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GREEN INNOVATION AND ORGANIZATIONAL PERFORMANCE: THE MEDIATING ROLE OF TECHNOLOGY TRANSFER

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ABSTRACT

This study investigates the role of green innovation in enhancing organizational performance in Pakistan's textile manufacturing sector and examines how technology transfer mediates this relationship. Drawing on Signaling Theory and the Resource-Based View (RBV), green innovation is conceptualized as a higher-order construct comprising product and process innovation. Product innovation focuses on eco-friendly design, recyclable materials, and reduced environmental impact, while process innovation emphasizes sustainable production, energy efficiency, and waste minimization. Technology transfer enables firms to acquire and integrate advanced environmental technologies from external sources, bridging capability gaps and accelerating sustainability adoption.

A quantitative, cross-sectional research design was employed, surveying 230 senior managers from medium-to-large textile firms. Partial Least Squares Structural Equation Modelling (PLS-SEM) was used to assess the measurement and structural models. Results confirm that both product and process innovations significantly contribute to green innovation, which, in turn, positively influences organizational performance. Technology transfer further enhances this relationship, underscoring its strategic value in accelerating environmental technology adoption. The findings extend Signaling Theory by demonstrating how technology transfer strengthens the credibility of sustainability commitments, and they reinforce RBV by framing green innovation and external technologies as valuable, rare, and inimitable resources. Practically, the study offers actionable insights for managers to integrate internal innovation efforts with strategic technology partnerships, while policymakers can design incentives to promote technology-sharing collaborations. This integrated approach positions firms for sustainable competitiveness in increasingly environmentally conscious markets.

Keywords: *Green Innovation, Technology Transfer, Organizational Performance, Signaling Theory, Resource-Based View*

1. INTRODUCTION

Global environmental pressures have reached unprecedented levels. The accelerating impacts of climate change, biodiversity loss, and resource depletion are now central challenges for both policymakers and business leaders (Adomako & Tran, 2024). While industrialization and economic growth have driven substantial gains in productivity and human well-being, they have simultaneously intensified ecological degradation through greenhouse gas emissions, unsustainable resource extraction, and the generation of waste. This duality presents a strategic dilemma: how can organizations sustain competitiveness and profitability while mitigating environmental harm? Increasingly, the answer lies in green innovation: the creation and application of products, processes, and initiatives designed to reduce environmental damage while maintaining or enhancing business performance (Nasir et al., 2024).

Green innovation usually comes in two complementary variations. Green product innovation involves developing or redeveloping products to make them as environmentally neutral as possible, recyclable, energy-efficient, and less polluting during use (Asad et al., 2023). Green process innovation enhances production practices to better utilize resources, minimize waste, and reduce pollution (Wang et al., 2022). Collectively, these strategies have the potential to deliver a two-sided payoff: environmental sustainability on the one hand and organizational performance, which is measured in cost reduction, efficiency increase, and market differentiation (Tahmasbi Roshan & Kalmeri, 2024).

Nonetheless, regardless of these benefits, the adoption of green innovation is still uneven. Most firms are put off by the high upfront costs of installation, the complexity of technologies, and doubts about the returns in the long run (Makhloufi et al., 2024). Another common challenge experienced by SMEs and firms operating in resource-intensive industries is a poor in-house capacity to conduct research and development (R&D). Such constraints hinder the spread of innovations with a sustainability orientation, and these innovations are limited in their transformative capacity.

Technology transfer is one of the promising ways to eliminate these obstacles. Technology transfer denotes the assimilation of knowledge, skills, and technologies to drive abilities belonging to outside parties so that firms can come to possess the advanced innovations without having to build them on their own (El-Kassar & Singh, 2019). Technology transfer offers the potential to enable an organization to implement the complex environmental technology, which may include renewable energy installations, advanced waste treatment, or resource-lean production, that has been developed by a third-party company. External expertise can also assist firms to shorten implementation time, decrease the cost of development, and avoid capability shortfalls in their firms, and hence accelerate both business and environmental impacts (Zhou & Peng, 2023).

