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Green Entrepreneurial Orientation and Sustainable Performance: A Moderated Mediation Analysis in Chinese Manufacturing

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Abstract: This study investigates the mechanisms through which green entrepreneurial orientation (GEO) influences sustainable performance (SuP) in Chinese manufacturing enterprises, focusing on the mediating role of green intellectual capital (GIC) and the moderating effect of environmental uncertainty (EU). Drawing on the Resource-Based View and Natural Resource Base View, we develop and test a moderated mediation model using data from 486 Chinese manufacturing firms. Results from partial least squares structural equation modeling (PLS-SEM) reveal that GEO positively influences SuP both directly and indirectly through GIC. Moreover, EU negatively moderates the relationship between GIC and SuP. These findings contribute to the literature on green entrepreneurship and sustainable performance by elucidating the complex relationships among GEO, GIC, EU, and SuP in the context of Chinese manufacturing. The study offers important implications for theory development and managerial practice in promoting sustainable development in manufacturing industries.

Keywords: Environmental uncertainty; Green Entrepreneurial Orientation; Green Intellectual Capital; SmartPLS; Sustainable Performance

1 INTRODUCTION

The traditional extensive production model, while generating significant short-term economic benefits for enterprises, has also led to severe environmental issues [1]. The negative impacts of economic growth on the environment have gradually increased, contributing to the continuous escalation of global environmental crises [2]. This production approach, characterized by high resource consumption and inefficiency, has caused widespread ecological degradation, including exacerbated pollution, resource depletion, and the imbalance of ecosystems [3, 4]. The conflict between economic efficiency and environmental degradation is intensifying, leading to a public demand for sustainable development. More than 138 countries around the world have proposed "carbon-free" or "carbon-neutral" targets. The Chinese government has additionally enacted various environmental policies and regulations that set higher sustainability requirements for companies and require them to disclose environmental information [5]. Simultaneously, green products are increasingly seen as a consumer advantage and a significant preference for consumers [6], who are willing to buy environmentally friendly products and pay a premium for them. For example, the explosive growth of new energy vehicles in Europe, America and Asia has led to the gradual recognition of "green cars" by consumers [7]. This change has also prompted companies to accelerate the pace of green transformation under the triple pressure of environmental pollution, policy constraints and social demands.

In this context, based on the Resource-Based View (RBV), some scholars argue that entrepreneurial activities can address environmental issues [8]. However, the impact of entrepreneurship on the environment is dual-sided: on one hand, it may result in environmental pollution, ecological degradation, and the depletion of non-renewable resources; on the other hand, it can also drive innovation to solve environmental problems [9]. The RBV posits that a firm's sustained competitive advantage stems from its internally possessed scarce and inimitable resources and capabilities. As a novel topic in the field of entrepreneurship, green entrepreneurial orientation enables firms to protect the environment while pursuing economic benefits, garnering sustained attention from both academia and business managers [10]. Although existing studies have mainly explored the relationship between GEO and green innovation, suggesting that green entrepreneurial orientation has a catalytic effect on green incremental innovation and green radical innovation [11], there are also some studies that confirm the positive impact of green entrepreneurial orientation on firms' financial performance [12], but ignore its key role in driving sustainable performance. Moreover, green intellectual capital, as a core resource of a firm, encompasses the knowledge, skills, and abilities that organizational employees contribute to creating and managing sustainable value, with the aim of integrating environmental protection principles into business operations [13]. Green intellectual capital supports firms in building sustainable development.

However, the existing literature has insufficiently addressed the role of green intellectual capital in implementing green entrepreneurial orientation and enhancing sustainable performance, and there is also a lack of research on environmental uncertainty. Environmental uncertainty refers to technological uncertainty and demand uncertainty [14], and current studies seldom consider the external environmental changes that firms face during the implementation of green entrepreneurial orientation [15]. In highly uncertain environments, firms need to be more flexible and innovative to respond to challenges.

