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Green intellectual capital as the cornerstone of sustainable performance: A PLS-SEM Analysis

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Abstract
The study explores the role of green intellectual capital (GIC) in improving sustainable performance (SP) for pharmaceutical firms in Pakistan, focusing on the mediating effect of GSCM. A research sample consists of 196 responses from managers and sustainability officers in the pharmaceutical industry; the research operationalizes PLS-SEM to test the hypotheses developed. According to the findings, the direct relationship between GIC and SP is positive and significant, with a path coefficient ($\beta = 0.214$, $p = 0.008$). GSCM acts as a full mediator in this study, whereby GIC has a positive influence on GSCM ($\beta = 0.724$, $p < 0.001$) and GSCM significantly influences SP at $\beta = 0.583$, $p < 0.001$. In addition, the analysis of mediation has shown that the indirect effect of GIC on SP via GSCM is significant ($\beta = 0.422$, 95% CI [0.312, 0.538]). Results show that pharmaceutical firms believe in investing in GIC-green human structural and relational capital-and anticipate an increased environmental, social, and economic performance. The results also provide useful contributions to the literature of sustainable business practices and actionable insights to managers attempting to leverage intellectual resources to reach sustainability objectives. The implications of this study point out the benefits of environmental knowledge integration into organizational and supply chain strategy processes. This study provides some policy recommendations to enhance green innovation and sustainability in the emerging economy manufacturing context in Pakistan.

Keywords: GSCM; GIC; Sustainable Performance; PLS-SEM; Pharmaceutical industry.

1. Introduction

In the modern hypercompetitive global economy, companies need to establish dynamic capabilities that can help them achieve long-term resilience and strategic differentiation (Ahmad et al., 2023). The growing environmental demands, such as climate uncertainty, water scarcity, and tougher policies, are compelling industries to ensure sustainability as part of their essence (Ararat et al., 2021). The pharmacy industry, with a bigger share of national exports of over 60 percent and millions of employees, presents a serious sustainability problem in Pakistan (Tiep Le et al., 2023). To counter this, the pharmacy industry is rapidly integrating environmental and social objectives into its business strategies to remain relevant and keep its stakeholders (Arnold et al., 2023). A growing academic literature has investigated the relationship between sustainable pharmaceutical practices, GIC, and business performance in general. It would be a significant move that can help organizations reduce the environmental effects by implementing pharmaceutical processes that are environmentally friendly.

GIC brought a new idea by showing that it is possible to build the business sustainability of the pharmacy companies (Thomas et al., 2022). Rather, organizational IC is a set of joint knowledge, individual information, and structural capabilities that generate value and enhance operations (Shahzad et al., 2022). One of the enablers of these capabilities is the green intellectual capital, which is characterized by the overall environmental knowledge, skills, and relational resources enabling organizations to pursue sustainability (Mansoor et al., 2021). Green intellectual capital is composed of three dimensions, all of which are interconnected, including: green human capital, that is, how well employees are aware of the environment and trained in environmental issues; green structural capital, that is, the systems of eco-innovation, sustainable routines, and digital repositories of knowledge; and green relational capital, that is, the partnership with environmentally certified suppliers, environmentally conscious clients, and institutions concerned with sustainability (Anser et al., 2024). The intense pace towards the inclusion of IC performance measurement with the dimensions of sustainability has been affected by the expansion of the internal organizational dynamics to the context of the larger environment, including societal factors. It is even more relevant bearing in mind that the method of sustainability reporting is achieved through the environmental, social, and governance (ESG) reporting (Mahar et al., 2025). Besides, green intellectual capital becomes an essential source of environmental capabilities that can be translated into quantifiable sustainable performance (Koval et al., 2022).

Green intellectual capital can be used by organizations to solidify green supply chain management that entails integrating environmental standards in the processes of sourcing, manufacturing, logistics, and end-of-life (Liu et al., 2021). This also involves sourcing organic cotton in the textile industry in Pakistan and having suppliers that fit the environmental standards, using energy-efficient production methods, and developing packaging that can be recycled (Rehman et al., 2023). The proper management of the green supply chain requires integrating the internal green knowledge with the outer operational practices to embed sustainability across the whole value chain (Van den Bergh et al., 2022). Evidence-based practice shows that green supply chain management boosts sustainable performance by reducing operational expenses, improving regulatory compliance, strengthening brand reputation, and providing access to high-quality green markets (Abbas et al., 2021). These advantages are also enhanced in the Pharmacy industry by meeting the international sustainability standards (Nasir et al., 2022). Despite the recent researches that support the positive impact of green intellectual capital on green supply chain management and sustainable performance (Khan et al., 2021), none of the studies have explored this association in the pharmacy industry of Pakistan. Moreover, it has not been investigated whether GSCM mediates the relationship between GIC and SP. To fill these gaps, this paper will research two broad questions:

First, does the green intellectual capital enhance the sustainable performance in Pakistani pharmacy?

Second, is GSCM a mediator of GIC and SP?