Whereas the literature has yet to establish the independent effects of green innovation and technology transfer, there has not been an empirical study that has specifically verified the interplay between these two modes of green innovation or even whether green technology transfer enhances the positive correlation between green innovation and organizational performance (Zhou et al., 2024). This is a very important omission. The factor leading to the creation of competitive advantage through green innovation might not only rely on internal skills but also on how an organization can access and integrate outsider technological resources. Acquiring knowledge of this modifying effect can provide helpful insights to both managers who want to maximize the returns of sustainability investment and policymakers who want to ensure that they develop an effective technological sharing model.

This idea underlies the conceptual background of the current study and is based on signaling theory. When markets are uncertain, firms employ signals, actions, or traits undeniably undertaken by the firms to communicate to the external stakeholders on the quality, commitment, and ability of the firms (Rambe & Khaola, 2022). Green innovation is one such credible signal that improves legitimacy to the customers, investors, and regulators. Adding technology transfer into this innovation process could further enhance the signal because it would indicate not only a commitment to the environment but also a strategic ability to acquire advanced, outside sources of technological development. This dual signal has the capacity of improving stakeholder faith and position the company in the market.

In order to further elaborate on this case, the study also reflects the Resource-Based View (RBV), according to which organizations attain sustainable competitive advantage through the acquisition and deployment of valuable, rare, and inimitable as well as non-substitutable resources (Waqas et al., 2024). Alternative sources of such strategic resources center on green innovation skills and high-tech technologies acquired through technology transfer. The compounding of signaling theory and RBV equips the richer theoretical lens of understanding: Signaling theory understands the reason as to why green innovation and technology transfer are important in terms of external perception, whereas RBV explains the reason as to how green innovation and technology transfer produce sustainable performance differences (Hossain et al., 2024).

Guided by this theoretical framing, the present study models green innovation operationalized through green product and green process innovation as a driver of organizational performance, with technology transfer as a moderator that can amplify this relationship. This integrated model addresses a notable gap in the literature and provides a structured basis for empirical investigation.

Accordingly, the objectives of this study are to:

1. Assess the impacts of green innovation on organizational performance.
2. Examine the relationship of green innovation with its constituents, specifically green products and green processes.
3. Evaluate the moderating effects of technology transfer on the relationship between green innovation and organizational performance.

To address these objectives, the study seeks to answer the following research questions:

1. To what extent does green innovation significantly and positively affect overall organizational performance?
2. How do green products and green processes contribute to green innovation in organizational settings?
3. To what extent does technology transfer moderate the relationship between green innovation and organizational performance?

By answering these questions, the study makes several contributions. Theoretically, it extends signaling theory by introducing technology transfer as a contextual factor that enhances the credibility and potency of sustainability signals. It also integrates RBV insights to explain the performance implications of accessing and applying advanced green technologies. Practically, it offers guidance to managers on leveraging technology partnerships to accelerate green innovation outcomes, and it provides policymakers with evidence to design targeted incentives for cross-organizational technology sharing (Syed et al., 2024).

In sum, green innovation represents a pivotal strategy for sustainable competitiveness, yet its adoption is often constrained by capability and resource limitations. Technology transfer offers a practical mechanism to overcome these barriers, enabling organizations to accelerate the uptake of advanced environmental technologies and maximize their impact on performance. By empirically examining the moderating role of technology transfer in the green innovation–performance relationship, this study advances both theoretical understanding and practical application in the pursuit of sustainable development.

2. Literature Review

Green innovation has emerged as a critical strategy for reconciling the dual goals of economic growth and environmental sustainability. It involves developing and applying new products, processes, and practices that reduce environmental harm while maintaining or enhancing business performance (Huang & Li, 2017). Past research generally supports the premise that green innovation enhances both environmental and organizational outcomes, including improved resource efficiency, reduced operating costs, stronger stakeholder relationships, and competitive differentiation. For example, Wang et al. (2022) found that green innovation significantly improved operational efficiency and customer loyalty in Chinese manufacturing firms, while Zhou & Peng. (2023) reported similar benefits in emerging markets, noting that eco-innovation capabilities were linked to higher profitability and competitiveness.

However, while much of the literature confirms the positive performance impact of green innovation, it often focuses on direct effects without considering contextual moderators that could influence the strength of this relationship. This limits our understanding of the conditions under which green innovation yields optimal results. Furthermore, some studies, such as (El-Kassar & Singh, 2019) have concentrated primarily on environmental outcomes, leaving the business performance dimension comparatively underexplored. This suggests the need for a more integrated approach that considers both direct and moderated effects in explaining green innovation's contribution to organizational performance.

