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GREEN ENTREPRENEURIAL ORIENTATION AND SUSTAINABLE PERFORMANCE IN CHINESE SMES: A DUAL-PATH MEDIATION AND MODERATION ANALYSIS

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ABSTRACT

In the context of global sustainable development and China's "dual carbon" goals, small and medium-sized enterprises (SMEs) play a vital role in China's economic transformation. They must balance economic growth with environmental responsibility. This study, grounded in resource-based view theory, dynamic capabilities theory, and contingency theory, proposes a dual-mediation model: Green entrepreneurial orientation - green innovation - green supply chain management - sustainable performance. It also examines green technology dynamism as a moderating factor to evaluate how green entrepreneurial orientation influences the sustainable performance of specialized and sophisticated SMEs in China. Using the partial least squares structural equation model (PLS-SEM) and data from 369 SMEs, the study revealed: (1) Green entrepreneurial orientation significantly enhances sustainable performance, highlighting the importance of green entrepreneurial strategies; (2) Green innovation and green supply chain management partially mediate the relationship between green entrepreneurial orientation and sustainability performance, with green innovation having a more substantial impact, suggesting it is a key pathway for translating green entrepreneurial into sustainable performance benefits; (3) Green technology dynamism positively moderates the pathways from green entrepreneurial orientation and sustainability performance, green innovation to sustainability performance, and green supply chain to sustainability performance. These findings expand the theoretical understanding of green entrepreneurial in Chinese SMEs, clarify the dual-path mechanism of green innovation and green supply chain management, and enrich green entrepreneurship research through the lens of dynamic capabilities. They also offer theoretical and practical insights for SME managers and policymakers in adopting green strategies.

KEYWORDS: Green Entrepreneurial Orientation, Green Innovation, Green Supply Chain Management, Green Technology Dynamism, Sustainable Performance, SRDI SMEs, Dual-Path Mediation Moderation Analysis.

1. INTRODUCTION

Amid escalating global environmental challenges, the push for green and low-carbon transformation, along with coordinated ecological development, has become an urgent international concern (Wang et al., 2024). As stated in the China's "dual carbon" strategic plan, small and medium-sized enterprises (SMEs) are crucial for promoting green and sustainable transformation due to their significant economic impact (Liu et al., 2024). Consistently, research indicates that SMEs are vital for achieving national carbon neutrality goals and are instrumental in advancing green technologies and sustainable innovation (Wu et al., 2024). Thus, thoroughly exploring the green transformation pathways for SMEs within the nation "dual carbon" framework holds substantial theoretical and practical significance.

Amongst the SMEs, specialized, refined, distinctive, and innovative SMEs (SRDI SMEs) represent the most dynamic segment of the SME sector, serving as a key driver of technological advancements, green transformations, global supply chain stabilization, and the low-carbon transition in the global economy (Sun et al., 2024). As reported by Chinese Ministry of Industry and Information Technology (2025), by mid-2025, China had established over 140,000 provincial-level SRDI SMEs, and these SMEs play a vital role in foundational manufacturing areas, enhancing industrial chains and promoting high-quality manufacturing development. Despite of their significant contribution to the nation growth, SRDI SMEs face unique structural challenges specifically the resource constraints and diseconomies of scale which result in high environmental input costs. Additionally, technological specialization can lead to path dependence and green technology lock-in, increasing uncertainties and risks during green transformation (Luan et al., 2023). With the global climate crisis and China's "dual carbon" goals, environmental sustainability has shifted from a corporate social responsibility to a core strategic management concern, driving the enterprise's competitive advantage and long-term resilience (Khan et al., 2021; Zhang et al., 2023). Thus, achieving synergy between economic growth and environmental responsibility is crucial for the high-quality development of SMEs.

Green entrepreneurial orientation (GEO) serves as a strategic approach for enterprises to identify green opportunities, embrace ecological innovation risks, and eliminate polluting assets. It is crucial for boosting economic, environmental, and social outcomes (Asadi et al., 2020; Muangmee et al., 2021). However, in emerging economies, where rapid institutional and market changes occur, the transformation of green entrepreneurial orientation into exceptional sustainable performance remains unclear. Furthermore, the mechanisms and boundary conditions of this transformation are not systematically explained (Liu et al., 2024). Current research identifies three main deficiencies. First, most studies emphasize large enterprises or macro-level analyses, often overlooking SMEs in emerging economies. Second, the literature typically examines either green innovation or green supply chain management as standalone mediators, lacking a comprehensive framework that integrates both internal innovation and external collaboration (Karim et al., 2024; Majali et al., 2022). Third, external environmental characteristics, particularly green technology dynamism, a crucial contextual variable significantly influence corporate strategic decisions and performance outcomes. Yet, existing empirical evidence is insufficient to determine moderating role of green technology dynamism, whether this variable acts as a catalyst or inhibitor to sustainable performance (Asad et al., 2023; Sulaiman et al., 2023).

