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Driving sustainable competitiveness: unveiling the nexus of green intellectual capital and environmental regulations on greening SME performance

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Within the evolving landscape of contemporary business, where sustainability and innovation intertwine, our study explores a strategic gap, presenting the rationale behind choosing green intellectual capital (GIC), absorptive capacity (AC), green innovation (GI), environmental regulations (ERs), and competitive advantage (CA) as main constructs. This model investigates the complex nature of the competitive landscape of SMEs within the vibrant manufacturing sector using the latest version of SmartPLS 4 for analyzing complex data. Drawing upon the theory of the natural resource-based view (NRBV), this study uncovers that GIC advances GI and AC, driving SMEs toward sustainable CA, particularly within the context of ER. These findings propose vital insights for SMEs looking to leverage their valuable resource, contributing to greening operations and reaching sustainable competitiveness while also contributing to theoretical developments in understanding resource-based perceptions on greening the manufacturing of SMEs. Findings reveal the significant impact of GIC on AC and GI and their subsequent impact on CA. Furthermore, ER uncovers the essential role in shaping the link between GIC and AC, thus enhancing SMEs' capacity to achieve sustainable competitiveness. This study discloses how SMEs utilize GIC to identify ER and achieve CA and how the NRBV develops an understanding of SMEs utilizing their unique resource endowments to drive GI and achieve CA. This study examines the mediating role of AC and GI in this relationship.

KEYWORDS

green intellectual capital, competitive advantage, absorptive capacity, green innovation, environmental regulations

1 Introduction

In an increasingly complex world, the ability to acquire and utilize skills, knowledge, expertise, and intangible assets within a company is essential, with a particular focus on environmental sustainability and ecological apprehensions. GIC based on employee knowledge serves as a vibrant ecosystem where the grouping and replacement of skills

and knowledge become significant drivers of innovation and development (Asiaei et al., 2023). The contemporary business landscape emphasizes sustainability, where enterprises strive to balance economic objectives with environmental responsibility. The concept of GIC, which encompasses a reservoir of intangible assets within a company that focuses on environmental sustainability and ecological concerns, is essential. GIC encompasses not only intellectual resources but also expertise and innovations that contribute to the adoption and implementation of environmentally friendly practices and policies. It involves intellectual resources and competencies that add to the progress, adoption, and execution of environmentally friendly practices, policies, and novelties (Begum et al., 2023; Marco-Lajara et al., 2023; Wei et al., 2023). The concept of GI encompasses the implementation of environmentally friendly practices and the creation of innovative, resource-efficient goods and services. It has emerged as a significant criterion for assessing the sustainable competitive advantage of profit-oriented organizations (Al Halbusi et al., 2022; Chan et al., 2022; Tan et al., 2022). GIC gives companies a first-mover advantage that lets them charge more for green goods and services to improve their revenue and enter new markets (Xie et al., 2019).

The current research has underscored the correlation between AC and GI (Albort-Morant et al., 2018), AC and green project performance organization (Gerdoçi et al., 2023; Singh et al., 2023), AC and FP (Forés and Fernández-Yáñez, 2023; Nureen et al., 2023), GIC and GI (Marco-Lajara et al., 2023), and ER and GI (Al Halbusi et al., 2022). However, our study examines the association between GIC, GI, and CA in SMEs' manufacturing sector through altering the role of government intervention in regulating environmental sustainability. This study highlights the mediating function of AC and the moderating influence of ER within manufacturing SMEs in enhancing both GI and CA. Furthermore, our investigation bridges these gaps through theoretical support by integration and investigating the role of NRBV in enhancing GI and CA to pursue environmental sustainability while enhancing their competitiveness. In this study, we consider the importance of the GIC, GI, and AC capabilities of SMEs in achieving sound knowledge of how SMEs implement this knowledge in pursuing environmental sustainability and competitiveness.

2 Literature review

2.1 Theoretical foundation of the NRBV

The concept of the NRBV highlights the strategic significance of organization-specific resources such as GIC and AC for achieving a competitive edge and remarkable innovation performance (Hart, 1995; Cabral and Dhar, 2019; Begum et al., 2023). The NRBV suggests that GPI and AC practices help gain GI and CA (Lin and Chen, 2017; Albort-Morant et al., 2018; Bhatia, 2021). This study is strongly built on the NRBV theory, a theoretical model that emphasizes the strategic role of organization-specific resources. Particularly, the NRBV focuses on the significant role of GIC and AC in achieving a CA and leading innovation performance (Shan et al., 2018). This study establishes the importance of the NRBV in understanding the role of GIC and AC in gaining CA and fostering sustainable innovation. Furthermore, our study seeks to extend the existing literature by conceptualizing the intricate relationships between GIC, AC, GI, and SMEs' performance in adopting ER.