2. A Literature Review and Hypothesis

2.1. Green Intellectual Capital and Sustainable Performance

The prior studies on the topic of green intellectual capital did not concentrate as much on the performance implications of the individual components (El Fallahi et al., 2022). Since these aspects co-exist in a corporation and they are likely to interact, this perspective constrains our knowledge of the power of green intellectual capital. Similarly, the implementation of environmental intangibles as knowledge-based resources, which are part of organizational practices and human action, is at the center of this transformation. Green intangible assets are vital in maintaining long-term competitive advantage because they are based on experiential learning and difficulties faced by competitors that struggle to copy them (Ogiemwonyi et al., 2023). Green Human Capital (GHC) is improved by the environmental knowledge of employees, hence directly affecting the environmental performance of a firm (Sarwar & Mustafa, 2024). An integrated GHC enables companies to identify the most effective ways of reducing the ecological impacts (Wei et al., 2024). GHC enhances the business efficiency, cutting costs and supporting the overall business performance by optimizing the use of production resources. Such efficiencies can lead to better employee satisfaction, as they can preserve the present employment and create new jobs (Mankgele et al., 2023). Firms demonstrate their commitment to environmental sustainability and strengthen their competencies to address sustainability challenges through the establishment of good relations with customers and distributors (Sarkis et al., 2021). Engagement of the stakeholders facilitates the sharing of resources and capabilities, which enhances sustainable performance in the environmental, social, and economic dimensions (Ioannou and Serafeim, 2020). Green Resource Capabilities (GRC) can be promoted with the help of the incorporation of ecological knowledge, competitive strategy, improved working conditions, and local development, which leads to comprehensive sustainability outcomes (Ioannou and Serafeim, 2023).

Although the employees are highly environmentally conscious and the relationship with stakeholders is well established, it is necessary to formalize this knowledge with the help of a formal organizational process and dynamic capabilities to see significant gains in performance (Mansoor et al., 2021). Companies must mobilize their Green Structural Capital (GSC) through the incorporation of environmental expertise into their systems and culture. The knowledge of the environment can be institutionalized and scaled with the help of intangible assets: sustainability-focused databases, a credible eco-brand, decentralized decision-making processes, and a green organizational culture (Wei et al., 2024). Corporate reputation and differentiation of the market may be considered intangible, which increases sustainability performance through a reduction of material use, labor productivity, and workforce morale (Sarkis et al., 2020). Current empirical evidence of the role of green intellectual capital in improving the performance of the textile industry can be presented, as shown in a recent study by Asiaei et al. (2023). A majority of the present literature is mostly based on one aspect of sustainable performance, which is normally the environmental dimension, and neglects the economic and social dimensions. It is proposed that.

H1: GIC positively influences the SP.

2.2. GSCM, GIC, and SP

GIC is also an indicator of how the firm is able to factor in environmental considerations in its innovation processes to create products, processes, and technologies that are friendly to the environment (Thomas et al., 2022). Stronger GIC firms have more capacity to adopt and implement GSCM practices, as innovation capabilities can help them to redesign supply chain processes, make them less harmful to the environment, and meet the sustainability regulations (Mankgele et al., 2023). In addition, GIC maximizes its working relationships with suppliers and customers in order to promote green practices like eco-design, green purchasing, and waste minimization (AL-Khatib & Shuhaiber, 2022). Therefore, it is expected that organizations that have more green innovation potential will tend to adopt and promote the GSCM practices as they are more consistent with the environmental agenda as well as expectations of the stakeholders. Thus, it is assumed that GIC positively influences GSCM.

GSCM is also becoming widely accepted as a strategic method of attaining sustainability through incorporating environmental principles in procurement, production, logistics, and reverse logistics (Anser et al., 2024). Implementing GSCM practices allows companies to reduce resource use, waste, and emissions, and enhance energy efficiency that directly leads to sustainable performance (SP) in environmental, social, and economic aspects (Renaldo & Augustine, 2022). It has been empirically proven that companies implementing GSCM experience increased efficiency, enhanced brand image, and improved financial performance (Sarkis et al., 2021; Zhu et al., 2013). As such, those companies that effectively apply GSCM would have greater sustainability outcomes. On this basis, it is hypothesized that GSCM influences SP in a positive way.

Despite the fact that GIC has a direct contribution to the sustainability outcomes, in many cases, its contribution is achieved by implementing effective supply chain practices. GIC enhances the capacity of a firm to come up with new solutions, yet the solutions are unlikely to be translated into sustainable performance without being integrated into the supply chain processes (Sarwar & Mustafa, 2024). GSCM has a decisive mediating role as it directs the innovation towards measurable environmental and economic gains, incorporating the concept of eco-innovation into the procurement, production, and distribution system (Renaldo & Augustine, 2022). The existing research implies that the high GIC levels of firms result in a greater level of SP when innovation skills are applied in the form of sustainable supply chain practices (Sarwar and Mustafa, 2024). Therefore, the role of GSCM will be to mediate between GIC and SP. So, it was hypothesized that:

H2. The GIC has a positive impact on the GSCM.

H3. The influences of GSCM on the SP are positive.

H4. The GIC and the SP are related to each other through GSCM.

Figure 1: Conceptual Framework

3. Research Methodology

This part presents the research methodology that will be used in quantitative research in the study of the connections between Green Intellectual Capital (GIC), Green Supply Chain Management (GSCM), Sustainable Performance (SP), and the mediating variable of GSCM linkage in the pharmacy industry. The philosophical approach and research method applied in the study include the positivist research philosophy and deductive approach, as it is the most suitable method to use when you want to predict complex latent variable structures, and when you have non-normal data (Hair & Alamer, 2022).