This study presents a comprehensive model to explore how green entrepreneurial orientation boosts the sustainable performance of SMEs via two mediating pathways: green innovation and green supply chain management. It also examines the moderating role of green technology dynamism. By combining internal innovation with external collaboration perspectives, this research seeks to enhance theoretical insights into the link between green entrepreneurial orientation and sustainable performance in emerging economies.

The study aims to achieve the following objectives:

1. To examine the direct impact of green entrepreneurial orientation on the sustainable performance of Chinese SMEs.
2. To examine the mediating effects of green innovation along the relationship between green entrepreneurial orientation and sustainable performance of Chinese SMEs.
3. To examine the mediating effects of green supply chain management along the relationship between green entrepreneurial orientation and sustainable performance of Chinese SMEs.
4. To examine how green technology dynamism moderates the aforementioned mechanisms.

This study's theoretical contribution shows that internal innovation and external collaboration together mediate the impact of green entrepreneurial orientation on enterprises' sustainable performance.

This addresses the academic need for integrated green entrepreneurship research. Additionally, by empirically confirming the moderating effect of green technology dynamism, the study broadens the applicability of contingency theory within the SME context. Practically, the findings offer valuable insights for policymakers and enterprise managers, providing targeted recommendations to support the sustainable transformation of SMEs under environmental constraints (OECD, 2023).

2. LITERATURE REVIEW

2.1. Green Entrepreneurial Orientation and Sustainable Performance

The Resource-Based View (RBV) identifies green entrepreneurial orientation as a strategic resource that is scarce, valuable, and challenging to replicate, providing businesses with sustainable competitive advantages 0; 0). According to RBV, a firm's strategic resources shape its current competitiveness and influence its long-term performance and market position (Tee et al., 2024). Likewise, green entrepreneurial orientation reflects a firm's commitment to integrating environmental goals and ecological values into its entrepreneurial activities. It combines strategic foresight with forward-thinking attributes, enabling firms to develop unique advantages in resource allocation, capability building, and market positioning (0; Song et al., 2025). SMEs with high green entrepreneurial orientation levels consistently innovate to create environmentally friendly products and clean production processes. This innovation meets the growing demand for green consumption and opens new niche markets, thereby enhancing economic performance (0; 0). Through proactiveness, firms adopt environmental standards that exceed current regulations, reducing future policy and compliance risks while enhancing corporate reputation, thus improving environmental and social performance (**Error! Reference source not found.**; 0). Moreover, a risk-taking orientation in green entrepreneurship encourages firms to invest strategically in green technologies and sustainability projects. Despite short-term uncertainties, these investments can yield first-mover advantages, create industry barriers, and generate synergistic gains across the economic, environmental, and social triple bottom lines 0).

The dynamic capability theory (DCT) elucidates how green entrepreneurial orientation enhances sustainable performance in dynamic environments. Green entrepreneurial orientation functions as a high-order dynamic capability, enabling enterprises to identify green opportunities and threats in their external environment and respond swiftly through resource integration and reconfiguration (Liu et al., 2024; Teece, 2018). Utilizing the "sensing-seizing-reconfiguring" mechanism, green entrepreneurial orientation converts static green resources into low-carbon products, process improvements, and innovative practices, thereby enhancing the synergy between economic and environmental goals (Shahzad et al., 2023). Empirical studies corroborate this perspective: Asad et al. (2024) demonstrated that green entrepreneurial orientation significantly increases the radicalness of green research and development in SMEs, thereby boosting environmental performance and market competitiveness. Similarly, Zhang et al. (2023) found that a proactive green orientation enhances enterprise performance by identifying sustainable opportunities. Based on the above theoretical reviews and empirical evidence, this study proposes the following hypotheses:

H1: Green entrepreneurial orientation positively influences the sustainable performance of SMEs in China.