2.2 GIC, AC, and GI

The literature reveals that GIC has a significant, direct, and positive influence on AC (Mady et al., 2022; Al Issa et al., 2023; Begum et al., 2023), sustainable business (Yusoff et al., 2019), and GI performance (Tran et al., 2023). The concepts of GIC and AC are widely acknowledged as the primary drivers of organizational innovation (Marco-Lajara et al., 2023). This is because the abilities, experiences, and skills of individuals are essential in contributing to the overall organizational capacity for GI (Tran et al., 2023; Wei et al., 2023). The literature has shown that workers must have excellent environmental knowledge and abilities to establish ecologically responsible corporate operations and product innovations (Marco-Lajara et al., 2023). When a company understands the implications of AC and has a highly skilled GHC, employees are expected to contribute more actively to environmental preservation (Rehman, Kraus et al., 2021; S. K; Singh et al., 2020).

Firms focusing on AC and GI are deeply intertwined with GHC and other environmentally conscious organizational resources and contribute to the development of new environment-friendly products and processes (Jardon and Dasilva, 2017; Demartini and Beretta, 2020; Yusliza et al., 2020). Few studies suggested that specific elements of the GSC and databases play a crucial role in enhancing the effectiveness of the GHC and implementing AC, leading to an increased ability to develop and implement green performance (Salvi et al., 2020; Mirani et al., 2021; Naveed et al., 2023). Likewise, enterprises with a high level of GSC exhibit an enhanced capacity for organizational learning, consequently leading to their GI augmentation (Ahmed et al., 2022). As a result, companies that enhance their GSC will observe a significant enhancement in their innovation performance (Marco-Lajara et al., 2023). Firms with strong absorptive capabilities and customer engagement can effectively identify and address customer needs during the development of novel environment-friendly products and processes, achieving successful CA (Wimalachandra et al., 2014).

AC plays a crucial role in recognizing environmental pressures, defining effective strategies to address manufacturing waste challenges, and fostering innovative green performance (Song et al., 2020; Mady et al., 2022). Organizations with AC are expected to utilize environmental opportunities to gain a CA. GIC is an essential component of the company's recognition and integration of environmental data obtained from external sources (Cassol et al., 2016; Begum et al., 2023). Previous studies showed that a firm's intellectual capital facilitates its assimilation ability and enhances AC (Engelman et al., 2017; Mahmood and Mubarik, 2020). Firms with solid primary competency can expand their manufacturing capabilities and integrate various technologies (Srivastava, 2005).

H1: There is a meaningful relationship between GIC and AC.

H2: There is a meaningful relationship between AC and GI.

2.3 GI and CA

A competitive advantage is a position of superiority in the market that allows a company to surpass its competitors in performance (Coyne, 1986; C.-H; Wang, 2019). GI has a positive, significant, and direct impact on CA (Chang, 2011; Chen et al., 2006; Chen and Chang, 2013; Nanath and Pillai, 2017; C.-H; Wang, 2019). To achieve a competitive advantage, it is essential for the company to generate a positive value that is either equivalent to or surpasses that of its rivals (Shah et al., 2021; Tian et al., 2023). Acquiring new customers, advancing one's market position, and achieving a competitive edge are all necessary steps in the process of elevating GI (Takalo and Tooranloo, 2021). In our empirical study, we found that there is a significant relationship between GI and CFA, as examined in several research studies (Alziady and Enayah, 2019; Junejo et al., 2022; Iqbal et al., 2023). GPSI, such as discovering new markets for environmentally responsible products, improving resource productivity and recycling, and improving environmental efficacy and service quality (Castellacci and Lie, 2017), are often cited in studies on corporate GI (Takalo and Tooranloo, 2021). Figure 2 highlights the combined use of current variables by different scholars in the literature.

H3: There is a meaningful relationship between GI and CA.

2.4 Mediating effects of AC and GI

The fourth industrial revolution is linked to a simultaneous shift toward reliance on intangible resources rather than physical resources as a means to attain a competitive edge (Mahmood and Mubarik, 2020). Chen (2008) found that the positive impact of GIC on CA is notable. GIC functions as a pivotal source for identifying, assimilating, and disseminating information related to environmental management, thereby contributing to the enrichment of knowledge in this domain (Chen, 2008b). The adoption of GIC is essential for businesses striving to increase the visibility and market appeal of their environmentally friendly products and services (Chen and Lin, 2015; Mazon et al., 2023). AC denotes an organization's capacity to identify, appreciate, assimilate, and apply novel external information pertaining to environmentally sustainable practices (Cohen and Levinthal, 1990; Albort-Morant et al., 2018). AC hinges on its capability to establish connections and seamlessly integrate new information with existing knowledge (Marco-Lajara et al., 2023). Zahra and George. (2002) found that potential absorptive capacity encompasses the procedures associated with acquiring and integrating knowledge. This facet equips organizations with the strategic flexibility and autonomy necessary to thrive within a dynamic and continually evolving context (Akhtar et al., 2023; Hongyun et al., 2023; Shodeinde et al., 2023). However, the organization might not necessarily apply the acquired knowledge (Leal-Rodríguez et al., 2014; Lee et al., 2021). GI presents multiple environmental advantages, including the reduction of environmental risks (Xie et al., 2022), decreased reliance on nonrenewable resources, and mitigation of pollution. SMEs that make strides in AC tend to benefit from enhanced GI (Pacheco et al., 2018). Consequently, the existing literature indicates a likelihood of AC acting as a moderator, amplifying the influences of GIC and conservation competencies on GI, and contributing to achieving CA.