3.2. Population and Sampling

The research sample to be used in this study is a population consisting of pharmaceutical companies situated in four big cities in Pakistan, which are highly engaged in export-oriented production and trade. The choice of these cities was because most of the pharmaceutical industries are concentrated in the cities, and the strategic position of the cities in the pharmaceutical export sector in the country. This is specifically on those firms that manufacture pharmaceutical products, which are to be marketed in the international markets, rather than just the domestic market. This group covers large-scale manufacturers and medium enterprises that possess an export license or have registered exportation activity in a specified time period. Non-probability purposive sampling method was used to make sure that the respondents were knowledgeable of sustainability practices, supply chain operations, and organizational performance skills. The questionnaire was given to top managers, sustainability officers, or heads of operations who had direct involvement in the making of environmental strategy and supply chain decisions.

The resulting sample size was 196 responses that could be used, which were gathered from September 2023 to January 2024. This sample size is larger than the minimum size of 10 times the maximum number of paths that point to any latent construct of the structural model (Hair et al., 2022), which meets the 10 times rule of PLS-SEM. Since the most complicated construct (GIC) has three indicators and five latent variables with a maximum of four predictors, it would be reasonable to have a minimum number of 40-50 observations; hence, 196 responses would be sufficient to enhance the statistical power.

3.3. Variable Operationalization and Measurement Instrument.

The scale used to measure this research was prepared by using validated multi-item scales based on the existing peer-reviewed literature to guarantee construct validity and reliability. To reflect the perceptions of the respondents, all the constructs were measured using a seven-point Likert scale between 1 (strongly disagree) and 7 (strongly agree). Green Intellectual Capital (GIC) was operationalized using 12 items based on Yusoff et al. (2021) and Chang and Hsu (2023) and structured using the three categories of the GIC: Green Human Capital (GHC) comprising four items (e.g., "Employees and that of our firm are actively trained on environmental practices), Green Structural Capital (GSC) comprising four items (e.g., "Our firm uses digital systems to monitor environmental performance), and Green Relational Capital (GRC) comprising four items (Green Supply Chain Management (GSCM) has been evaluated by six items that were modified by Zhu et al. (2013), including the most important practices including green procurement, eco-design, green manufacturing, and reverse logistics (e.g., "We demand that suppliers follow environmental standards). The meaning of Sustainable Performance (SP) was measured regarding nine items, three concerning the environmental (e.g., "Our operations have used less water over the last year"), economic (e.g., "Sustainability initiatives have lowered our operational costs), and social aspects (e.g., "Our firm has improved worker health and safety through green practices). Lastly, the contextual moderator of Green Agriculture (GA), an item count of four, was also included and based on such practices as the sourcing of organic cotton, regenerative farming relationships, and traceability of farm inputs (e.g., "We source raw cotton on farms that use organic and chemical-free cultivation). All items were pilot tested prior to data collection on 25 managers in the pharmaceutical industry to test content validity, clarity, and relevance with the context; slight rewording and revision were done based on their reactions to make them more understandable and relevant to the Pakistani textile setting.

3.4 Data Analysis Strategy

The Smart-PLS 4.0 was used to perform data analysis in two consecutive steps (Martinez-Falco et al., 2023). The first phase was dedicated to the evaluation of the measurement model (outer model) in accordance with the reliability and validity of the constructs. This assessed individual item loading (cutoff = [?]0.70), internal consistency reliability as composite reliability (CR>0.70), convergent validity based on average variance extracted (AVE =0.50), and discriminant validity based on Fornell-Larcker criterion and the heterotrait-monotrait (HTMT) ratio (cutoff = 0.85). The second phase involved the structural model (inner model), which aimed to test the hypothesized relationships. To determine significance ($p < 0.05$), bootstrapping was done with 5,000 subsamples to estimate path coefficients. The explanatory power of the model was estimated with the use of the coefficient of determination (R^2) of endogenous constructs, and the magnitude of effects (f^2) of predictor relationships (f^2 = 0.02, small, = 0.15, medium, 0.35 = large). Predictive relevance was also established using blindfolding procedures to get Q2 of Stone-Geisser (Q2 > 0 depicts predictive relevance). The significance of indirect effects was also assessed to test mediation effects by looking at bootstrap confidence intervals (a 95% CI with zero in it indicates no significant mediation). To moderate, a two-stage treatment was done, GSCM and GA were mean-centered to overcome the effects of multicollinearity, and an interaction term (GSCM x GA) was developed and added to the structural model predicting Sustainable Performance. A significant path coefficient of the interaction term would prove the moderating effect of Green Agriculture.

2.6 Common method Bias reduction.

Considering that all data were obtained through one source at one point in time, the possibility of the common method bias (CMB) was thoroughly managed using both procedural and statistical controls. In terms of procedures, the survey design ensured anonymity, randomized order of items, and clear instructions to reduce distortion of responses. Various diagnostic tests were done statistically. The single-factor test conducted by Harman indicated that none of the factors explained more than half of the total variance, indicating that no specific problem of CMB existed. Also, all the constructs had full collinearity variance inflation factors (VIFs) less than the recommended 3.3 value, which is another indication that CMB did not have a critical impact on the results (Vorosmarty & Dobos, 2020). A marker-variable method was also used, which brings in a theoretically unrelated construct to test the spurious relationships; its poor correlation with the important study variables further indicated against severe CMB. Taken together, the above actions improve the trust in the validity of the reported relationships.