2.2. The Mediating Role of Green Innovation

Green innovation (GI) involves enterprises creating and implementing innovations in products, processes, or management practices to minimize environmental impact, improve resource efficiency, and generate sustainable value. It is a vital mechanism for converting a firm's green strategic orientation into measurable performance outcomes (Jirakraisiri et al., 2021; Luan et al., 2023). Enterprises with a strong green entrepreneurial orientation can proactively identify green opportunities, optimize resource allocation, and invest in green technology. Their innovative, forward-looking, and risk-taking traits enable them to accumulate unique and hard-to-replicate green resources (Asadi et al., 2020; Muangmee et al., 2021). This orientation drives continuous improvements in green products and processes. Green product innovation allows premium pricing due to unique design and environmental value, enhancing economic performance. Meanwhile, green process innovation improves environmental performance by optimizing resource utilization and reducing waste and energy consumption (Cheng et al., 2023; Dhrifi et al., 2020; Wang & Ahmad, 2024). Additionally, positive green innovation behaviors demonstrate a firm's commitment to corporate social responsibility, enhance corporate image and stakeholder trust, and contribute to improved social performance (Sarfraz et al., 2023; Song et al., 2024).

Green entrepreneurial orientation merges environmental values with market opportunities, prompting firms to pursue green innovation in product design, process improvement, and technology development. Chen et al. (2025) empirically analyzed manufacturing and service firms in emerging economies, showing that green entrepreneurial orientation significantly boosts green innovation capabilities. Similarly, Coelho et al. (2024) studied European firms and found that green entrepreneurial orientation enhances sustainable performance by encouraging both green products and process innovations. This research clarified the internal mechanisms linking green entrepreneurial orientation to green innovation through various innovation types, confirming their strong connection. Additionally, Mondal (2024) conducted an integrative analysis considering corporate social responsibility, policy environment, and innovation perspectives. The study demonstrated that green entrepreneurial orientation positively influences sustainable development through innovation and other pathways, reinforcing the mediating role of green innovation.

Empirical research underscores the critical role of green innovation in linking green entrepreneurial orientation to corporate sustainable performance. Numerous studies highlight its significance in this context (Mondal, 2024; Shahzad et al., 2020), empirically supported green innovation facilitates the transformation of strategic orientation into enhanced economic, environmental, and social outcomes. Additionally, it helps companies sustain green competitive advantages (Chen et al., 2025; Coelho et al., 2024).

Building on this theoretical and empirical basis, this study proposes the following hypotheses:

- **H2:** Green entrepreneurial orientation has a positive impact on green innovation.
- **H3:** Green innovation has a positive impact on sustainable performance.
- **H4:** Green innovation mediates the relationship between green entrepreneurial orientation and sustainable performance.

2.3. Mediating Role of Green Supply Chain Management

Green supply chain management (GSCM) posits that firms can boost both environmental and economic performance by collaborating with external partners, such as suppliers and customers, through practices like green procurement and environmental cooperation (Holling & Backhaus, 2023; Li et al., 2022). Unlike green innovation, which targets internal technological changes, green supply chain management extends environmental responsibilities across the entire supply chain. By implementing green procurement, ecological design, clean production, and waste minimization, green supply chain management optimizes the flow of materials, information, and capital. This strategy reduces environmental impact, enhances supply chain efficiency and resilience, and ultimately improves environmental and economic outcomes for enterprises (Holling & Backhaus, 2023; Liu et al., 2024).

Dynamic capabilities theory asserts that green supply chain management serves as both an external governance mechanism and a demonstration of a company's ability to integrate and reconfigure green resources (Teece, 2018; Wu et al., 2024). By identifying, absorbing, and reconfiguring green knowledge and technological resources, companies enhance their environmental responsiveness and supply chain flexibility. This adaptability fosters a rapid evolution of the green value chain, leading to sustainable competitive advantages (Chen et al., 2024; Nguyen et al., 2023). Empirical research indicates that green supply chain management significantly mediates the relationship between green entrepreneurial orientation and performance. For instance, Habib et al. (2021) found that in the Bangladeshi textile industry, green entrepreneurial orientation significantly promotes the adoption of green supply chain management practices, which in turn enhances sustainable performance. These findings imply that green entrepreneurial orientation not only directly affects a company's green behavior but also indirectly boosts performance by improving collaboration and capabilities within the supply chain. Similarly, Borazon et al. (2021) found that in the Taiwanese electronics industry, green market orientation indirectly influences organizational performance through green supply chain management capabilities, underscoring the mediating role of these capabilities from a relational perspective. Dzikriansyah et al. (2023) also reported that in Indonesian SMEs in the food and beverage sector, green supply chain management directly boosts environmental performance and amplifies the positive effects of government environmental regulations. Recent studies confirm that enterprises with a strong green environmental orientation are more likely to employ green information systems to enhance supply chain collaboration, thereby improving environmental performance (Karim et al., 2024).