AC demands a focus on control and consistency, contrasting with the flexibility, adaptability, and creativity that are integral to potential AC (Bjorvatn and Wald, 2018). On the other hand, AC involves the process of acquiring fresh insights and results through the integration of both existing and recently acquired information into an organization's operations. Additionally, it encompasses the transformation and application of knowledge (Albort-Morant et al., 2018; Singh et al., 2023). The AC framework facilitates the assimilation and integration of external knowledge, enabling its conversion and subsequent utilization to attain desired outcomes (Zahra and George, 2002; Singh et al., 2023). Cohen and Levinthal (1990) introduced the concept of absorptive capacity (AC), laying the groundwork for understanding its role in knowledge acquisition and firm innovation. Building on prior research, Cohen and Levinthal (1990) explored the concept of AC, which paved the way for later studies examining its link to business innovation (Rauniar et al., 2023). AC plays a crucial role in a company's ability to generate fresh perspectives on products and external knowledge. This equips organizations to innovate by creating new products, services, and ideas, ultimately securing a competitive edge and harnessing the advantages of knowledge acquisition (Albort-Morant et al., 2018; Cohen and Levinthal, 1990; Shodeinde et al., 2023; A. K; Singh, Jain et al., 2023). Investigating the relationship between AC and GI has unveiled that an organization's efforts and investments in knowledge acquisition significantly influence the outcomes of green innovation (Leal-Rodríguez et al., 2013; Nisar et al., 2019). The concept of absorptive capacity (Danquah et al., 2018) has garnered substantial scholarly interest and is broadly acknowledged as a pivotal catalyst for engaging in innovative endeavors (Aboelmaged and Hashem, 2019). The potency of AC aids companies in enhancing GI and attaining a lasting competitive advantage by harnessing both external and internal expertise in green practices. Prior studies have explored the impact of organizational green capabilities on a firm's competitive advantage through the NRBV (Hart, 1995). Khan et al. (2022) discovered that the adoption of GI within manufacturing organizations could result in substantial enhancements in environmental sustainability and financial performance, culminating in the achievement of CA.

H4a: AC significantly mediates the relationship between GIC and GI.

H4b: AC and GI significantly mediate the relationship between GIC and CA.

H5: GI significantly mediates the relationship between AC and CA.

2.5 The moderating role of ER

ER functions as an external catalyst that facilitates the exchange of novel information and skills across various organizations. Consequently, this process creates avenues for pursuing

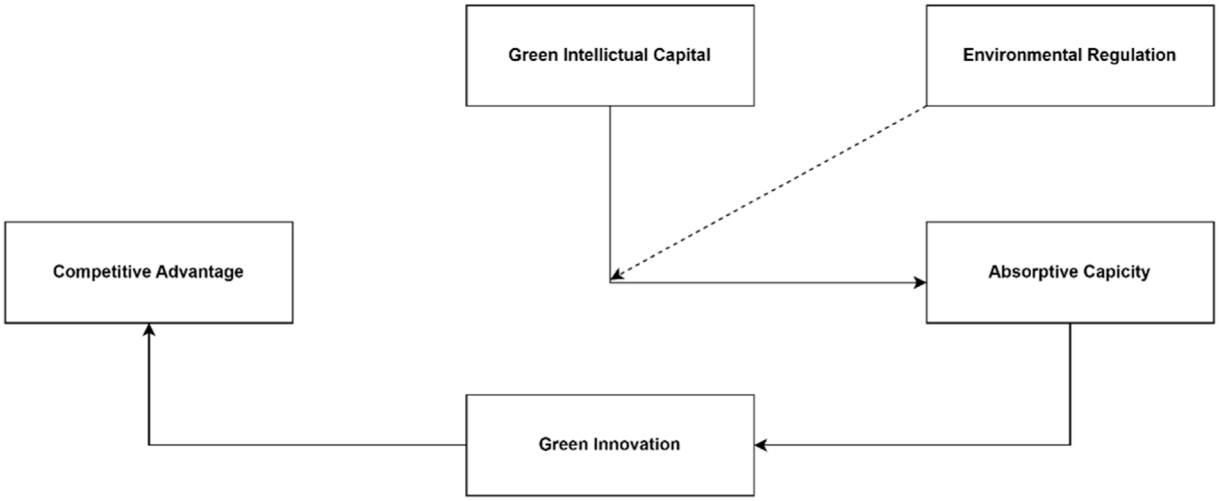

FIGURE 1
Conceptual framework.

environmentally conscious initiatives. Notably, ER exerts a substantial and favorable impact on GI, encompassing both products PRI and GPSI (Jaffe and Palmer, 1997; Javeed et al., 2023; Liang et al., 2023). Increasing levels of environmental concern and related challenges (De Medeiros et al., 2022) have required governments to enact more stringent policies (Jiang et al., 2018). Environmental regulations have imposed constraints on research regarding GI, and academic institutions hold divergent viewpoints on how these regulations affect corporate interests in green innovation. These regulations establish a formal framework that subjects corporations to substantial institutional pressure (Ling Guo et al., 2017). Stringent regulations can curtail capabilities, leading to reduced efficiency in GIC in alignment with AC and GI (Li et al., 2022). Environmental regulations often set benchmarks and goals for GI and environmental performance. These encompass targets such as emission reduction and improved resource efficiency (Singh et al., 2023). Figure 1 shows the conceptual framework and Table 1 shows the literature of variables (GIC, ER, GI, and CA).