Therefore, this study aims to emphasize how firms can effectively integrate and utilize internal resources to gain sustainable advantages when facing external environmental challenges, based on the Resource-Based View (RBV) theory. It explores the pathways through which green entrepreneurial orientation influences sustainable performance, focusing on the mediating role of green intellectual capital and the moderating effect of environmental uncertainty. By employing Structural Equation Modeling with Partial Least Squares (SEM-PLS) to analyze questionnaire data from Chinese manufacturing enterprises, the study validates the relationships among the variables. The findings provide empirical support for the theoretical model and offer managerial recommendations for firms on how to respond to environmental uncertainty and enhance sustainable performance during the green transformation process.

2 LITERATURE REVIEW

2.1 Green Entrepreneurial Orientation and Sustainable Performance

The growing number of environmental issues in the world gave rise to the idea of "green entrepreneurship." Many international organizations stress the need of businesses embracing a green business paradigm and call for a worldwide shift to green development [16]. Green business orientation is a strategic approach in which companies proactively adopt various environmental measures, innovations and management practices with environmental protection and sustainable development at the center of their business processes. Academics generally agree that an entrepreneurial mindset improves the success of businesses. Instead of only concentrating on generating short-term profits, entrepreneurs are now also adopting social responsibility and long-term corporate sustainability [17]. Elkington [18] introduced the concept of SuP and argued for corporate development that considers the natural environment, social and economic performance simultaneously. This perspective has been recognized by a wide range of scholars [19] and it is consistent with the triple bottom line principle, which emphasizes that SuP should prioritize social responsibility and environmental preservation in addition to economic rewards [20].

GEO has been shown to make it easier for companies to engage in green activities, enabling them to seize development opportunities and gain new competitive advantages amid complex environmental changes [12]. Previous studies have documented the influence of GEO on various facets of business operations, including green innovation and green management [21]. Ullah and Qaiser Danish [22] found that a GEO can stimulate firms to innovate and adopt environmentally friendly production methods, thereby positively impacting performance. Companies with a GEO have a higher level of environmental performance [23]. Fatoki [20] discovered a strong relationship between GEO and financial, environmental and social performance. Thus, this research posits the following hypotheses.

H1: Green entrepreneurial orientation has a positive impact on sustainable performance.

2.2 Green Entrepreneurial Orientation and Green Intellectual Capital

The concept of GIC was originally introduced by Chen [24] and has since gained wide recognition. Organizational intellectual capital is the combined inventory of intangible assets, information, skills, and connections held by people and organizations inside a company who are involved in environmental preservation or green innovation [25, 26]. Based on the resource-based view (RBV), organizations that implement a particular strategy can accumulate a set of resources aligned with that strategy. Organizations that adopt a green business orientation focus on integrating green technologies into their production processes and strive to minimize resource consumption [27]. This promotes environmental awareness among organizational members, facilitates the accumulation of knowledge, experience and skills related to environmental protection [24], and culminates in the creation of green capital. A company's strategic development and commitment significantly influence employee behavior [19]. Companies actively engage in environmental initiatives and collaborate with various stakeholders such as government agencies, non-governmental organizations (NGOs) and customers to cultivate a green corporate ecosystem. This collaboration enables employees to acquire advanced environmental technologies and management skills while promoting the development of green relational capital. Therefore, the study hypothesizes the following.

H2: Green entrepreneurial orientation has a positive effect on green intellectual capital.

2.3 Green Intellectual Capital and Sustainable Performance from an Intellectual Capital Perspective

Knowledge is the most important strategic resource for any organization. The intellectual capital perspective highlights the central role of intellectual resources, including knowledge, skills and innovation, within organizations, especially in today's knowledge-based economy and innovation-driven era. Within the intellectual capital perspective, sustainability serves as a driving force for the development of future organizations that are able to meet the challenges of sustainable development through knowledge [28]. Intellectual capital plays a crucial role in sustainable development as it provides an effective organizational approach to achieve both economic and social benefits [29]. Cavicchi and Vagnoni [30] believe that intellectual capital forms the basis for sustainable activities in companies. GIC represents a special form of intellectual resource that emphasizes non-economic goals, promotes sustainable thinking and helps companies achieve long-term competitive advantages [24]. In addition to improving environmental performance, GIC facilitates effective resource management in the manufacturing process, which lowers operating costs and boosts the business's overall performance [31]. Therefore, the study hypothesizes the following.