Based on theoretical reviews and empirical

evidence, this study proposes the following hypotheses:

H5: Green entrepreneurial orientation positively influences green supply chain management.

H6: Green supply chain management has a positive impact on sustainable performance.

H7: Green supply chain management mediates the relationship between green entrepreneurial orientation and sustainable performance.

2.4. The Moderating Role of Green Technology Dynamism

Environmental dynamism, especially in green technology, significantly influences corporate strategic orientation efficacy (Teece, 2018). Green technology dynamism (GTD) involves rapid and unpredictable changes in green technologies and innovation environments, moderating key relationships in green entrepreneurship and innovation research (Asad et al., 2023). High green technology dynamism indicates an environment with swift iterations and frequent technology replacements, offering innovation opportunities but also introducing uncertainty and performance variability (Asad et al., 2023; Gazali & Zainurrafiqi, 2023). In such dynamic settings, companies must continuously adapt their strategic positioning and capability configurations to maintain competitive advantages and enhance sustainable performance (Abid et al., 2024).

Contingency theory (CT) posits that the dynamic external environment affects the alignment between a company's internal strategic orientation and its capabilities, which in turn influences performance (Donaldson, 2001; Venkatraman, 1989). In highly dynamic green technology environments, rapid technological changes and increased market uncertainty drive firms with strong green entrepreneurial orientations to proactively pursue green innovation. This approach allows them to seize emerging opportunities and gain first-mover advantages (Öztürk et al., 2024; Yu et al., 2022). Empirical evidence shows that such dynamic green technological contexts enhance firms' green dynamic capabilities, enabling swift responses to environmental changes and improving sustainable performance.

Furthermore, high green technology dynamism conditions underscore the strategic importance of supply chain agility and inter-organizational collaboration. Under such volatile environments, effective green supply chain management practices—supported by digital technologies and technological integration—help firms mitigate environmental uncertainty, enhance operational resilience, and simultaneously improve environmental and economic performance (Zeng et al., 2022; Zhang et al., 2025). Although extreme technological turbulence may lead to innovation obsolescence or instability in supply chain collaboration, the prevailing literature suggests that moderate-to-high levels of green technology dynamism generally strengthen the positive relationship between green strategic orientation and firm performance by reinforcing adaptive innovation and supply chain responsiveness.

Empirical evidence shows that environmental dynamism positively influences the link between green entrepreneurial orientation and sustainable performance mechanisms. For example, it enhances the indirect effect of green entrepreneurial orientation on triple-bottom-line sustainable outcomes through boundary-spanning search (Ye et al., 2022). Meta-analytic findings also reveal a consistent positive relationship between green entrepreneurial orientation and sustainable firm performance across various contexts (Öztürk et al., 2024). In green supply chain management, effective practices boost both green innovation and environmental performance, emphasizing the importance of contextual factors like technological and market uncertainty (Gelmez et al., 2024; Khan et al., 2024). Thus, green technology dynamism is vital for strengthening green strategies, providing crucial external support for transforming performance in green entrepreneurial orientation, green innovation, and green supply chain management.

Based on this analysis and evidence, this study proposes the following hypotheses:

H8: Green technology dynamism moderates the relationship between green entrepreneurial orientation and sustainable performance.

H9: Green technology dynamism moderates the relationship between green innovation and sustainable performance.

H10: Green technology dynamism moderates the relationship between green supply chain management and sustainable performance.

This study, based on a theoretical framework, developed a moderated dual-mediation model to testify how green entrepreneurial orientation impacts sustainable performance, both directly and indirectly. Green entrepreneurial orientation, as the independent variable, influences sustainable performance through two mediation paths: green innovation and green supply chain management. Additionally, green technology dynamism moderates these relationships. Figure 1 illustrates the

theoretical framework of this study.