H6: ER significantly moderates the relationship between GIC and AC

3 Research methodology

3.1 Data collection and sample

Research data were collected from manufacturing SMEs operating in all provinces of Pakistan. Questionnaires were distributed online through email and WhatsApp, and two reminders were sent after

TABLE 1 Literature review of different variables.

Reference	Focus (IV and DV)	Categorization	Focus (mediator and moderator)	Categorization	Sample	Application area/ research setting
Yusoff et al. (2019)	GIC	IV	_____	_____	200 full-time employees of Malaysian SMEs	Malaysia
Zhou et al. (2021)	ER and GI	IV and DV	AC	Moderator	133 top management	China
Kuo et al. (2022)	CA	DV	_____	_____	238 firms	Iraq
Begum et al. (2023)	GIC	IV	AC	Mediator	268 manufacturing firms	Pakistan
Albort-Morant et al. (2018)	GI	DV	_____	_____	112 Spanish firms	Spain
Al Issa et al. (2023)	GIC	IV	AC	Mediator	387 healthcare organizations	Iraq
S. K. Singh et al. (2019)	CA	DV	_____	_____-	364 managers' response	UAE
Zaragoza-Sáez et al. (2023)	GIC	IV	_____	_____	120 Spanish hotels	Spain
Zhang et al. (2020)	ER	IV	CA	Moderator	274 firms	Taiwan

TABLE 2 Company and demographic information.

Particular	Category	Number	Percent (%)
Types of industry	Manufacturing	148	100
No of employees	Less than two hundred (small or medium)	212	62.5
	More than two hundred (large)	127	37.5
Gender	Male	227	67
	Female	112	33

every week. After an in-depth analysis and the feasibility of getting accurate and quick responses, manufacturing SMEs were considered for analysis. Only those SMEs were included in the data collection process that believe in current environmental effects, follow and implement green practices, and actively work on environmental improvement to adopt and implement pro-environmental policies. To ensure the right sample selection, SMEs that are really active in practicing environmental development were finalized as the sample. The exclusion of certain companies was based on their limited engagement with green initiatives and a lack of active involvement in environmental improvement efforts. This rigorous criterion was applied to ensure that the selected SMEs truly represented the context of interest and contributed to the objectives of our study.

CEOs, directors, or managers were considered to complete the surveys as they had better knowledge about valuable intellectual capital, current environmental policies, and green practices that have been followed and implemented by the SMEs in the last 7 years. A total of 920 questionnaires were distributed, and the response rate was 47.5%

TABLE 3 Reliability and validity.

	Item	Loading	Alpha	rho_a	CR	AVE	Outer VIF
ER (Gu, 2022)	ER1	0.820	0.844	0.855	0.895	0.680	1.691
	ER2	0.802					1.765
	ER3	0.824					2.013
	ER4	0.851					2.308
CA (Rehman, Bresciani et al., 2021)	CA1	0.924	0.936	0.946	0.954	0.838	4.427
	CA2	0.902					3.393
	CA3	0.924					3.881
	CA4	0.912					3.421
AC (Xue et al., 2019)	AC1	0.859	0.914	0.919	0.935	0.743	2.546
	AC2	0.870					2.624
	AC3	0.856					2.856
	AC4	0.847					2.633
	AC5	0.878					2.978
GIC (Zaragoza-Sáez et al., 2023)	GIC1	0.883	0.923	0.927	0.940	0.732	3.586
	GIC2	0.867					3.241
	GIC3	0.847					2.893
	GIC4	0.840					2.516
	GIC5	0.831					2.549
	GIC6	0.803					2.151
GI (Wang and Juo, 2021)	GI1	0.841	0.895	0.896	0.923	0.705	2.381
	GI2	0.863					2.567
	GI3	0.821					2.145
	GI4	0.837					2.267
	GI5	0.834					2.225

TABLE 4 Discriminant validity and correlations.

HTMT ratio of correlations					
	CA	ER	AC	GIC	GI
CA					
ER	0.273				
AC	0.261	0.273			
GIC	0.249	0.084	0.268		
GI	0.327	0.330	0.312	0.196	
Fornell–Larcker criterion					
	CA	ER	AC	GIC	GI
CA	**0.916**				
ER	0.246	**0.824**			
AC	0.245	0.250	**0.862**		
GIC	0.230	0.073	0.248	**0.850**	
GI	0.304	0.293	0.285	0.179	**0.839**

Bold values are the the square roots of AVE.