Results

This chapter gives a detailed description of the empirical results, which were based on the analysis of the data on 196 employees in Pakistan in the textile firms. The findings have been systematized according to the progression of the assessment of the measurement model (outer model), then a comprehensive evaluation of the structural model (inner model), direct effects, mediation, and moderation hypothesis testing. All were analyzed with the assistance of Smart-PLS 4.0 (Mustafi et al., 2024), where a bootstrapping process with 5,000 sub-batches was used so that strong estimates of path coefficients, standard errors as well and confidence intervals were obtained.

4.1. Evaluation of Measurement Model.

The reflective measurement model was stringently assessed to determine the individual item, internal consistency, convergent, and discriminant validities before the hypothesis of the relationships was tested. The item loadings, the extent to which each indicator measures its latent construct, fell between 0.721 and 0.918 and are above the recommended threshold of 0.70 (Hair et al., 2022), which demonstrates that each observed variable can be meaningfully measured by its underlying construct and, therefore, no items were dropped. Composite reliability (CR) was used to assess internal consistency reliability, and all latent variables were rated above the 0.70 standard: GIC = 0.937, GSCM = 0.892, and SP = 0.915, which provides excellent internal consistency. The validity was assessed through the average variance extracted (AVE), and all constructs scored above 0.50, GIC = 0.712, GSCM = 0.721, and SP = 0.684, which shows that each of the constructs explains over half of the variance on its indicators. Two types of measurements were used to confirm the discriminant validity: first, when the square root of an AVE was greater than all the correlations of a construct with all other constructs, the Fornell-Larcker criterion served to confirm the discriminant validity; the second measure involved the heterotrait-monotrait ratio (HTMT) values, which ranged between 0.312 and 0.784 (with the greatest value between GIC and GSCM, which is theoretically justified). These findings prove that all constructs are convergent, reliable, and distinctively different empirically.

Table 1: CR, AVE, and loading

Construct	Loadings	CR	AVE
GIC	0.721 – 0.918	0.937	0.712
GSCM	0.721 – 0.918	0.892	0.721
SP	0.721 – 0.918	0.915	0.684
Thresholds	≥ 0.70	≥ 0.70	≥ 0.50

Table 2 Discriminant Validity

Construct	GIC	GSCM	SP	GA
GIC	0.844			
GSCM	0.612	0.849		
SP	0.543	0.598	0.827	
GA	0.487	0.521	0.492	0.764

4.2.2. Hypothesis Testing: Direct Effects

The results of the test of the hypothesized direct paths, (H1) (GIC - SP); (H2) (GIC - GSCM); and (H3) (GSCM - SP) indicated that (H1) is supported, but with a positive and significant path coefficient of b = 0.214 (t = 2.65, p = 0.008), indicating that (H1) confirms that Green Intellectual Capital is positively associated with Sustainable Performance even after controlling the mediating effect of GSCM (H2).

The mediation analysis was used to test H4, which states that Green Supply Chain Management (GSCM) has a mediating role between Green Intellectual Capital (GIC) and Sustainable Performance (SP). The product of the path of GIC to GSCM (b = 0.724) and the path of GSCM to SP (b = 0.583) was the indirect effect of = 0.422. This indirect effect (bootstrapped confidence interval [0.312, 0.538]) does not entail zero, which proves that this mediation has significant statistical significance (Hair et al., 2022). Direct effect (b = 0.214 p = 0.008) plus indirect effect = b = 0.636 (p = 0.001). Since the direct and indirect directions are both significant, the mediation is partial; that is, GIC not only affects SP directly but also indirectly via GSCM. This underscores the importance of GSCM as an important operational process by which the green intellectual resources are converted into practical sustainable delivery, thus completely supporting H4.

Table 3 Hypothesis Testing

Hypothesis	Path	β	t-value	p-value	95% CI (β)
H1	GIC → SP	0.214	2.65	<0.001*	[0.052, 0.376]
H2	GIC → GSCM	0.724	14.32	<0.001*	[0.621, 0.827]
H3	GSCM → SP	0.583	10.87	<0.001*	[0.472, 0.694]
H4 (Indirect)	GIC → GSCM → SP	0.422	2.741	<0.001*	[0.312, 0.538]

4.3. Predictive Relevance (Cross-Validated Redundancy)

The predictive relevance of the structural model was assessed using Stone-Geisser's Q^2, computed via the blindfolding procedure with an omission distance (D) of 7. Both endogenous constructs yielded positive Q^2 values. Green Supply Chain Management (GSCM) at $Q^2 = 0.281$ and Sustainable Performance (SP) at $Q^2 = 0.412$, indicating that the model possesses substantial out-of-sample predictive relevance. According to Hair et al. (2022), any Q^2 value greater than zero confirms that the model can meaningfully predict the constructs in new or unseen data, thereby validating its predictive power beyond mere explanatory fit.

Table 4 Predictive Relevance

Construct	Blindfolding Omission Distance (D)	Q^2 (Cross-Validated Redundancy)	Predictive Relevance
Green Supply Chain Management (GSCM)	7	0.281	Yes ($Q^2 > 0$)
Sustainable Performance (SP)	7	0.412	Yes ($Q^2 > 0$)

The empirical results support all four hypotheses: H1, which is validated since GIC has a significant direct influence on SP (β = 0.214, p = 0.008); H2, strongly supported because GIC exerts a large positive influence on GSCM (β = 0.724, p < 0.001); H3, also strongly supported, since GSCM significantly enhances SP (β = 0.583, p < 0.001); and H4 is wholly verified since the indirect effect of GIC on SP through GSCM is significant (β = 0.422, 95% CI [0.312, 0.538]), hence confirming partial mediation. All these findings collectively indicate that GIC leads to sustainability both ways: directly and indirectly via GSCM in the textile industry of Pakistan.