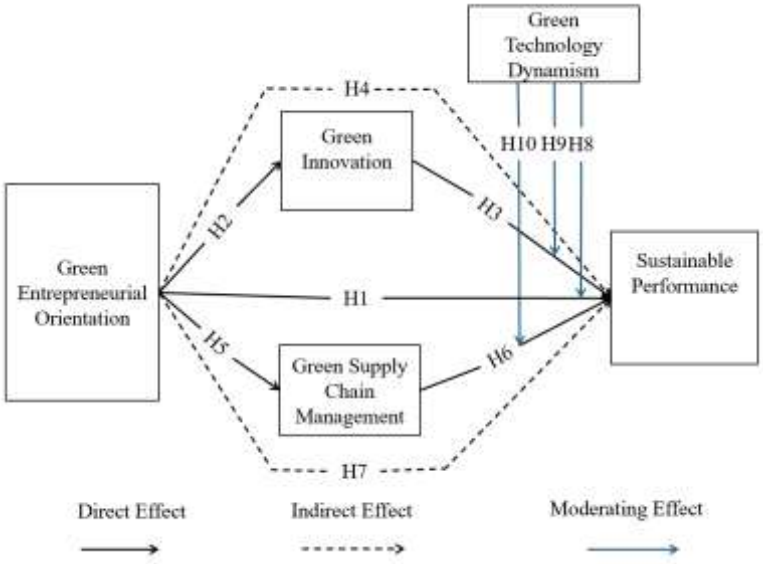

Figure 1: Research Framework.

3. METHODOLOGY

3.1. Sampling and Data Collection

This study uses a quantitative research design to investigate how green entrepreneurial orientation affects the sustainable performance of specialized, refined, distinctive, and innovative SMEs. We utilized partial least squares structural equation modeling (PLS-SEM) to rigorously test the hypothesized relationships among latent variables, enhancing both model robustness and path analysis accuracy (Tee et al., 2025). The research focuses on "little giant" SMEs, identified by China's Ministry of Industry and Information Technology (MIIT) for their strong innovation capabilities, high specialization, and unique industrial positioning. These attributes make them ideal for research and ensure the generalizability of the results. Data was collected using a convenience sampling method. Questionnaires were distributed via a professional online survey platform, resulting in 416 responses. After excluding invalid or incomplete responses, 369 valid samples were retained.

This sample size was adequate for subsequent statistical analysis. To ensure data quality and internal validity, the study used anonymous responses and randomized item presentation to minimize common method bias. Harman's single-factor test, and a VIF-based statistical method confirmed no significant bias. Thus, the data quality met the requirements for subsequent model measurement and structural path analysis.

3.2. Instruments

Most of the well-established and extensively validated instruments were adapted to measure all constructs. These scales have consistently demonstrated strong reliability and validity in fields such as green management, innovation, and sustainable development across various countries and industries. Green entrepreneurial orientation adapting scales developed by Majali et al. (2022), consists of 5 items evaluated a firm's innovation investment, risk-taking, and proactive behavior within an environmental framework. Green innovation was measured with scales from Muangmee et al. (2021) and Asadi et al. (2020), totaling 6 items. This measurement included two dimensions: green product innovation and green process innovation, reflecting the firm's capabilities in green technology and process improvement. The green supply chain management scale adapted from Habib et al. (2021), included 6 items to address external green practices such as green procurement, ecological design, waste minimization, and collaboration with supply chain partners. Green technology dynamism was measured using scales from Jiang (2018), consisting of 4 items. These items captured the firm's perception of the speed of green technology updates, technology path uncertainty, and competitive pressure. Sustainable performance was measured using the 14-items triple-bottom-line scale developed by Muangmee et al. (2021). These scales assessed the firm's overall sustainable development in terms of economic, environmental, and social performance.

This study utilized a translation-back-translation method to ensure linguistic accuracy and cultural

adaptability. Expert review was conducted by three scholars specializing in green and sustainability management. A pre-test on 50 valid responses prompted moderate adjustments to item wording based on the feedback. All items were measured using a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). The reliability and validity of each construct were then tested in the subsequent measurement model evaluation section.