(437). After removing 98 incomplete responses based on missing and unfilled responses, the remaining 339 responses were retrieved and considered for further analysis. As per Hair et al. (2014), data size should be greater than 10 times the number of structural paths, leading to a particular parameter in the structural model, and the sample size used has met the criteria. To validate the questionnaire, academic and industrial experts analyzed the questionnaire before sending it directly to the respondents. A 5-point Likert scale was used to range the responses from 1 for "strongly disagree" to 5 for "strongly agree." The industrial and demographic information is shown in Table 2. All adopted measures are mentioned in Table 3.

3.2 Reliability and validity

This study used PLS-SEM to analyze the data using SmartPLS latest version 4. A measurement model was used to establish validity and reliability. In Table 3, we have all the measures (factor loadings (FL), Cronbach alpha (CA), composite reliability (CR), average variance extracted (AVE), and variance inflation factor (inner VIF)) to check the reliability and validity of data. All values meet the threshold criteria (Henseler et al., 2015; Kock, 2017; Hair Jr et al., 2021) (FL > 0.704, CA > 0.70, CR > 0.70, AVE >0.50, and inner VIF <5). Notably, all factor loadings exceed the recommended threshold of 0.704, confirming the reliability of the measurement model. The alpha values meet the threshold of 0.70, establishing high reliability by implying that the items within each construct consistently measure the intended latent variable. The AVE exceeds the recommended threshold of 0.50, indicating a substantial proportion of the variance in the observed construct is attributed to the underlying variable. Hence, reliability and validity are established, and all the values are shown in Table 3. GIC 7 was excluded due to low factor loadings, indicating insufficient contribution to the measurement of green intellectual capital, and all other items were kept for analysis.

Furthermore, two criteria were used to address discriminant validity: the HTMT and Fornell–Larcker criteria. Table 4 highlights that both criteria meet the threshold value (Henseler et al., 2015). The HTMT values are <0.85, and the diagonal elements in the Fornell–Larcker criterion are higher than the correlations with other constructs. The highest and lowest HTMT values are 0.084 and 0.330, respectively, and the square root of AVE for AC is 0.862, which is higher in the entire row and column. Hence, discriminant validity is also established.

3.3 Common method bias

This paper observed data using the variance inflation factor (both inner and outer VIF values) to address multicollinearity issues. We used VIF values to ensure the methodological robustness of our study and address potential common method bias. The careful consideration of VIF values strengthens the validity of our findings by minimizing the impact of common method bias. Table 5 shows that all VIF values meet the threshold (VIF <5) (Kock, 2017) (ranging from 1 to 1.18 for inner VIF), indicating that the data are a good fit for the model. VIF values are effective in identifying multicollinearity issues, but they may not capture all nuances related to common method bias. The reliance on statistical measures alone may not fully account for all potential sources of bias in survey-based research. F^2 or effect size is to identify the strength of the relationship in the endogenous variable explained by a specific exogenous construct that there are moderate, high, and satisfactory correlations as f^2 ranges from 0.060 to 0.101.

4 Results

4.1 R-square and adjusted R-square

The values of R-squared (R^2) and adjusted R-squared (R^2 adjusted) provide information about how well the independent variables explain the variance in the dependent variable and estimate the model's fitness. The explanatory power of a model

TABLE 5 Variance inflation factor and F-square.

VIF (inner)			
	CA	AC	GI
ER		1.006	
AC			1.000
GIC		1.160	
GI	1.000		
F-square			
	CA	AC	GI
ER		0.060	
AC			0.088
GIC		0.083	
GI	0.101		

TABLE 6 R-square and $PLS_{Predict}$ (HOC).

	R2	R2 adjusted	Q^2 predict	RMSE
CA	0.092	0.089	0.015	0.788
AC	0.137	0.129	0.114	0.752
GI	0.081	0.078	0.049	0.772
SRMR	0.047			
Chi-squared	619.338			
NFI	0.891			

can be quantified by calculating its R^2 value. For the AC, the R^2 value is 0.137, indicating that approximately 13.7% of the variance is explained by the exogenous variables over AC and the remaining 86.3% variation is unexplained in the model (see Table 6). To evaluate the predictive power of the model, researchers used the Q^2 value technique (Shmueli et al., 2019). $PLS_{Predict}$, SRMR, RMSE, chi-squared, and NFI values are used to predict the model's goodness of fit as R^2 does. Table 6 shows that the SRMR, chi-squared, and NFI values are 0.047, 619.338, and 0.891, respectively, suggesting that the model is a good fit. The value of SRMR suggests a good fit, indicating that the model's predicted correlations closely align with the observed correlations. A better model fit is indicated by a lower SRMR value. The value of NFI closer to 1 suggests a more accurate representation of the observed data. Q^2 helps determine how much an exogenous construct influences an endogenous construct. Q^2 values of CA, AC, and GI are 0.015, 0.114, and 0.049, respectively, which suggests a significant predictive importance of the model. These values represent the proportion of variance in each endogenous construct that is predictable based on the exogenous constructs. All other values are shown in Table 6.