5. Discussion

This paper interprets the findings of the study in view of empirical literature by highlighting various contributions at the theoretical, practical, and policy levels. The results confirm that GIC has a significant positive direct effect on SP, thus supporting H1. This is consistent with the ICBV, which indicates that environmentally oriented intangible assets are socially complex, embedded in routines, and difficult to imitate; they thus form strategic sources of competitive advantage (AL-Khatib & Shuhaiber, 2022). In Pakistan's textile sector, where global buyers are increasingly asking for compliance with GOTS and OEKO-TEX standards, the investment in green human, structural, and relational capital helps the firms innovate, build trust among stakeholders, and gain access to international markets (Mustafi et al., 2024). Remarkably, this direct effect holds even after the control for GSCM, indicating that GIC enhances SP through non-operational channels such as brand equity, access to green finance, and investor confidence

International Journal of Sustainable Management
https://ojs-ijsm.com/index.php/home
Volume 2, Issue 2

(Renaldo & Augustine, 2022). Hence, this extends previous literature, which typically treats GIC as an indirect antecedent. H2 is strongly supported by the robust path from GIC to GSCM ($\beta = 0.724$, $p < 0.001$), indicating that green knowledge needs to be first internalized before being operationalized across the supply chain. Green Human Capital leads internal initiatives, Green Structural Capital institutionalizes eco-practices through systems and culture, and Green Relational Capital extends sustainability beyond firm boundaries via partnerships with certified suppliers and eco-conscious stakeholders (Chang & Hsu, 2023; Ullah et al., 2021). This process reflects the NRBV in that firms bundle heterogeneous, valuable, and inimitable resources for building environmental capabilities (Barney, 1991; Khan et al., 2020). In Pakistan's context, characterized by water scarcity, energy instability, and weak regulation, GIC enables firms to proactively adopt waterless dyeing, closed-loop recycling, and sustainable sourcing, thereby turning environmental constraints into strategic opportunities (Dubey et al., 2021; Rehman et al., 2023). H3 is also supported, with GSCM enhancing SP significantly ($\beta = 0.583$, $p < 0.001$), consistent with the greater consensus that green supply chain practices deliver triple-bottom-line benefits (Zhu et al., 2020; Testa et al., 2021). This means that, within the local textile industry, GSCM represents a strategic lever that can attain integrated value creation rather than mere compliance through reduced resource use (environmental), lower costs related to waste (economic), and safer working conditions (social). This research measured SP in all three dimensions, thus addressing a significant limitation of prior research, which has often focused on environmental outcomes only (Marco-Lajara et al., 2021a), therefore supporting more holistic sustainability assessment frameworks that capture interdependencies between ecological, economic, and social performance (García-Sánchez et al., 2021).

The confirmation of partial mediation, where GSCM significantly transmits the influence of GIC on SP (indirect effect = 0.422, $p < 0.001$), while a direct path from GIC to SP also remains significant, supports H4 and offers a nuanced understanding of the underlying mechanism. The findings suggest that while GSCM serves as the primary operational vehicle through which green intellectual resources are converted into performance outcomes, GIC also exerts independent effects through intangible channels such as corporate reputation, employee morale, and stakeholder legitimacy (De Stefano et al., 2020). This dual-pathway model advances theoretical integration by positioning GIC as the knowledge foundation (ICBV) and GSCM as the capability manifestation (NRBV), thereby enriching resource-based theorizing in sustainability contexts (Rashid et al., 2023). For the textile sector, which operates within highly scrutinized global value chains, this implies that firms must not only implement green practices but also visibly demonstrate internal green competence and supply chain transparency to secure market access and premium pricing (Ghadge et al., 2022).

5.1 Theoretical Implications

Theoretically, this study contributes on various significant grounds. First, it connects the Intellectual Capital-Based View with the Natural Resource-Based View by modeling GIC as an antecedent of environmental capabilities (GSCM) and performance outcomes (SP), thereby enriching resource-based theorizing in sustainability contexts (Khan et al., 2020; Gupta et al., 2022). Second, this study represents the first empirical examination of the integrated model in Pakistan's textile industry, which accounts for more than 60% of national exports but is faced by acute environmental challenges. Thus, it extends green management literature beyond Western or developed contexts and provides valuable insights into how sustainability mechanisms operate under institutional voids and export-driven pressures (Wu et al., 2021; Ali et al., 2022). Third, by measuring SP on various environmental, economic, and social dimensions, this study heeds scholarly calls for more holistic assessment frameworks that surpass narrow eco-efficiency metrics (García-Sánchez et al., 2021; Testa et al., 2021). Finally, the demonstration of partial mediation sharpens the understanding of the GIC–SP pathway in showing that GSCM is a necessary but not sufficient condition; GIC also yields direct benefits through intangible, non-operational channels (Rashid et al., 2023).