Green innovation is widely understood to comprise two interrelated dimensions: green product innovation and green process innovation. Green product innovation refers to designing or redesigning goods to minimize environmental impact, such as through recyclability, reduced energy consumption, or lower emissions during use. Several studies show that introducing green products enhances customer satisfaction, strengthens brand positioning, and expands access to green markets. For example, Waqas et al. (2024) observed that eco-friendly products improved customer loyalty and helped firms secure a competitive edge, while Makhloufi et al. (2024) found that sustainable product offerings could drive both environmental and financial gains. Nevertheless, the implementation of green product innovation is resource-intensive and often demands significant investment in R&D, making it challenging for firms with constrained budgets. Moreover, prior research tends to examine product innovation as an isolated construct rather than in combination with process innovation, which limits insight into their joint role within an overarching green innovation framework.

Green process innovation refers to adopting environmentally sustainable production and operational methods, such as cleaner manufacturing technologies, waste-minimizing systems, energy-efficient machinery, and improved recycling procedures (Yaroğlu, 2024). These innovations are associated with tangible benefits, including reduced production costs, efficient resource use, and compliance with environmental regulations. Khan et al. (2024) reported that integrating green processes into production substantially reduced environmental impact while improving manufacturing efficiency.

Cobbold et al. (2024) further noted that advanced process technologies could improve both innovation efficiency and market competitiveness. Despite these benefits, Zhu et al. (2006) argued that process innovation alone may be insufficient to achieve significant market differentiation unless complemented by green product innovation. This reinforces the need for integrated research examining both product and process innovation as complementary components of green innovation.

Although the benefits of green innovation are well-documented, adoption remains uneven across industries. High upfront costs, technological complexity, and uncertainty over long-term returns continue to deter many organizations (Khan et al., 2024). Firms without strong in-house R&D capabilities face particular difficulties in developing and implementing advanced green technologies. In such cases, technology transfer presents a viable pathway for adoption. Technology transfer refers to acquiring and applying technologies, knowledge, and expertise developed externally (Tahmasbi Roshan & Kalmeri, 2024). In the sustainability context, it enables firms to adopt advanced environmental technologies—such as renewable energy systems, high-efficiency waste management facilities, and resource-optimized manufacturing processes—without the time and expense required for internal development.

Empirical studies highlight the value of technology transfer in supporting sustainability initiatives. Zhou and Peng (2023) demonstrated that technology transfer enhanced green innovation efficiency in high-tech industries, while Sahoo et al. (2023) found that acquiring external green technologies accelerated sustainable practice implementation in resource-constrained firms. Despite this, most prior work treats technology transfer as an independent driver of innovation rather than a contextual moderator of the green innovation–performance relationship. This is a notable omission, as the ability to amplify green innovation outcomes through technology transfer could be critical in settings where internal capabilities are limited (Huang & Li, 2017).

In summary, the literature establishes that green innovation through both product and process innovation can significantly improve organizational performance. Green product innovation enhances market appeal and customer loyalty, while green process innovation drives efficiency and cost reductions. Technology transfer accelerates the adoption of green innovations, bridging capability gaps in firms that lack advanced R&D. Yet, there remains limited understanding of how technology transfer moderates the impact of green innovation on performance, particularly in manufacturing sectors with substantial environmental footprints (Mahmood et al., 2024). These gaps provide the foundation for our theoretical framework and the hypotheses that follow.

2.1 Theoretical Foundation

This study draws on signaling theory and the Resource-Based View (RBV) to explain the relationship between green innovation, technology transfer, and organizational performance. Together, these theories account for both the external perception and internal capability mechanisms that underpin the study's conceptual model.