H3: Green intellectual capital has a positive impact on sustainable performance.

2.4 The Mediating Role of Green Intellectual Capital in Green Entrepreneurial Orientation and Sustainable Performance

The RBV theory assumes that resources and capabilities within an organization are critical to achieving competitive advantage. By implementing green strategies, organizations can invest in and accumulate various forms of GIC, including expertise, technical know-how and green brand reputation. The use of GIC to develop new products that meet the environmental protection needs of stakeholders not only improves a company's environmental image [32], but also strengthens its competitiveness in the field of sustainability and environmental protection [19]. In addition, building GIC contributes internally to the SuP of the company, which brings economic, environmental and social benefits [32]. As a result, the research makes the hypotheses that follow.

H4: Green intellectual capital mediates the relationship between green entrepreneurial orientation and sustainable performance.

2.5 The Moderating Role of Environmental Uncertainty in Green Entrepreneurial Orientation and Sustainable Performance

Green Entrepreneurial Orientation, which is recognized as an important organizational resource, is believed to positively influence the SuP of firms [19]. According to RBV theory, organizations facing technological and demand-side uncertainty tend to rely more on internal resources to compensate for the instability of the external environment. Increasing EU poses a huge challenge for organizations and makes it difficult to accurately predict and respond to future trends [33, 34]. Firms need to consider their own resources and capabilities and adopt proactive approaches to manage environmental performance in order to achieve sustainable development [35]. This can affect the effectiveness of organizational knowledge acquisition, technological innovation and collaboration between organizational members [36], forcing companies to make major investments to acquire additional knowledge and new skills from external sources [34]. In essence, the knowledge and skills inherent in firms' resources may hinder their adaptability and anticipation of changes in the external environment and consequently reduce their efficiency in addressing environmental challenges. This potential reduction in the positive effect of GIC on SuP forms the basis for the following hypothesis put forward in this study.

H5: Environmental uncertainty moderates the relationship between Green intellectual capital and corporate sustainable performance.

Fig. 1 shows the research framework.