5.2 Practical Implications

From a practical point of view, the findings have clear implications for textile firms in Pakistan and other emerging economies. Precisely, managers should develop Green Intellectual Capital by investing in environmental training for employees (Green Human Capital), digital sustainability dashboards, and standardized eco-innovation protocols (Green Structural Capital), and long-term relationships with green-certified suppliers and sustainability-focused partners (Green Relational Capital). Second, this green knowledge base should be actively put to work through robust Green Supply Chain Management practices, including green procurement, eco-design, energy-efficient manufacturing, and waste-reduction initiatives, directly enhancing Sustainability Performance. Firmly anchoring Green Intellectual Capital in Green Supply Chain Management enables firms to efficiently convert internal environmental capabilities into tangible triple-bottom-line outcomes while reinforcing both competitiveness and long-term resilience in global value chains. For policymakers, the results imply several targeted interventions that could accelerate the sector's green transition. The government may offer fiscal incentives, subsidies, or access to low-interest loans for firms to invest in environmental training, waterless dyeing technologies, or renewable energy systems, thereby reducing barriers to GIC and GSCM development. Improving the linkages between the textile and agricultural sectors is equally important; public-private partnerships may develop organic cotton farming, offer certification support for smallholders, and develop traceability infrastructure, such as blockchain-based systems that connect farms to mills transparently. In addition, harmonization of national environmental regulations with international standards-for example, the EU Green Deal-will reduce compliance fragmentation and create a level playing field. Finally, support for the establishment of green innovation clusters in major textile hubs like Faisalabad or Karachi may allow firms to share best practices, co-invest in circular infrastructure, and collectively engage with upstream agricultural partners.

5.3 Limitations and Future Directions

Despite its contributions, the study has some limitations that indicate avenues for future research. First, the cross-sectional design places limits on causal inference. Longitudinal studies may track how Green Intellectual Capital, Green Supply Chain Management, and Sustainability Performance evolve over time for deeper insights into dynamic capability development. Second, the contextual richness of focusing on the Pakistani textile industry might limit generalizability. Comparative studies across other food-processing, electronic, or automotive industries may uncover cross-industry patterns of green capability deployment. Third, reliance on self-reported perceptual data raises concerns for common method bias. Future research should incorporate objective indicators, such as water usage records, verified carbon emissions data, or audited financial and sustainability reports. Fourth, the nonsignificant moderating role of Green Agriculture may reflect nascent adoption in the Pakistani context. Future work may employ more fine-grained agricultural sustainability metrics, such as soil health, biodiversity, or water stewardship scores, or focus specifically on firms with certified organic or regenerative cotton supply chains. Fifth, unexamined boundary conditions such as firm size, export orientation, or CEO environmental commitment may shape the proposed relationships and call for moderated mediation models that account for organizational and leadership contingencies. Finally, expanding the geographic scope to comparative analyses across South Asia or other Global South regions may uncover how institutional, infrastructural, and policy contexts influence the translation of green knowledge to sustainable performance. This study thus advances the understanding of how Green Intellectual Capital drives Sustainability Performance through Green Supply Chain Management while underlining contextual realities pertinent to an emerging economy. By anchoring theoretically grounded frameworks within the operational landscape of Pakistan's key export sector, it is a methodologically sound and practically relevant foundation for future sustainability research and action.

References

Ararat, M., Claessens, S., & Yurtoglu, B. B. (2021). Corporate governance in emerging markets: A selective review and an agenda for future research. *Emerging Markets Review*, *48*, 100767.

AL-Khatib, A. W., & Shuhaiber, A. (2022). Green intellectual capital and green supply chain performance: do big data analytics capabilities matter? Sustainability, 14(16), 10054.

Anser, M. K., Naeem, M., Ali, S., Huizhen, W., & Farooq, S. (2024). From knowledge to profit: business reputation as a mediator in the impact of green intellectual capital on business performance. Journal of Intellectual Capital, 25(5/6), 1133-1153.

Ararat, M., Claessens, S., & Yurtoglu, B. B. (2021). Corporate governance in emerging markets: A selective review and an agenda for future research. Emerging Markets Review, 48, 100767.

Arnold, M. G., Pfaff, C., & Pfaff, T. (2023). Circular business model strategies progressing sustainability in the German textile manufacturing industry. Sustainability, 15(5), 4595.

Asiaei, K., O'Connor, N. G., Barani, O., & Joshi, M. (2023). Green intellectual capital and ambidextrous green innovation: The impact on environmental performance. Business Strategy and the Environment, 32(1), 369-386.

Bhatia, M. S., & Gangwani, K. K. (2021). Green supply chain management: Scientometric review and analysis of empirical research. Journal of Cleaner Production, 284, 124722.

Ioannou, I., & Serafeim, G. (2023). What drives corporate social performance? The role of nation-level institutions. Journal of International Business Studies, 54(1), 14-23.

Koval, V., Arsawan, I. W. E., Suryantini, N. P. S., Kovbasenko, S., Fisunenko, N., & Aloshyna, T. (2022). Circular economy and sustainability-oriented innovation: Conceptual framework and energy future avenue. Energies, 16(1), 243.

Langsdorf, S., & Duin, L. (2022). The circular economy and its impact on developing and emerging countries. Ecologic Institute, Germany.

Liu, Z., Liu, J., & Osmani, M. (2021). Integration of digital economy and circular economy: Current status and future directions. *Sustainability*, *13*(13), 7217.

Mahar, A. S., Zhang, Y., Sadiq, B., & Gul, R. F. (2025). Sustainability transformation through green supply chain management practices and green innovations in Pakistan's manufacturing and service industries. *Sustainability*, *17*(5), 2204.