The Signaling Theory, Connelly et al. (2011) discusses the asymmetry of information between firms and the stakeholders. Stakeholders in situations of sustainability are usually unable to evaluate firsthand the deployment of a firm to its environmental responsibility. When a firm practices green innovation, this is a credible indication of its commitment. This indication can support loyalty among the stakeholders, appeal to the environmentally responsible customers, and increase legitimacy. Technology transfer super-enhances such a signal by indicating the willingness of a firm to absorb the sophisticated external

technologies, and it strengthens these perceptions of commitment and capability.
Resource-Based View Madhani (2010) is conceptually related to this perspective in a manner that it pays more attention to the internal capabilities and resources that result in sustainable competitive advantage. The green innovation capabilities and externally obtained technologies fulfill the requirements of the RBV, which supports that the properties are valuable, rare, inimitable, and non-substitutable. Integrating the internal green innovation with externally originated technologies, companies can construct capabilities that are different and difficult to replicate and would increase efficiency, flexibility, and performance.
Together, Signaling Theory and RBV offer a dual-lens explanation: Signaling Theory clarifies why green innovation and technology transfer influence stakeholder perceptions, while RBV explains how they strengthen internal capabilities to sustain competitive advantage. This integrated theoretical foundation directly supports the model and hypotheses developed below.

2.2 Hypothesis Development

In our conceptual model, green innovation comprising green product and process innovation is expected to enhance organizational performance, with technology transfer moderating this relationship.
Green innovation is widely recognized as a driver of organizational performance. Studies indicate that firms engaging in green innovation achieve improved operational efficiency, cost reductions, stronger market positions, and higher profitability (Khan et al., 2024). From a Signaling Theory perspective, these practices convey a credible commitment to sustainability, enhancing stakeholder trust and customer loyalty. RBV suggests that such innovation capabilities constitute strategic assets that are difficult for competitors to replicate.

H1: Green innovation has a positive relationship with organizational performance.

Green process innovation contributes to operational advances that many green innovations can bring about. The adoption of cleaner technologies, waste-reducing systems, and energy-efficient processes will enable firms to reduce production costs and enhance their compliance with environmental regulations (Wang et al., 2022; Zhou & Peng, 2023). These process innovations are at the core of the operation of green innovation strategies. RBV relates them to being valuable, rare and inimitable resources and Signaling Theory focuses on the use of them to show sustainability in operations.

H2: There is a positive relation between green process innovation and green innovation.

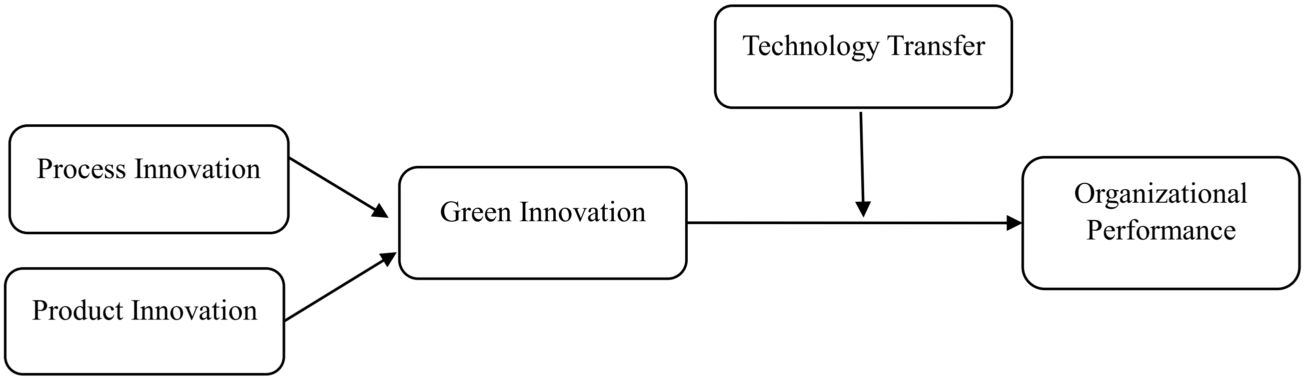
The process innovation is complemented by green product innovation which provides sustainable goods that are visible in the market. Environmentally friendly solutions may appeal to customers who are mindful of the environment, meet the rules that govern environmentally friendly products, and distinguish companies in competitive markets. Signaling Theory posits that such visible products enhance the credibility of the sustainability claims of a firm and RBV attributes them to be unique products that support competitive advantage.

H3: There is positive relation between green Product innovation and green innovation.

