the proposed relationships were tested using a moderated mediation framework (PROCESS Model 7). The results provide strong empirical support for the proposed model. First, supplier trust was found to have a significant positive effect on both GSCI and ES. This finding aligns with long-standing theoretical arguments in supply chain and interorganizational relationship research, which suggest that trust reduces relational uncertainty and encourages firms to engage in coordination, goal alignment, and resource-sharing behaviors that facilitate integration (Uddin et al., 2025). In the context of environmentally sensitive industries such as pharmaceuticals, this trust-based relational climate appears to translate into improved environmental outcomes by lowering transaction frictions and enabling the adoption of more complex and collaborative green practices. These findings are consistent with prior empirical evidence reported by Zhang et al. (2022).

The study further demonstrates that GSCI plays a central mediating role in the relationship between supplier trust and ES. The positive association between GSCI and ES indicates that coordinated environmental activities across supply chain partners enhance sustainability performance. Integrated green processes—such as shared environmental standards, synchronized green operations, and jointly developed eco-solutions—improve transparency, reduce waste, and enable firms to respond more effectively to regulatory and market pressures. These results reinforce recent findings suggesting that GSCI serves as a critical mechanism through which relational resources are transformed into tangible environmental improvements (Santos et al., 2025).

Moreover, information sharing was found to significantly condition the indirect relationship between supplier trust and ES, highlighting that trust alone is insufficient to unlock higher levels of green integration. Instead, trust must be complemented by transparent, timely, and reliable information exchange to translate relational intent into coordinated green action (Naz et al., 2024; Zhang et al., 2024). When information sharing is high, trust functions as a stronger signal of commitment and openness, prompting supply chain partners to engage in deeper integration. Conversely, when information sharing is limited, the positive effect of trust on integration weakens, suggesting that trust without actionable information is unlikely to foster effective cross-organizational environmental coordination. These findings are consistent with signaling theory, which emphasizes that signals must be observable and credible to influence partner behavior (Li et al., 2017) and align with recent empirical evidence reported by Santos et al. (2025).

5.2 Research Implications

This study offers several important theoretical and practical implications. From a theoretical perspective, the study extends signaling theory into the domain of green supply chain management, where it has been relatively underexplored compared to its application in marketing and organizational research. By demonstrating how supplier trust and information sharing jointly function as relational and informational signals, the study provides a nuanced explanation of how sustainability outcomes are shaped in interorganizational contexts. Second, the findings clarify the antecedents of GSCI. While prior research has often treated GSCI as a structural or capability-driven construct, the results highlight that relational factors—particularly supplier trust supported by effective communication—are foundational to the emergence of green integration. Integration is not an automatic outcome of technical capabilities; rather, it is socially constructed through cooperative norms, transparency, and shared understanding between supply chain partners. Finally, the study contributes to sustainability theory by demonstrating a conditional mediation mechanism. The moderated mediation framework shows that the influence of supplier trust on ES is not merely direct or indirect through GSCI, but contingent upon the level of information sharing. This insight adds depth to existing theories by illustrating how and when relational signals translate into sustainability outcomes.

5.3 Managerial Implications and Recommendations

The findings offer several practical recommendations for managers and supply chain decision-makers. First, firms should invest in long-term, partnership-oriented relationships with suppliers by promoting transparent communication, fair contracting practices, and consistent performance feedback. Trust-based relationships reduce coordination costs, encourage early disclosure of environmental challenges, and enhance suppliers' willingness to collaborate on sustainability initiatives. Second, managers should prioritize the development of robust information-

sharing systems. Implementing digital platforms and structured reporting mechanisms that enable real-time sharing of data related to emissions, waste, resource usage, and regulatory compliance can significantly enhance green collaboration. Standardized data-sharing protocols allow firms to identify inefficiencies more quickly and support joint decision-making grounded in reliable information. Third, firms can improve environmental performance by actively integrating suppliers into green product design, cleaner production planning, and eco-friendly logistics initiatives. Co-developing green materials, sustainable packaging, and waste management systems fosters shared accountability and generates measurable sustainability gains. Regular environmental audits and supplier capability-building initiatives—such as training programs, cleaner technology adoption, and waste-reduction workshops—can further strengthen compliance while cultivating a culture of continuous environmental improvement.

6 STUDY CONCLUSION

This study demonstrates that supplier trust enhances environmental sustainability both directly and indirectly through green supply chain integration, and that this indirect effect is contingent upon the level of information sharing. The findings underscore the importance of relational attributes, such as trust, and transparent communication in enabling effective green supply chain integration. By framing these relationships through signaling theory, the study provides a more nuanced understanding of how firms mobilize interorganizational relationships to achieve sustainability objectives. Despite its contributions, the study has several limitations that offer avenues for future research. First, the use of cross-sectional data limits causal inference. Future studies could employ longitudinal or experimental designs to validate the causal ordering implied in the moderated mediation framework. Second, expanding the sample size or conducting multi-country studies would enhance the generalizability of the findings. Examining other sectors, such as manufacturing, textiles, or services, may also provide valuable comparative insights. Finally, future research could extend the model by examining specific types of information sharing—such as environmental performance indicators, life-cycle assessments, or digital traceability systems—to identify which signals most strongly shape the relationship of supplier trust and GSCI.

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