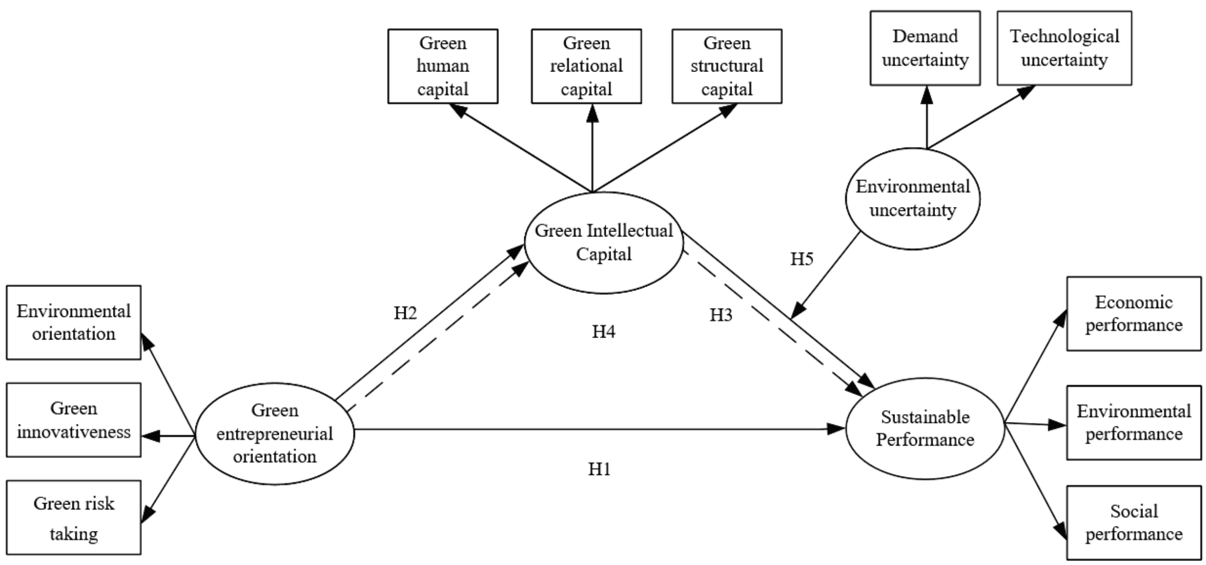

Figure 1 Conceptual Framework

3 MATERIAL AND METHODS

3.1 Measures

The study utilized the Environmental Orientation (EO), Green innovativeness (GI), Green risk taking (GRT) to measure GEO, which has been validated in previous research [37]. This scale comprises 10 items. To measure GIC, the study employed the Green human capital (GHC), Green relational capital (GRC), Green structural capital (GSC) to measure GIC, which has been validated in previous research [38], consisting of 12 items. For SuP, the study used the Economic performance (EcP), Environmental performance (EP), Social performance (SP) to measure SuP, which has been validated in previous research [39], which include 13 items. The study also measured EU using the Demand uncertainty (DU), Technological uncertainty (TU) scales, validated by Wu [14], comprising 6 items. All the reference scales for CEO, GIC, SuP, and EU demonstrated good reliability (with all $CR > 0.7$) and utilized a 5-point Likert scale.

3.2 Population, Sample, and Data Collection

Manufacturing is an important pillar of China's economic development, but also the most resource-consuming industry, so how to balance the development of the manufacturing industry and environmental governance is a difficult problem that needs to be dealt with urgently. In this study, the manufacturing industry in China was selected as the research area, and CEOs or departmental managers and deputy managers of manufacturing enterprises were the research subjects. The study used a questionnaire to obtain data, and data collection lasted two months. After eliminating the samples with the same answers to multiple questions and too short filling time, 486 valid questionnaires were obtained. Specifically, according to the China Statistical Yearbook 2023, 335 questionnaires were sent to the Light Textile Industry (29%), 424 to the Resource Processing Industry (36%), and 411 to the Machinery and Electronic Manufacturing sector (approximately 35%), totaling 1170 questionnaires. Data collection spanned two months. After excluding samples with multiple identical answers and excessively short completion times, 486 valid questionnaires were obtained. Of these, 323 respondents were male (66.46%) and 163 female (33.54%). In terms of education, 12 respondents had a secondary school degree or less (2.47%), 56 had a junior college degree (11.52%), 322 had a college degree (66.26%), and 96 had a postgraduate degree or higher (19.75%). In terms of age, 45 of the respondents were under 30 years old (9.26%), 138 were between 31 and 40 years old (28.40%), 204 were between 41 and 50 years old (41.98%) and 99 were over 51 years old (20.37%). The sample comprised 79 general managers (16.26%), 342 middle managers (70.37%) and 65 top managers (13.37%). In terms of company size, 77 companies had 51-299 employees (15.84%), 264 had 300-1000 employees (54.32%) and 145 had 1,000 or more employees (29.84%). In addition, 133 companies were in the textile industry (27.37%), 196 in the raw materials processing industry (40.33%) and 157 in the machinery and electronics industry (32.30%).

SPSS was used for data collection, screening, demographic analysis and descriptive analysis. In this study, SmartPLS was used for both measurement model and structural model analysis. Compared to other methods, Partial Least Squares Structural Equation Modeling (PLS-SEM) is particularly well-suited for handling complex multi-structured models and managing intricate causal relationships between variables. Moreover, PLS-SEM does not require the data to strictly adhere to normal distribution assumptions, making it effective in generating reliable results even when sample sizes are limited or data distribution is skewed. Therefore, this study employs PLS-SEM to ensure the robustness of the research model and the validity of the findings.

Additionally, to address common method bias, measures such as reverse-coded items and randomized response order were incorporated into the questionnaire design to mitigate its effects. During the data collection process, ethical norms were followed, all participants gave informed consent, and the data were kept strictly confidential to ensure the legitimacy of the study and the voluntary nature of participation.

4 RESULTS

The model presented in this study is a higher-order model characterized by a reflective-reflective structure and was calculated using the repeated indicators method. Consequently, the analyses of the measurement model and the structural model were performed after the construction of the model using the repeated indicators method (see Fig. 2).