4.2 Direct path analysis

The direct path analysis examines the direct relationships between the independent and dependent variables. Figure 2 shows all hypotheses from H1 to H3 are direct, positive, and significant. H1 suggests that GIC is positively associated with AC (beta-value = 0.289 and *p*-value 0.000), confirming a significant relationship. Further results are shown in Table 7.

4.3 Specific indirect path analysis/mediation

The specific indirect path analysis examined the mediating effect of constructs, and the total indirect path analysis suggests partial and full mediations. All mediating paths (H4a to H5) are positive, indirect, and significant. H4b shows that the mediating effect of GIC on CA through AC and GI is weak, positive, and significant (beta-value: 0.025; *p*-value: 0.000). All indirect paths are significant and partially mediated. Further results are shown in Table 8.

4.4 Moderation

In addition, we observed the moderating role of ER between GIC and AC. Table 9 highlights that the moderating path is found

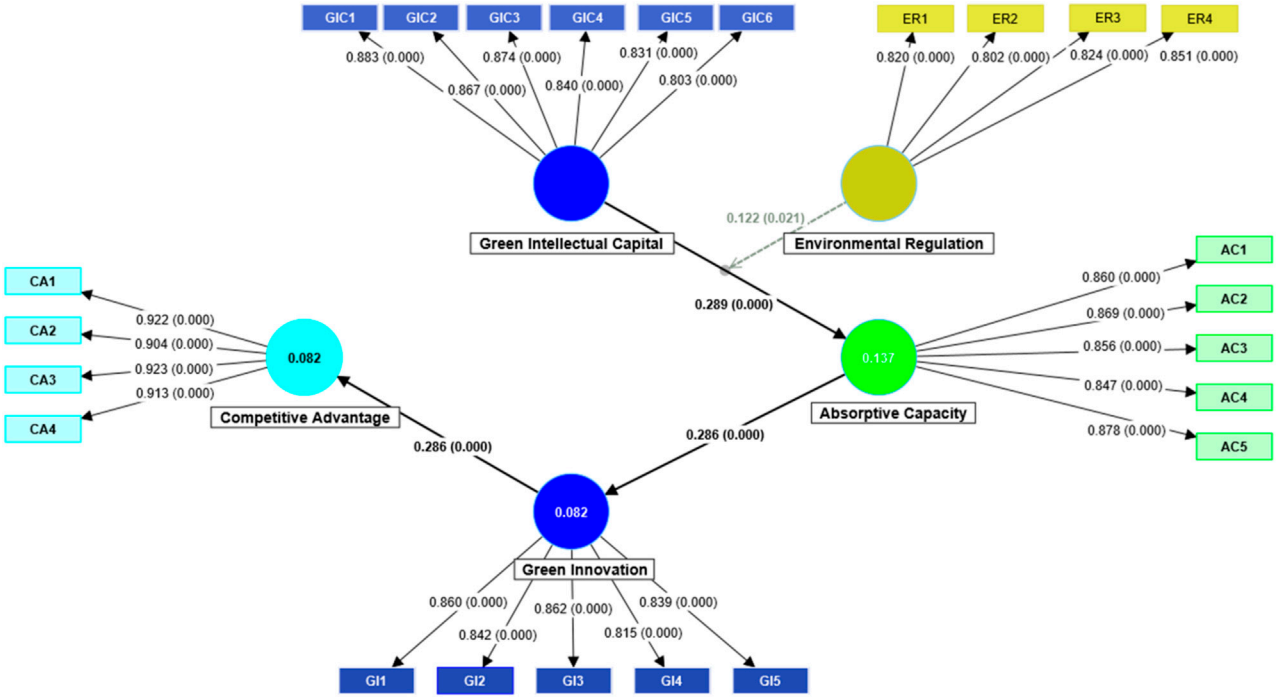

FIGURE 2
Structural model.

TABLE 7 Direct path analysis.

Direct path							
	Beta	SD	CIBC 2.5%		CIBC 97.5%	*p*-values	*Dec*
H1	*GIC - > AC*	0.289	0.066	0.159	0.419	0.000	*Sup*
H2	*AC - > GI*	0.286	0.060	0.160	0.394	0.000	*Sup*
H3	*GI - > CA*	0.286	0.058	0.182	0.410	0.000	*Sup*
	CIBC (confidence interval bias-corrected)						

TABLE 8 Specific indirect path analysis/mediation.

Mediation							
		Beta	SD	CIBC 2.5%	CIBC 97.5%	*p*-values	*Dec*
H4a	*GIC - > AC - > GI*	0.082	0.026	0.040	0.143	0.002	*Sup*
H4b	*GIC - > AC - > GI - > CA*	0.025	0.011	0.010	0.053	0.020	*Sup*
H5	*AC - > GI - > CA*	0.086	0.029	0.037	0.149	0.003	*Sup*
Total indirect path							
		Beta	SD	CIBC 2.5%	CIBC 97.5%	*p*-values	*Dec*
	GIC - > GI	0.082	0.026	0.040	0.143	0.002	*Sup*
	GIC - > CA	0.025	0.011	0.010	0.053	0.020	*Sup*
	AC - > CA	0.086	0.029	0.037	0.149	0.003	*Sup*

TABLE 9 Moderation.