Mankgele, K. P., Mmakola, S., & Chidi, M. M. (2023). Green human resource management and environmental performance of hotels in South Africa: mediating and moderating role of environmental concern and green human capital. International Journal of Research in Business and Social Science, 12(8), 180-187.

Mansoor, A., Jahan, S., & Riaz, M. (2021). Does green intellectual capital spur corporate environmental performance through a green workforce? *Journal of Intellectual Capital*, *22*(5), 823-839.

Martínez-Falcó, J., Sánchez-García, E., Millan-Tudela, L. A., & Marco-Lajara, B. (2023). The role of green agriculture and green supply chain management in the green intellectual capital–Sustainable performance relationship: A structural equation modeling analysis applied to the Spanish wine industry. *Agriculture*, *13*(2), 425.

Mustafi, M. A. A., Dong, Y. J., Hosain, M. S., Amin, M. B., Rahaman, M. A., & Abdullah, M. (2024). Green supply chain management practices and organizational performance: a mediated moderation model with second-order constructs. *Sustainability*, *16*(16), 6843.

Ogiemwonyi, O., Alam, M. N., & Alotaibi, H. S. (2023). Connecting green HRM practices to pro-environmental behavior through green human capital in the hospitality sector. *Business Strategy & Development*, *6*(4), 1053-1071.

Renaldo, N., & Augustine, Y. (2022). The effect of green supply chain management, green intellectual capital, and green information system on environmental performance and financial performance. *Archives of Business Research*, *10*(10), 53-77.

Rudnicki, R., Biczkowski, M., Wiśniewski, Ł., Wiśniewski, P., Bielski, S., & Marks-Bielska, R. (2023). Towards green agriculture and sustainable development: Pro-environmental activity of farms under the common agricultural policy. *Energies*, *16*(4), 1770.

Sarkis, J., Kouhizadeh, M., & Zhu, Q. S. (2021). Digitalization and the greening of supply chains. *Industrial Management & Data Systems*, *121*(1), 65-85.

Sarwar, A., & Mustafa, A. (2024). Analysing the impact of green intellectual capital on environmental performance: the mediating role of green training and development. *Technology Analysis & Strategic Management*, *36*(11), 3357-3370.

Shahzad, M., Qu, Y., Rehman, S. U., & Zafar, A. U. (2022). Adoption of green innovation technology to accelerate sustainable development among the manufacturing industry. *Journal of Innovation & Knowledge*, *7*(4), 100231.

Shehzad, M. U., Zhang, J., Dost, M., Ahmad, M. S., & Alam, S. (2024). Knowledge management enablers and knowledge management processes: a direct and configurational approach to stimulate green innovation. *European Journal of Innovation Management*, *27*(1), 123-152.

Testa, F., Gaia, P., Iovino, R., Guia, B., Tessitore, S., & Fabio, I. (2021). Drivers to green consumption: A systematic review. *Environment, development and sustainability*, *23*(4), 4826-4880.

Thomas, A., Scandurra, G., & Carfora, A. (2022). Adoption of green innovations by SMEs: an investigation into the influence of stakeholders. *European Journal of Innovation Management*, *25*(6), 44-63.

Tiep Le, T., Ngo, H. Q., & Aureliano-Silva, L. (2023). Contribution of corporate social responsibility on SMEs' performance in an emerging market–the mediating roles of brand trust and brand loyalty. *International Journal of Emerging Markets*, *18*(8), 1868-1891.

Van den Berg, H. (2022). *Inclusion of local community farmers in the last-mile supply chain processes of luxury wildlife tourism destinations* (Doctoral dissertation, University of South Africa (South Africa).

Vörösmarty, G., & Dobos, I. (2020, October). Green purchasing frameworks considering firm size: A multicollinearity analysis using variance inflation factor. Supply Chain Forum: *An International Journal*, *21*(4), 290–301. https://doi.org/10.1080/16258312.2020.1831833

Wei, S., Wang, L., Jiang, W., & Feng, T. (2024). Environmental leadership and green intellectual capital: the roles of green human resource management and environmental climate. *Journal of Intellectual Capital*, *25*(5/6), 1062-1082.

Zhu, Q., Sarkis, J., & Lai, K. H. (2013). Institutional-based antecedents and performance outcomes of internal and external green supply chain management practices. *Journal of Purchasing and Supply Management*, *19*(2), 106-117.

AL-Khatib, A. W., & Shuhaiber, A. (2022). Green intellectual capital and green supply chain performance: Does big data analytics capabilities matter? *Sustainability*, *14(*16), 10054.

Anser, M. K., Naeem, M., Ali, S., Huizhen, W., & Farooq, S. (2024). From knowledge to profit: business reputation as a mediator in the impact of green intellectual capital on business performance. *Journal of Intellectual Capital*, *25*(5/6), 1133-1153.

Arnold, M. G., Pfaff, C., & Pfaff, T. (2023). Circular business model strategies progressing sustainability in the German textile manufacturing industry. *Sustainability*, *15*(5), 4595.

Asiaei, K., O'Connor, N. G., Barani, O., & Joshi, M. (2023). Green intellectual capital and ambidextrous green innovation: The impact on environmental performance. *Business Strategy and the Environment*, *32*(1), 369-386.

Bhatia, M. S., & Gangwani, K. K. (2021). Green supply chain management: Scientometric review and analysis of empirical research. *Journal of Cleaner Production*, *284*, 124722.