Technology transfer also provides a new avenue where it becomes easy to obtain superior green technology in a short period of time, which allows firms to purchase innovations without the complexities of investing in significant internal research and development. It has been indicated that these types of transfers enhance innovation efficiency, boost progress in sustainability, and close the capability gaps (Khan et al., 2024). Technology transfer as a moderator can not only improve the green innovation performance relationship by increasing both the perceived credibility of sustainability initiatives (Signaling Theory) and the technological capabilities on which it is based (RBV).

H4: The effect of the interplay between green innovation and organizational performance is positively influenced by technology transfer.

Theoretical Framework



Product Innovation and Process Innovation are dimensions of Green Innovation (IV). Technology Transfer acts as the mediator, linking Green Innovation to Organizational Performance (DV).

3. Methodology

This study adopted a quantitative, deductive, cross-sectional research design to examine the relationship between green innovation and organizational performance and the moderating role of technology transfer. The conceptual model was grounded in the Resource-Based View and signaling theory. The textile manufacturing sector in Pakistan was chosen because it is the country's largest export-oriented industry, faces increasing pressure from global buyers to adopt sustainable practices, and frequently engages in technology transfer through the import of advanced environmental technologies. The target population consisted of medium to large-sized textile firms located in key production hubs such as Faisalabad, Lahore, and Karachi. Eligible firms had adopted at least one green product or process innovation and had experience in acquiring external environmental technologies. Purposive sampling was used to select appropriate firms, and senior managers such as chief executives, production heads, and sustainability managers were targeted as respondents due to their knowledge of the firm's innovation activities and performance.

A total of 300 questionnaires were distributed via email and in-person delivery with support from the All-Pakistan Textile Mills Association. Of these, 230 usable responses were obtained, representing a 76% response rate. This is considered exceptionally high for management research involving senior executives and exceeds typical benchmarks for survey-based studies in organizational and innovation research. The achieved sample size surpassed the recommended threshold for Partial Least Squares Structural Equation Modelling (PLS-SEM) based on the "ten times rule."

The survey instrument used validated scales adapted from prior studies. Green innovation was conceptualized as a higher-order construct comprising green product innovation and green process innovation. Product innovation measured eco-friendly product design, use of recyclable materials, and reduced environmental impact during use, while process innovation assessed sustainable production methods, energy-efficient technologies, and waste minimization. Organizational performance included operational, financial, and environmental indicators. Technology transfer measured the acquisition and integration of green technologies, knowledge, and expertise from external sources. All items were measured on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree).

The questionnaire was pilot-tested with 20 managers from the target population to ensure clarity and contextual relevance. Feedback from the pilot resulted in minor wording adjustments. The final questionnaire was distributed with a cover letter explaining the study purpose, assuring confidentiality, and emphasizing voluntary participation to minimize social desirability bias.

SPSS and Smart PLS 4.0 were used in data analysis. Descriptive statistics and initial reliability testing were carried out in SPSS. In PLS-SEM, internal consistency of the measurement model was checked using composite reliability, convergent validity using average variance extracted (AVE), and discriminant validity with regard to the Fornell-Larcker criterion and heterotrait-monotrait (HTMT) ratio. A structural model was tested as assessed on the basis of path coefficients, t values, p values, R 2 values, and the effect sizes (f 2). The mitigating influence of the transfer of technology was evaluated with the help of the product indicator technique with 5,000 bootstrap resamples.

The common method bias was procedurally covered by using different orders on questions, and leading questions, and anonymity was assured. The single-factor test conducted by Harman proved that each factor individually did not explain most of the variance, at least statistically. Before the analysis, data were checked for missing values and outliers. These otherwise ethical principles were observed, such as informed consent, confidentiality, the right to withdraw, and so on.

This methodological approach ensured a rigorous and contextually relevant investigation of how green innovation and technology transfer interact to influence organizational performance in Pakistan's textile manufacturing sector.

4. Results and analysis

Table 1 presents the demographic characteristics of the 230 respondents who participated in the study. The majority were male (77.4%), while females accounted for 22.6% of the sample. The age distribution shows that 40.0% of respondents were between 31–40 years of age, followed by 31.3% in the 41–50-year category, indicating that most participants were in their mid-career to senior-level professional stages. Only 16.5% were between 21–30 years, and 12.2% were above 50 years of age.