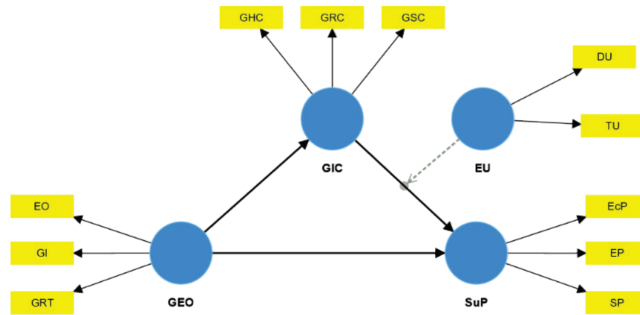

Figure 2 Reduced Form Model

4.1 Assessment of the Measurement Model

Following the methodology proposed by Roldán and Sánchez-Franco [40], we first analyzed the loadings of the indicators (>0.7) [41], Cronbach's alpha (α> 0.7), composite reliability (*CR* > 0.7) [42] and average variance extracted (*AVE* > 0.5) [43, 44]. The present study uses PLS to calculate these metrics and confirms that they exceed the thresholds recommended in the literature (see Tab. 1).

Table 1 Validity and reliability of measurement model

	Item	Loadings	*α*	*CR*	*AVE*
Green entrepreneurial orientation	Environmental orientation	0.852	0.784	0.793	0.698
	Green innovativeness	0.869			
	Green risk-taking	0.783			
Green intellectual capital	Green human capital	0.838	0.796	0.796	0.710
	Green relational capital	0.844			
	Green structural capital	0.845			
Sustainable performance	Economic performance	0.831	0.794	0.794	0.708
	Environmental performance	0.849			
	Social performance	0.845			
Environmental uncertainty	Demand uncertainty	0.887	0.722	0.723	0.783
	Technological uncertainty	0.882			

Furthermore, we performed a discriminant validity calculation to accurately assess the extent of differentiation and independence between the different constructs. In our analysis, we followed closely the criteria described by Fornell and Larcker [45] and compared the Average Variance Extracted (*AVE*) values of each construct with its squared variance. This comparison ensures that each construct adequately explains its respective metrics while maintaining its exclusivity. The results of these comparisons can be found in Tab. 2.

In addition, we analyzed the values of the external loading metrics for each of the constructs of cross loadings. These values (in bold) were all significantly higher than any of their cross-loading values on the other constructs, in line with the criteria of [46], further confirming the differentiation of the constructs (see Tab. 3).

Table 2 Fornell-Larcker Criterion

	EU	GEO	GIC	SuP
EU	0.885			
GEO	–0.303	0.836		
GIC	–0.301	0.571	0.843	
SuP	–0.324	0.573	0.518	0.842

Table 3 Cross Loading Analysis

	GEO	GIC	SuP	EU	EU × GIC
EO	0.852	0.474	0.448	–0.207	–0.099
GI	0.869	0.540	0.519	–0.267	–0.159
GRT	0.783	0.408	0.465	–0.289	–0.085
GHC	0.482	0.838	0.436	–0.283	–0.109
GRC	0.500	0.845	0.432	–0.251	–0.063
GSC	0.461	0.845	0.441	–0.226	–0.114
EcP	0.471	0.438	0.831	–0.290	–0.308
EP	0.472	0.433	0.849	–0.261	–0.336
SP	0.502	0.436	0.845	–0.267	–0.321
DU	–0.271	–0.233	–0.289	0.887	0.046
TU	–0.266	–0.301	–0.284	0.882	0.027
EU × GIC	–0.140	–0.113	–0.382	0.041	1.000

For a more comprehensive assessment of discriminant validity, we incorporated the Heterotrait-Monotrait Ratio of Correlations ($HTMT < 0.9$) as proposed by Henseler, Ringle and Sarstedt [47] as an evaluation criterion. After completing the PLS calculation, we found that the HTMT for all constructs was below 0.9, which confirmed the discriminant validity of our constructed model. The detailed results can be found in Tab. 4.