4. RESULTS

In this study, the researcher employed Partial Least Squares Structural Equation Modelling (PLS-SEM) for data analysis. Given the exploratory nature of our research, the PLS method was suitable. PLS-SEM is a widely accepted tool for validating theories with empirical data (Hair et al., 2014). It allows for the simultaneous estimation of multiple path relationships and effectively analyses mediating effects. Additionally, it offers robust estimation capabilities for complex models with moderating effects (Hair, 2022; Sarstedt et al., 2020). Thus, the PLS-SEM method fulfilled the theoretical validation and analysis needs of our study.

4.1. Descriptive Statistics

Table 1 details the respondents' demographics. Gender distribution was nearly balanced, with females at 51.22% and males at 48.78%. The largest age group was 30–39 years, comprising 43.36% of the sample, highlighting a predominance of young to middle-aged individuals. Educationally, 49.86% of respondents held a bachelor's degree, 26.83% had an associate degree, and 17.62% possessed a master's degree or higher, indicating a generally high educational level. In job positions, business and department managers were the largest groups at 37.94% and 33.88% respectively, suggesting middle management was the primary group surveyed. CEOs/presidents and other senior level executives made up 21.14%, ensuring a reasonable representation of senior management in the sample.

Table 1: Demographic profile.

Variable	Category	Frequency	Percentage (%)
Gender	Female	189	51.22
	Male	180	48.78
Age	Under 30 years	102	27.64
	30–39 years	160	43.36
	40–49 years	76	20.60
	50 years and above	31	8.40
Educational Qualification	High school or below	21	5.69
	College/associate degree	99	26.83
	Bachelor's degree	184	49.86
	Master's degree or above	65	17.62
Position	CEO/President	23	6.23
	Entrepreneur	16	4.34
	Business manager	140	37.94
	Department manager	125	33.88
	Top management	55	14.91
	Others	10	2.71

Table 2 details the characteristics of the respondents' enterprises. Companies with 51–100 employees form the largest group, comprising 48.78%, which underscores the prevalence of small- and medium-sized enterprises. Regarding establishment age, firms operating for 5–10 years and 10–15 years together constitute 85.36%, indicating that most surveyed firms possess stable market experience. Industry distribution reveals that sectors like new materials, new energy, electronic equipment, and software and information technology services each exceed 20%, collectively accounting for 73.71%. This highlights the dominance of high-tech and emerging industries. Regionally, East China leads with 48.51%, followed by South China and North China, showing a concentration of surveyed firms in the eastern coastal areas and a distinct regional distribution.

Table 2: Firm Characteristics of the Sample.

Variable	Category	Frequency	Percentage (%)
Number of employees	Less than 10	13	3.52
	11–50	23	6.23
	51–100	180	48.78
	101–300	119	32.25
	301–1000	34	9.21

Firm age	Less than 5	31	8.40
	5–10	163	44.17
	10–15	152	41.19
	More than 15	23	6.23
Industry	Chemical industry	6	1.63
	New materials & new energy	91	24.66
	Machinery & equipment	66	17.89
	Biology & pharmaceuticals	25	6.78
	Electronic devices	92	24.93
	Software & IT services	89	24.12
Region of Operation	Northeast China	6	1.63
	East China	179	48.51
	Central China	22	5.96
	North China	40	10.84
	South China	62	16.80
	Municipalities	32	8.67
	Northwest China	9	2.44
	Southwest China	19	5.15

4.2. Assessing Measurement Model

This study evaluated the measurement model by assessing reliability, discriminant validity, and convergent validity. Reliability and convergent validity were determined by Cronbach's alpha (α), composite reliability (CR), factor loadings, and average variance extracted (AVE) for each latent variable. The results are shown in Table 3. Cronbach's α values ranged from 0.824 to 0.891, and composite reliability ranged from 0.842 to 0.917, both exceeding the critical threshold of 0.70 as suggested by Hair et al. (2014), indicating strong internal consistency. All factor loadings exceeded 0.6, and AVE values ranged from 0.571 to 0.667, surpassing the standard of 0.50, thus supporting convergent validity. According to Fornell and Larcker (1981), the significant factor loadings for each item on its respective construct and the satisfactory AVE values confirm that the measurement model demonstrates high consistency and convergent validity.

Table 3: Constructs' reliability and convergent validity.