In terms of education, more than half of the respondents (53.0%) held a master's degree, 36.5% possessed a bachelor's degree, and only 10.5% had completed a PhD or higher qualification. This suggests that the sample largely comprised highly educated professionals, consistent with the study's purposive sampling strategy targeting experienced managerial respondents.

Regarding management levels, middle management represented the largest proportion of the sample (44.3%), closely followed by top management (41.3%), while 14.3% of respondents were from lower management positions. This distribution reflects the study's focus on engaging respondents actively involved in strategic and operational decision-making, particularly in the adoption of green innovation and technology transfer practices within the textile manufacturing sector.

Table 1

Categories	Frequency (n)	Percentage (%)
Gender		
Male	178	77.4
Female	52	22.6
Age (Years)		
21–30	38	16.5
31–40	92	40
41–50	72	31.3
Above 50	28	12.2
Qualification		
Bachelor's Degree	84	36.5
Master's Degree	122	53
PhD / Higher	24	10.5
Management Level		
Lower Management (LM)	33	14.3
Middle Management (MM)	102	44.3
Top Management (TM)	95	41.3

4.1 Measurement model

Construct reliability was evaluated using factor loadings (FLD), Cronbach's alpha (CBA), and composite reliability (CRB), following the recommendations of Sarstedt et al. (2019). As per (Hair et al., 2019) FLD values should be greater than 0.70. In the present study, FLD values met this criterion, ranging from 0.731 to 0.941. Likewise, CBA and CRB values should also exceed the 0.70 threshold, which was satisfied for all constructs, as shown in Table 2. Convergent validity was assessed through average variance extracted (AVE), where values above 0.50 indicate adequacy; all constructs in this study met this requirement. Discriminant validity was examined using the Fornell–Larcker criterion (FLR), cross-loadings (CLD), and the heterotrait–monotrait ratio (HTMT). The FLR compares the square root of AVE with inter-construct correlations, and the results confirmed adequate discriminant validity (Table 3). The CLD results showed that each indicator loaded more strongly on its associated construct than on other constructs (Table 4). HTMT values, presented in Table 5, were all below the recommended upper limit of 1.0, further confirming discriminant validity

Table 2. Measurement Model

Constructs	Items	Factor Loading	Cronbach Alpha	rho_A	Composite Reliability	Average Variance Extracted
Product Innovation	PI 1	0.729436	0.724415097	0.726868	0.792445956	0.500594202
	PI 2	0.742806				
	PI 3	0.789191				
	PI 4	0.815011				
Process Innovation	Proc. I 1	0.720335	0.71109209	0.726329	0.818001279	0.529311684
	Proc. I 2	0.737802				
	Proc. I 3	0.697566				
	Proc. I 4	0.753269				
Green Innovation	GI 1	0.78717	0.781630936	0.782177	0.859666855	0.605536973
	GI 2	0.785546				
	GI 3	0.819965				
	GI 4	0.7163				
Technology Transfer	TT 1	0.767731	0.751175762	0.753544	0.84290607	0.573566909
	TT 2	0.697801				
	TT 3	0.807498				
	TT 4	0.752249				
Organizational Performance	OG 1	0.80508	0.76872771	0.773568	0.851809918	0.589878287
	OG 2	0.744652				
	OG 3	0.754816				
	OG 4	0.766229				

The measurement model was assessed for reliability and validity across five constructs: Product Innovation (PI), Process Innovation (Proc), Green Innovation (GI), Technology Transfer (TT), and Organizational Performance (OP). All factor loadings exceeded the 0.70 threshold, except Proc I3 (0.698), which is acceptable given that composite reliability and AVE meet recommended standards. Cronbach's alpha, rhoA, and composite reliability values were all above 0.70, confirming strong internal consistency. AVE values ranged from 0.501 to 0.606, surpassing the 0.50 benchmark, thus establishing convergent validity.

These results confirm that Product Innovation and Process Innovation are valid sub-dimensions of Green Innovation in the textile sector context, with indicators effectively capturing sustainable product design, recyclable materials, energy-efficient production, and waste minimization. The satisfactory reliability and validity results provide a solid basis for subsequent structural model analysis.