Table 4 Heterotrait-Monotrait Ratio (HTMT)

	EU	GEO	GIC	SuP	EU × GIC
EU					
GEO	0.404				
GIC	0.397	0.718			
SuP	0.428	0.724	0.652		
EU × GIC	0.048	0.154	0.127	0.429	

4.2 Structural Modelling Evaluation

(1) Collinearity Issue

In this study, GEO, GIC, SuP and EU are all second-order variables and should ideally show no covariance between the indicators of the individual structures. Multicollinearity is usually assessed using the variance inflation factor (*VIF*). If the *VIF* reaches or exceeds a value of 5 or falls below 0.2, problems with covariance may occur [41]. In our study, the values of *VIF* ranged from 1.453 to 1.820. Hence, the issue of covariance does not adversely affect the path coefficients of the structural model in this study.

(2) Model Fit

The SRMR of this model is 0.066 (<0.08) [48], d_ULS is 0.289 (<0.95), and d_G is 0.170 (<0.95) [49] indicating that the model has a good fit to the set of sample data. Hypothesis testing can be performed.

(3) Structural Model Relationship

Using the bootstrap method offered by SmartPLS, the sample size was set to 5000 and the significance level was set to 0.05. Structural equation modeling was then performed to derive the path relationships (β) between the variables along with the corresponding t-values, p-values and 95% confidence intervals (95% *CI*) (see Tab. 5). The research hypotheses H1, H2, H3, H4 and H5 were then validated (see Fig. 3).

Table 5 Bootstrapping results for structural model evaluation

Hypothesis	Relationship	β	t-value	95% *CI*	Decision
H1	GEO→SuP	0.352	8.254***	[0.268, 0.435]	Supported
H2	GEO→GIC	0.571	19.018***	[0.511, 0.631]	Supported
H3	GIC→SuP	0.243	5.257***	[0.151, 0.335]	Supported
H4	GEO→GIC→SuP	0.139	5.020 ***	[0.086, 0.194]	Supported
H5	EU x GIC→SuP	–0.304	8.643 ***	[-0.372, -0.233]	Supported

Note: * denotes $P < .05$, ** denotes $P < .01$, *** denotes $P < .001$

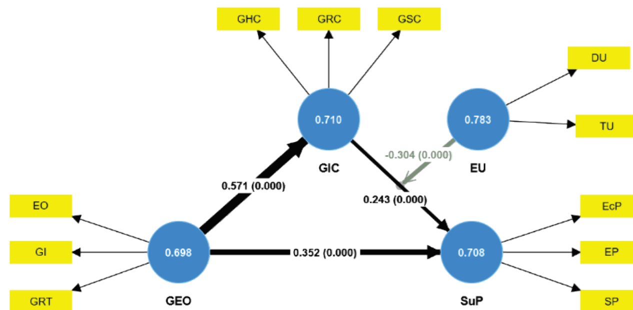

Figure 3 Evaluation of the Structural model (Note: Thicker arrow line means that the effect of independent variable on dependent variable is higher.)

Table 6 Mediation effect test

Hypothesis	Independent variable	Mediating variable	Dependent variable	Direct effect	Indirect effect	Total effect	VAF	Decision
H4	GEO	GIC	SuP	0.352	0.139	0.491	0.283	Partial

Notes: bootstrapping ($n = 5000$).

In addition, this study investigated the mediating effect of GIC. The mediating effect is only considered valid if the direct effect of the non-mediator is significant and the indirect effect of the mediator is significant. Our results show that GEO exerted a direct effect on SuP and GEO also had a significant indirect effect on SuP through GIC (see Tab. 5), indicating a potential mediating effect. In addition, the variance explained (*VAF*) was estimated to measure the magnitude of the mediating effects. In this study, a *VAF* value of 0.283, ranging from 0.2 to 0.8, suggests that GIC partially mediates the relationship between GEO and SuP (see Tab. 6).