Construct	Item	Outer Loading	AVE	Cronbach's Alpha	CR
Sustainable Performance (Financial, Environmental & Social Performance)	SP1	0.737	0.571	0.824	0.842
	SP2	0.750			
	SP3	0.778			
	SP4	0.776			
	SP5	0.743			
	SP6	0.785			
	SP7	0.734			
	SP8	0.759			
	SP9	0.724			
	SP10	0.783			
	SP11	0.724			
	SP12	0.769			
	SP13	0.751			
	SP14	0.778			
Green Entrepreneurial Orientation	GEO1	0.835	0.659	0.871	0.906
	GEO2	0.784			
	GEO3	0.804			
	GEO4	0.820			
	GEO5	0.815			
Green Supply Chain Management	GSCM1	0.792	0.647	0.891	0.917
	GSCM2	0.768			
	GSCM3	0.824			
	GSCM4	0.812			
	GSCM5	0.833			
	GSCM6	0.797			
Green Innovation	GI1	0.811	0.631	0.883	0.911
	GI2	0.783			
	GI3	0.808			
	GI4	0.789			

	GI5	0.783			
	GI6	0.790			
Green Technology Dynamism	GTD1	0.833	0.667	0.834	0.889
	GTD2	0.792			
	GTD3	0.822			
	GTD4	0.819			

Note: SP=Sustainable Performance; GEO= Green Entrepreneurial Orientation; GSCM = Green Supply Chain Management; GI = Green Innovation; GTD = Green Technology Dynamism.

Table 4 presents the assessment of discriminant validity using the heterotrait-monotrait ratio of correlations (HTMT). HTMT is a more reliable and stringent criterion for evaluating discriminant validity and is now preferred in PLS-SEM research (Hair et al., 2019). The HTMT values ranged from 0.360 to 0.584, all below the recommended threshold of 0.85 set by Henseler et al. (2015), confirming the model's strong discriminant validity.

Table 4: Discriminant Validity Assessment Using the HTMT Criterion.

Construct	SP	GSCM	GEO	GI	GTD
SP					
GSCM	0.514				
GEO	0.578	0.547			
GI	0.573	0.574	0.584		
GTD	0.404	0.431	0.360	0.482	

Note: SP = Sustainable Performance; GEO = Green Entrepreneurial Orientation; GSCM = Green Supply Chain Management; GI = Green Innovation; GTD = Green Technology Dynamism.

4.3. Assessing Structural Model

To assess multicollinearity among latent variables, the Variance Inflation Factor (VIF) was calculated. The VIF values for all variables range from 1.690 to 2.341, which are below the critical threshold of 5.0 recommended by Hair et al. (2017). This suggests no significant multicollinearity issue in the model. After confirming no collinearity interference in the model, we proceed to testify the direct as well as indirect (i.e., mediating and moderating) relationships among these variables. The results in **Table 5** show that green entrepreneurial orientation (GEO) significantly and positively impacts both green innovation (GI) (β = 0.515, t = 13.582, p < 0.001) and green supply chain management (GSCM) (β = 0.485, t = 12.897, p < 0.001). This suggests that enterprises with a strong GEO are more likely to enhance resource integration and green practices through internal innovation and external collaboration. Further analysis reveals that GEO also positively affects sustainable performance (SP) (β = 0.206, t = 3.871, p < 0.001). This indicates that GEO not only indirectly boosts performance through mediating paths (i.e., GI & GSCM) but also directly enhances enterprises' economic, environmental, and social performance. Additionally, both GI and GSCM significantly and positively influence sustainable performance (GI→SP: β = 0.220, t = 4.322, p < 0.001; GSCM→SP: β = 0.147, t = 2.862, p = 0.004). These findings demonstrate that enterprises can effectively enhance their sustainable competitiveness through innovation and green supply chain practices.

Table 5: Path coefficients and hypotheses testing results.

Path	Path Coefficient (β)	Std. Deviation (STDEV)	t- value	p-value	Decision
GEO-> GI	0.515	0.038	13.582	0.000	Supported
GEO-> GSCM	0.485	0.038	12.897	0.000	Supported
GEO-> SP	0.206	0.053	3.871	0.000	Supported
GI -> SP	0.220	0.051	4.322	0.000	Supported
GSCM-> SP	0.147	0.051	2.862	0.004	Supported

Note: SP = Sustainable Performance; GEO = Green Entrepreneurial Orientation; GSCM = Green Supply Chain Management; GI = Green Innovation; GTD = Green Technology Dynamism.