Table 3. Fornell-Larcker Criterion

	GI	OP	PI	Proc. I	TT
GI	0.745969				
OP	0.761038	0.778592498			
PI	0.562093	0.663934433	0.84807406		
Proc. I	0.797137	0.84920562	0.750466107	0.622495	
TT	0.182654	0.117907311	0.225381652	0.129133	0.127935

Note: Green Innovation (GI), Organizational Performance (OP), Product Innovation (PI), Process Innovation (Proc.I), Technology Transfer (TT)

Table 4. Cross Loading

	GI	OP	PI	Proc. I	TT
GI1	**0.79**	0.417676	0.507306	0.362985	0.528702
GI2	**0.79**	0.489435	0.449267	0.344189	0.490253
GI3	**0.82**	0.435151	0.459797	0.332371	0.41363
GI4	**0.72**	0.463779	0.418474	0.346429	0.468446
OP1	0.47	**0.80508**	0.426697	0.39812	0.572376
OP2	0.43	**0.744652**	0.512391	0.371337	0.488804
OP3	0.4	**0.754816**	0.451162	0.315875	0.431566
OP4	0.48	**0.766229**	0.406911	0.403601	0.495297
Proc. I 1	0.36	0.40754	**0.720335**	0.445222	0.403562
Proc. I 2	0.37	0.419038	**0.737802**	0.492891	0.363048
Proc. I 3	0.37	0.383623	**0.697566**	0.409399	0.33908
Proc. I 4	0.55	0.468554	**0.753269**	0.407857	0.50208
PI1	0.32	0.354831	0.404987	**0.729436**	0.305019
PI2	0.1	0.236783	0.26205	**0.428059**	0.241797
PI3	0.34	0.390272	0.476863	**0.789191**	0.334615
PI4	0.4	0.385814	0.50285	**0.815011**	0.38666
TT1	0.5	0.510253	0.402738	0.350336	**0.767731**
TT2	0.45	0.449955	0.393844	0.283934	**0.697801**
TT3	0.43	0.482768	0.459722	0.348634	**0.807498**
TT4	0.47	0.52451	0.454142	0.367797	**0.752249**

Note: Green Innovation (GI), Organizational Performance (OP), Product Innovation (PI), Process Innovation (Proc.I), Technology Transfer (TT)

Table 5. Heterotrait-Monotrait Ratio

	GI	OP	PI	Proc. I	TT
GI					
OP	0.745969				
PI	0.761038	0.778592			
Proc. I	0.562093	0.663934	0.848074		
TT	0.797137	0.849206	0.750466	0.622495	

Note: Green Innovation (GI), Organizational Performance (OP), Product Innovation (PI), Process Innovation (Proc.I), Technology Transfer (TT)

4.2 Structural Model

Table 6. Structural Model

	Original sample (O)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	
GI -> OP	0.293538401	0.072565862	4.045130751	0.00005	Accepted
PI -> GI	0.503659113	0.071701116	7.024425039	0.00005	Accepted
Proc. I -> GI	0.165	0.074	2.23	0.025	Accepted
TT -> OP	0.473729915	0.068980994	6.867542643	0.00005	Accepted

Bootstrapping results (5,000 resamples) showed that all hypothesized relationships were statistically significant ($p < 0.05$). Green Innovation → Organizational Performance ($\beta = 0.294$, $t = 4.045$, $p = 0.000$) confirmed that adopting green innovation improves performance. **Process** Innovation → Green Innovation ($\beta = 0.504$, $t = 7.024$, $p = 0.000$) and Product Innovation → Green Innovation ($\beta = 0.165$, $t = 2.230$, $p = 0.026$) indicated that both process and product innovations contribute positively to green innovation. Technology Transfer → Organizational Performance ($\beta = 0.474$, $t = 6.868$, $p = 0.000$) highlighted that acquiring external green technologies significantly boosts performance. These findings support all proposed hypotheses.

5. Discussion

The empirical findings underscore the pivotal role of green innovation in enhancing organizational performance within Pakistan's textile manufacturing sector. Both process and product innovation emerged as critical drivers, with process innovation exerting a more pronounced effect. This suggests that cleaner production technologies, energy-efficient operations, and waste-minimization systems are more immediately impactful than product-level changes, though the latter also contributes meaningfully through eco-friendly designs and recyclable materials. Technology transfer demonstrated a strong positive effect on performance, signifying its capacity to bridge capability gaps and accelerate the adoption of advanced environmental technologies. These outcomes corroborate Signaling Theory, whereby visible sustainability practices enhance legitimacy and stakeholder trust, and align with the Resource-Based View, which positions green innovation and acquired technologies as valuable, rare, and difficult-to-replicate resources. Collectively, the results advocate for an integrated innovation strategy that simultaneously cultivates internal capabilities and leverages external technological resources for superior environmental and competitive outcomes.