Moderation							
		Beta	SD	CIBC 2.5%	CIBC 97.5%	*p*-values	*Dec*
H6	*ER x GI - > AC*	0.122	0.053	0.021	0.229	0.021	*Sup*

positive and significant with a beta-value of 0.122 and *p*-value of 0.021, suggesting the acceptance of hypothesis H6. Table 9 and Figure 3 show that ER strengthens the positive relationship between GIC and AC. The moderation result suggests that, in the context of Pakistani SMEs, compliance with ER strengthens the ability of an organization to absorb and utilize GIC effectively. SMEs should consider aligning strategies with ER to not only meet compliance standards but also enhance their AC, thereby fostering sustainable CA.

5 Discussion and findings

Findings reveal that GIC and AC are vital in enhancing GI and maintaining SMEs' competitive advantage. It has been observed that AC can enhance SMEs' green innovative performance through ER. The NRBV is effective for enhancing green performance and competitiveness when integrated with GIC and AC. Unlocking SMEs' potential requires continued government support, clear guidelines, incentives, addressing policy obstacles, and advice for a smooth transition toward a sustainable future (Kumar et al., 2022; Kumar et al., 2023). Furthermore, we have elaborated the discussion section in more detail in Table 10.

6 Conclusion

This study investigates vital interrelationships among constructs within the context of Pakistani SMEs. The model, grounded in the NRBV, examines the nexus involving GIC, AC, GI, ER, and CA. The study is significant in leveraging SMEs' competitive edge via GIC, facilitated by AC and ER. Notably, GIC has a direct and positive impact on AC and GI, affirming its significant role in shaping SMEs' innovative capacities. Mediation analyses underscore AC and GI's role in transmitting GIC's effects onto CA. ER's moderation role and its impact on GIC and AC emphasize the importance of aligning with external regulations. This collective insight underscores SMEs' need for a comprehensive sustainable innovation approach. The findings highlight that fostering GIC support CA through AC and GI strengthens the competitive advantage.

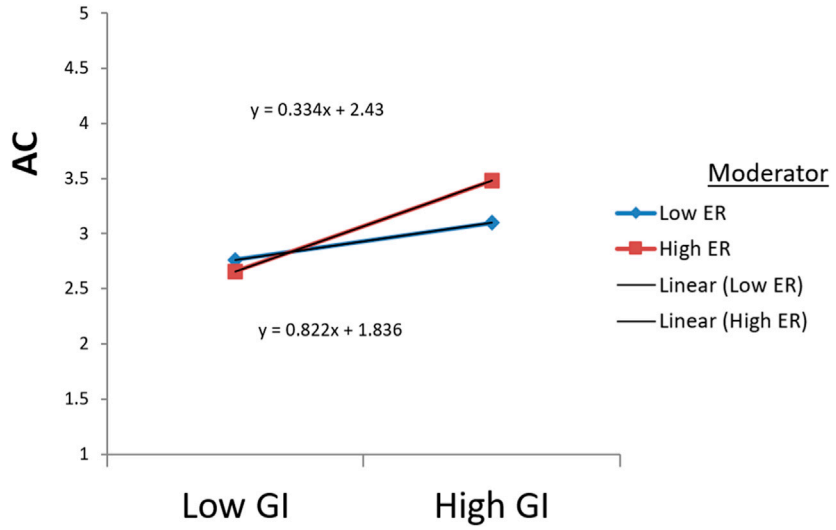

FIGURE 3
Moderation (ER*GI - > AC).

TABLE 10 Discussions and findings.

Author year	Research objectives	Key findings	Similarities/dissimilarities with our research findings
Mazon et al. (2023)	This paper examines how green innovation processes affect sustainable development and provides a research model combining absorptive capacity, green dynamic capability, and green service innovation to describe how these interactions work in universities	This study demonstrates the significance of adopting greening processes and incorporating sustainable goods within an organization. Additionally, it elucidates strategies for enhancing sustainability	The results of our study are similar to this study as it highlights the significance of AC in adopting GPI
Albort-Morant et al. (2018)	This study examines how knowledge-based internal and external pressures affect company green innovation. This research then examines green innovation success and absorptive aptitude, connection, learning, etc.	The empirical evidence suggests that the relationship between absorptive capacity and green innovation is influenced by relationship learning. Furthermore, both absorptive capacity and relationship learning have a significant positive effect on the dependent variable	Our model has consistent results with the underlying study as our finding suggests that AC significantly mediates the relationship between GIC and AC
Al Issa et al. (2023)	This research examines how green intellectual capital (GIC) components promote sustainable healthcare, as shown by sustainable performance. We also examined environmental disturbances and absorptive capacity (AC) moderators	The findings of this research indicate that GIC is a significant predictor of green performance, while only green human capital is a predictor of economic performance. AC plays a significant moderating role in the interplay between green performance, green structural capital, and green human capital	The findings of our study are consistent as they indicate that GIC significantly interprets the GI. AC significantly mediates the rations between GIC and GI in the manufacturing sector
(S. K. Singh et al., 2019)	This research used resource-based view (RBV) and dynamic capability (DC) frameworks to examine ideas from the literature concerning environmental ethics, training, performance, and competitive advantage	This study analyzed assumptions about environmental ethics, training, performance, and competitive advantage based on resource-based view (RBV) and dynamic capacity (DC) theories	The findings are consistent as we also used the NRBV to examine ideas from the literature, concerning ER, AC, GIC, and CA
Li et al. (2022)	This article aims to explore the relationships among environmental regulation (ER), technological innovation, and employment	This research found that the relationship between ER, employment, and innovation is complex. ER has a negative but significant effect on employment, which leads to lower the innovative capability of human intellectual capital	The results are also not consistent with the underlying study. ER has a positive and significant impact on the relationship between GIC (human capital is a major antecedent of GIC) and AC. This relationship suggests that ER may vary from firm to firm based on their working environment, capability, and cultural diversity. Managers and policymakers should design ERs as per the industry and organizational structure