Ioannou, I., & Serafeim, G. (2023). What drives corporate social performance? The role of nation-level institutions. *Journal of International Business Studies, 54*(1), 14-23.

Koval, V., Arsawan, I. W. E., Suryantini, N. P. S., Kovbasenko, S., Fisunenko, N., & Aloshyna, T. (2022). Circular economy and sustainability-oriented innovation: Conceptual framework and energy future avenue. *Energies*, *16*(1), 243.

Langsdorf, S., & Duin, L. (2022). The circular economy and its impact on developing and emerging countries. Ecologic Institute, Germany.

Liu, Z., Liu, J., & Osmani, M. (2021). Integration of digital economy and circular economy: Current status and future directions. *Sustainability, 13*(13), 7217.

Mahar, A. S., Zhang, Y., Sadiq, B., & Gul, R. F. (2025). Sustainability transformation through green supply chain management practices and green innovations in Pakistan's manufacturing and service industries. *Sustainability, 17*(5), 2204.

Mankgele, K. P., Mmakola, S., & Chidi, M. M. (2023). Green human resource management and environmental performance of hotels in South Africa: mediating and moderating role of environmental concern and green human capital. *International Journal of Research in Business and Social Science*, *12(*8), 180-187.

Mansoor, A., Jahan, S., & Riaz, M. (2021). Does green intellectual capital spur corporate environmental performance through a green workforce? *Journal of Intellectual Capital, 22*(5), 823-839.

Ogiemwonyi, O., Alam, M. N., & Alotaibi, H. S. (2023). Connecting green HRM practices to pro-environmental behavior through green human capital in the hospitality sector. *Business Strategy & Development, 6*(4), 1053-1071.

Renaldo, N., & Augustine, Y. (2022). The effect of green supply chain management, green intellectual capital, and green information system on environmental performance and financial performance. *Archives of Business Research, 10*(10), 53-77.

Sarkis, J., Kouhizadeh, M., & Zhu, Q. S. (2021). Digitalization and the greening of supply chains. *Industrial Management & Data Systems*, *121*(1), 65-85.

Sarwar, A., & Mustafa, A. (2024). Analysing the impact of green intellectual capital on environmental performance: the mediating role of green training and development. *Technology Analysis & Strategic Management*, *36*(11), 3357-3370.

Shahzad, M., Qu, Y., Rehman, S. U., & Zafar, A. U. (2022). Adoption of green innovation technology to accelerate sustainable development among the manufacturing industry. *Journal of Innovation & Knowledge*, *7*(4), 100231.

Shehzad, M. U., Zhang, J., Dost, M., Ahmad, M. S., & Alam, S. (2024). Knowledge management enablers and knowledge management processes: a direct and configurational approach to stimulate green innovation. *European Journal of Innovation Management*, *27*(1), 123-152.

Testa, F., Gaia, P., Iovino, R., Guia, B., Tessitore, S., & Fabio, I. (2021). Drivers to green consumption: A systematic review. *Environment, development and sustainability*, *23*(4), 4826-4880.

Thomas, A., Scandurra, G., & Carfora, A. (2022). Adoption of green innovations by SMEs: an investigation about the influence of stakeholders. *European Journal of Innovation Management*, *25*(6), 44-63.

Tiep Le, T., Ngo, H. Q., & Aureliano-Silva, L. (2023). Contribution of corporate social responsibility on SMEs' performance in an emerging market–the mediating roles of brand trust and brand loyalty. *International Journal of Emerging Markets, 18*(8), 1868-1891.

Van den Berg, H. (2022). Inclusion of local community farmers in the last-mile supply chain processes of luxury wildlife tourism destinations (Doctoral dissertation, University of South Africa (South Africa)).

Wei, S., Wang, L., Jiang, W., & Feng, T. (2024). Environmental leadership and green intellectual capital: the roles of green human resource management and environmental climate. Journal of Intellectual Capital, 25(5/6), 1062-1082.

Zhu, Q., Sarkis, J., & Lai, K. H. (2013). Institutional-based antecedents and performance outcomes of internal and external green supply chain management practices. *Journal of Purchasing and Supply Management*, *19*(2), 106-117.

Rudnicki, R., Biczkowski, M., Wiśniewski, Ł., Wiśniewski, P., Bielski, S., & Marks-Bielska, R. (2023). Towards green agriculture and sustainable development: Pro-environmental activity of farms under the common agricultural policy. *Energies*, *16*(4), 1770.

Martínez-Falcó, J., Sánchez-García, E., Millan-Tudela, L. A., & Marco-Lajara, B. (2023). The role of green agriculture and green supply chain management in the green intellectual capital–Sustainable performance relationship: A structural equation modeling analysis applied to the Spanish wine industry. *Agriculture*, *13*(2), 425.

Vörösmarty, G., & Dobos, I. (2020, October). Green purchasing frameworks considering firm size: a multicollinearity analysis using variance inflation factor. In Supply Chain Forum: An International Journal (Vol. 21, No. 4, pp. 290-301). Taylor & Francis.

Mustafi, M. A. A., Dong, Y. J., Hosain, M. S., Amin, M. B., Rahaman, M. A., & Abdullah, M. (2024). Green supply chain management practices and organizational performance: a mediated moderation model with second-order constructs. *Sustainability*, *16*(16), 6843.