5.1 Theoretical Implications

This study advances the scholarly discourse on sustainability-oriented innovation by integrating Signaling Theory and the Resource-Based View (RBV) into a unified explanatory framework. It demonstrates that the interplay between internal green innovation capabilities and externally acquired technologies generates a synergistic effect, strengthening both market signals and resource endowments. By conceptualizing green innovation as a higher-order construct encompassing product and process innovation, the research offers a refined operationalization that enables holistic examination of its performance implications. From a signaling perspective, the combined visibility of innovation outcomes and technological sophistication projects credibility, thereby enhancing stakeholder confidence. From the RBV lens, both internally developed and externally sourced innovations qualify as VRIN resources, underpinning long-term competitiveness. Furthermore, the study extends theoretical models by introducing technology transfer as a contextual moderator that amplifies the innovation–performance nexus, suggesting that future theory-building should explicitly account for such enabling mechanisms within sustainable innovation research.

5.2 Practical Implications

The findings have presented the strategic necessity of encompassing product and process innovation as mutually authentic avenues to environmental and economic performance to the industry practitioners. Process changes, such as energy-efficient processes and manufacturing, and other simple waste-reduction systems, provide instant operational efficiencies as well as benefits through regulatory compliance. Sustainable design and recyclable material are product innovations that increase the brand differentiation and match the changing consumer preferences. Technological transfer should also be used as an effective tool in capacity-building by getting quick access to green technologies through alliances, licenses, or joint R&D. This is especially useful to companies facing limitations in the development capacity within the company since it reduces the duration of innovation and it also reduces the costs incurred in development. To enhance their competitiveness and legitimacy, managers need to actively undertake sustainability disclosures, eco-certifications and special marketing of these initiatives. By loading incentive structures that should encourage tech-sharing concepts, policymakers can help in making such projects possible and speed up the industry shift towards sustainability without compromising the strength of the economy.

5.3 Conclusion

This examination justifies that the two aspects of green innovation, i.e., green product innovation and green process innovation, can greatly improve the performance of an organization in the fabric and textile manufacturing business. This relationship is further enhanced by the introduction of the technology transfer and consequent ability of the firms to acquire the advanced environmental technologies and be able to implement them quickly. Based on Signaling Theory, these initiatives serve as reliable signals of sustainable commitment and will give trust and legitimacy to stakeholders. In terms of the RBV approach, green innovation abilities and learned technologies are strategic and un-imitable capabilities which form the sustainable competitive advantage. The study makes a methodological contribution as well since it models green innovation as a higher-order construct and thus offers a modelling approach to the assessment. The results have specific significance to emerging economies where there are escalating demands of sustainability, but they curtail internal resources of innovation. In general, the research endorses a twin-strangle approach that would entail achieving high internal innovations on the one hand, and fostering external technologies alliances, on the other hand, to propel the shift towards sustainable competitiveness in green markets.

5.4 Limitations and Future Directions

While the study delivers valuable insights, several limitations must be acknowledged. The focus on medium-to-large textile firms in Pakistan may limit generalizability to other industries or smaller enterprises. Comparative studies across sectors and geographies could enhance external validity. The cross-sectional design precludes temporal inferences, suggesting that longitudinal research is needed to capture the evolving interplay between green innovation, technology transfer, and performance. Furthermore, reliance on self-reported managerial data may introduce perceptual bias, despite the application of procedural safeguards; future work should integrate objective performance metrics and multi-source datasets. Although technology transfer was examined as a moderating factor, additional contextual variables such as regulatory intensity, supply chain collaboration, and market volatility warrant exploration. Future research should also investigate digital transformation's potential to synergize with green innovation. Addressing these gaps would deepen theoretical understanding and offer richer managerial insights into achieving sustainable and competitive advantage in dynamic industrial contexts.

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