6.1 Limitation and future recommendations

Limitations serve as potential avenues for future research, and this paper has underscored certain limitations. Conducting research in a specific region and organization restricts the data scope, limiting the generalizability of the results. The specific regional and organizational focus of our study may limit the applicability of results to other regions or industries. Furthermore, scholars often overlook Pakistan's distinct contextual factors, including regulations and market conditions. These factors could potentially exert varying influences on the connections between GIC, AC, GI, and firm competitiveness in the manufacturing sector, and the same study may have different findings in other countries, which can also be used for comparative analysis of future studies. To enhance the robustness of our findings and contribute to a more comprehensive understanding, future research should involve comparative analyses with studies conducted in other countries and industries. By systematically exploring the commonalities and disparities in the connections between GIC, AC, GI, and firm competitiveness, researchers can better discern the impact of contextual variables. This comparative analysis aids in comprehending how contextual variables affect the connections between GIC, AC, and performance outcomes across diverse contexts. Exploring the potential moderating influence of ER on linkages between GIC and AC would involve understanding Pakistan's unique regulatory constraints and opportunities, and the same effect may vary depending on different regions and types of industries. Integrating these future recommendations could enhance the validity, relevance, and practical application of research outcomes.

6.2 Theoretical implications

Using the NRBV, this study investigated the relationships between GIC and AC over GI and of GI over CA.

Within the context of sustainability and green practices, the findings of this study enrich the theoretical model proposed by the NRBV theory. Particularly, it highlights how GIC serves as a distinctive resource that, when leveraged effectively through AC and GI, provides SMEs with a sustainable CA. This extension of the NRBV to the green realm advances the understanding of how green resources contribute to enhancing environmental performance, aligning with the broader goals of sustainable development. SMEs in developing nations can unlock circular growth by embracing not just digital innovation but also the circular economy, driven by entrepreneurship direction and market direction toward sustainability (Dwivedi et al., 2023). Achieving sustainable growth in manufacturing requires prioritizing greenhouse gas performance and encouraging low-carbon products to ensure a green and sustainable future for manufacturing SMEs (Dwivedi et al., 2023).

Furthermore, our model contributes to the existing theory of NRBV by extending its application to the context of sustainability and green practices (Hart, 1995; Campbell, 2007). Furthermore, the positive moderation effect of ER on the relationship between GIC and AC underscores the importance of supportive ER. Policymakers should consider these findings to design and implement regulations that not only encourage but also strengthen the relationship between GIC and AC in the context of SMEs in Pakistan. This can, in turn, contribute to the overall sustainable development goals of the country. This model goes beyond theoretical exploration by offering empirical validation of the main arguments proposed by the NRBV. Particularly, the findings of this study substantiate the NRBV theory claim that AC and GI are integral and vital green resources that significantly boost the performance of firms. The empirical results underscore the CA gained by SMEs through the effective utilization of AC and GI, aligning with the fundamental ideas of the NRBV. This confirmation further emphasizes the relevance and applicability of the NRBV theory in the context of green practices within the SME's manufacturing sector.

Data availability statement

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent (from the patients/participants or patients'/participants' legal guardian/next of kin) was not required to participate in this study in accordance with the national legislation and institutional requirements.

Author contributions

JS: conceptualization, data curation, formal analysis, investigation, methodology, project administration, software, supervision, validation, visualization, writing–original draft, and writing–review and editing. TH: conceptualization, methodology, supervision, validation, and writing–review and editing. IJ: conceptualization, formal analysis, methodology, and writing–review and editing. SA: data curation, investigation, methodology, validation, and writing–original draft. FE: data curation, formal analysis, investigation, software, validation, and writing–review and editing. AD: Methodology, funding acquisition, data curation, resources, validation, and writing–review and editing. MH: Conceptualization, methodology, data curation, formal analysis, investigation, validation, software, and writing–review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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