When analyzing the predictive power of the endogenous structure, a key indicator we look at is R^2. The R^2 values for SuP, which are 0.326 and 0.485 respectively, indicate weak predictive power based on the classification criteria established by Hair Jr, Babin and Anderson [42]. Another critical indicator is f^2, which measures the extent of the effect of the explanatory variables on the endogenous variables. The f^2 values in this study ranged from 0.075 to 0.484, which meets the criteria for judgement. Following Cohen [50] criteria, we find that the effect of GEO on GIC reaches a large effect level. Conversely, GIC shows the smallest effect on SuP and is in the small effect range. To evaluate the predictive accuracy of the model, we calculated the Stone-Geisser test (Q^2), which according to [51] must be greater than 0. Our analysis shows that both GIC (0.227) and SuP (0.334) exceed this threshold (see Table 7). To summarize, despite the R^2 value indicating weak predictive power, the model is reliable to elucidate the relationship between endogenous variables and the predictive accuracy is satisfactory as evidenced by f^2 and Q^2.

5 DISCUSSIONS AND IMPLICATIONS

5.1 Discussion

In response to increasing pressures from environmental concerns, regulatory measures and changing consumer demands, organizations are becoming more motivated to enhance their performance improvement methods by strategically implementing corporate initiatives. This study examines the relationships among green entrepreneurial orientation (GEO), green intellectual capital (GIC), environmental uncertainty (EU), and sustainable performance (SuP) in the context of Chinese manufacturing enterprises. The findings underscore the pivotal role of GEO in driving SuP, as well as the mediating effect of GIC on the relationship between GEO and SuP.

GEO has a positive impact on SuP ($\beta = 0.352, p < 0.001$). We found a positive correlation between GEO and SuP, consistent with recent studies in the business field. For instance, research by Jiang, Chai, Shao and Feng [12] and Fatoki [20], focusing on Chinese enterprises and the South African hotel industry, respectively, confirmed similar phenomena. Sustainable development is closely related to entrepreneurial intentions [52]. Adopting GEO not only helps firms better fulfill their social and environmental responsibilities but also enables them to gain a competitive edge in a fiercely competitive market.

Furthermore, this study shows a positive relationship between GEO and GIC ($\beta = 0.571, p < 0.001$), a finding that differs from previous research. While Wu and Yu [53] postulated a significant positive correlation between GIC and entrepreneurial orientation based on hospital samples and emphasized the constructive effects of relational and structural capital on entrepreneurial orientation, the study conducted by Al-Jinini, Dahiyat and Bontis [54] uncovered the positive influence of intellectual capital on entrepreneurial orientation using Jordanian SMEs as the research cohort. However, despite the intertwining of entrepreneurial orientation and GEO, the latter places a greater emphasis on green business development. This focus not only strengthens market competitiveness but also effectively promotes the accumulation and value enhancement of GIC. In addition, small and medium-sized enterprises (SMEs), constrained by limited resources and facing intense competition in the market, often encounter challenges in pursuing green development before they reach a certain scale. As Chen [24] points out, a deep understanding of the green industry is essential for companies to succeed in the environmentally conscious market. Structuring and utilising corporate resources enables resource accumulation [55]. By adopting a GEO, companies acquire expertise about the green market through practical experience. Consequently, GEO exerts a positive influence on GIC.

Furthermore, this study confirms the positive influence of GIC on SuP ($\beta = 0.243$, $p < 0.001$). From an intellectual capital perspective, the GIC proves to be a crucial catalyst for the SuP of companies. It facilitates companies to achieve environmental innovation, adaptability and resource efficiency, laying the foundation for long-term success in a changing business landscape. This finding aligns with Yusliza, Yong, Tanveer, Ramayah, Faezah and Muhammad [19], who emphasized the pivotal role of GIC in addressing environmental issues and its significant contribution to sustainable performance. Additionally, Martínez-Falcó, Sánchez-García, Millan-Tudela and Marco-Lajara [31] further confirmed this relationship using a sample of Spanish wineries.

This study highlights the mediating role of GIC between GEO and SuP ($\beta = 0.139$, $p < 0.001$) and uncovers the inherent link between corporate strategy, intellectual capital and performance. Collaborative networks have an impact in promoting innovation [56]. The adoption of green strategies by companies in conjunction with the advancement of green supply chain management [39] facilitates collaboration and information sharing between different stakeholders. This dissemination of knowledge empowers corporate managers to integrate environmental principles more skillfully and promotes the accumulation of GIC, thereby improving SuP.

Nevertheless, the negative moderating effect of EU on the relationship between GIC and SuP ($\beta = -0.304$, $p < 0.001$). The application of entrepreneurial methods enables firms to continuously accumulate capital and effectively respond to the ever-changing market environment [57]. Dangelico and Pontrandolfo [58] demonstrated, based on the Natural Resource-Based View, that environmental management capabilities significantly influence both the market competitiveness and performance of enterprises. Due to fluctuations in environmental regulations, uncertainties in technological innovations, and variations in consumer demand for sustainable products, companies face multifaceted challenges in green entrepreneurship [14]. This finding aligns with the resource dependency theory, which posits that organizations facing uncertainties tend to rely more heavily on internal resources to compensate for external instability [36]. These environmental uncertainties not only test a firm's strategic vision and responsiveness but also profoundly impact its green intellectual capital and sustainable performance.

5.2 Theoretical Implication

The RBV emphasizes that firms can achieve competitive advantage by integrating internal and external resources. This study, grounded in the RBV, deepens the understanding of how firms can achieve sustainable development in the context of finite natural resources and environmental pressures. Our research reveals that the implementation of GEO actively fosters the accumulation and development of GIC, providing new insights into the resource accumulation process and extending the application of RBV in green management. Furthermore, while previous studies have often overlooked the specific pathways through which GEO affects SuP, this study not only confirms the importance of GIC as a mediating variable but also highlights how GEO influences the accumulation of internal green resources, thereby enhancing firms' sustainable performance. This provides a more comprehensive theoretical framework for understanding the relationship between GEO and sustainable development pathways. Finally, the study explores the complex interactions between EU, GEO, GIC, and SuP, revealing how firms navigate environmental uncertainty in the process of green resource accumulation and entrepreneurial orientation to optimize their sustainable performance. This provides a new perspective on how firms can strategically adapt and allocate green resources in uncertain market conditions to achieve green entrepreneurial success and long-term sustainable development.

5.3 Managerial Implication

This study provides significant managerial implications for Chinese manufacturing firms, particularly in resource management and addressing environmental uncertainty. First, firms should position GEO as the core of their strategy, integrating resource and environmental management to address the constraints of finite natural resources and environmental pressures. Managers should prioritize sustainability by embedding it deeply into strategic planning and day-to-day operations to ensure a competitive edge in future markets. Second, firms need to strengthen the accumulation and management of GIC by implementing employee training programs, adopting green technologies and knowledge, and enhancing green innovation capabilities. For Chinese manufacturing enterprises, managers can establish dedicated green R&D departments and collaborate with external research institutions to drive green technology innovation and product-service upgrades, thereby creating a differentiated advantage in green competition. Furthermore, in the face of EU, firms must flexibly adjust their strategies and product designs to adapt to changing conditions. Companies should also establish effective market sensing and response mechanisms, continuously accumulating GIC to promote green technology innovation and product development, thereby driving the green transformation of the supply chain. Managers can leverage both internal R&D and external collaborations to proactively respond to market dynamics and shifts in consumer demands, ensuring long-term sustainable development in a highly competitive landscape. These strategies are not only applicable to the Chinese manufacturing sector but also offer valuable managerial insights for firms in other regions worldwide.

6 CONCLUSION

This study advances our understanding of the relationship between green entrepreneurial orientation and sustainable performance in Chinese manufacturing enterprises. By identifying the mediating role of green intellectual capital and the moderating effect of environmental uncertainty, we provide a more nuanced view of how firms can leverage their green strategies to enhance sustainability outcomes. Our findings highlight the importance of developing green intellectual capital as a key mechanism for translating green entrepreneurial orientation into improved sustainable performance. However, the negative moderating effect of environmental uncertainty underscores the challenges firms face in maintaining performance in volatile environments. These insights offer valuable guidance for managers seeking to implement effective sustainability strategies in the manufacturing sector. Future research should explore these relationships in different industrial and national contexts, consider potential non-linear effects, and investigate additional mediators and moderators to further refine our understanding of the green entrepreneurship-sustainability performance link.

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