Table 6 presents the R^2 values, which quantify the influence of exogenous variables on endogenous variables. This measure indicates the proportion of variance in an endogenous latent variable that is explained by its associated exogenous variables (Hair et al., 2014). In this study, the endogenous latent variables are GI, GSCM, and SP, with R^2 values of 0.265, 0.235, and 0.453, respectively. These values indicate that the exogenous latent variables in the model moderately explain the variance in these endogenous variables (Hair et al., 2017)0. To validate the robustness of our research findings, we assessed the effect size (f^2) to determine the relative contribution of exogenous constructs to the explanatory power of endogenous constructs. According to Chin et al. (2003)0 and Hair et al. (2019),

f^2 value of 0.02 indicates a small effect, 0.15 a medium effect, and values over 0.35 a large effect. As shown in **Table 6**, GEO had a large effect on both green innovation (f^2 = 0.360) and green supply chain management (f^2 = 0.308). This suggests that GEO significantly drives firms' internal green innovation activities and green collaboration across the supply chain. In contrast, GEO effect on sustainable performance was modest (f^2 = 0.044), indicating a small-to-medium effect. Additionally, GI had a moderate effect on SP (f^2 = 0.052), while GSCM effect on SP was small (f^2 = 0.023) but statistically significant. Overall, the effect size analysis confirms that GEO is a core driving construct in the proposed model, exerting a meaningful influence on green innovation, supply chain collaboration, and sustainable performance.

The model's predictive relevance was assessed using Stone–Geisser's Q^2 through cross-validated redundancy. A Q^2 value above zero signifies predictive relevance for the endogenous constructs, while a value below zero indicates a lack of it. Typically, Q^2 values of 0.02, 0.15, and 0.35 correspond to small, medium, and large predictive relevance, respectively (Henseler et al., 20090). As shown in **Table 6**, all endogenous constructs have Q^2 values above zero: sustainable performance has a Q^2 of 0.245, green supply chain management has a Q^2 of 0.150, and green innovation has a Q^2 of 0.163. Thus, the model exhibits satisfactory predictive relevance, with an acceptable fit and medium predictive capability.

Table 6: Results of the structural model assessment.

Path	Path Coefficient (β)	Std. Deviation (STDEV)	t- value	R^2	f^2	Q^2
GEO-> GI	0.515	0.038	13.582	0.265	0.36	0.163
GEO->GSCM	0.485	0.038	12.897	0.235	0.308	0.150
GEO-> SP	0.206	0.053	3.871	0.453	0.044	0.245
GI-> SP	0.22	0.051	4.322		0.052	
GSCM-> SP	0.147	0.051	2.862		0.023	

Note: SP = Sustainable Performance; GEO = Green Entrepreneurial Orientation; GSCM = Green Supply Chain Management; GI = Green Innovation; GTD = Green Technology Dynamism.

4.4. Assessing Mediation Model

After confirming the structural model's overall fit and the significance of the paths, we examined the mediating effects of green innovation (GI) and green supply chain management (GSCM) between green entrepreneurial orientation (GEO) and sustainable performance (SP). **Table 7** shows that both mediating paths were statistically significant. First, the indirect effect of GEO on SP through GI was significant (β = 0.113, t = 4.072, p < 0.001), indicating that GI partially mediates the relationship between GEO and SP. This finding suggests that enterprises can enhance their sustainable performance by directing GEO towards advancements in green products, processes, or technologies. supporting hypothesis H4. In addition, GEO also indirectly improves SP through GSCM (β = 0.071, t = 2.763, p = 0.006), demonstrating that GSCM partially mediates the relationship between GEO and SP, supporting hypothesis H7. This implies that GEO promotes collaboration with supply chain partners in green procurement, collaborative governance, and environmental management, thereby boosting performance. Notably, the effect size of the GI path was greater than that of the GSCM path, indicating that GI is a more effective mediating mechanism for enhancing SP through GEO.

Table 7: Results of mediation effects.

Path	Path Coefficient (β)	Std. Deviation (STDEV)	t- value	p -value	Decision
GEO->GSCM-> SP	0.071	0.026	2.763	0.006	Supported
GEO-> GI -> SP	0.113	0.028	4.072	0.000	Supported

Note: SP = Sustainable Performance; GEO = Green Entrepreneurial Orientation; GSCM = Green Supply Chain Management; GI = Green Innovation; GTD = Green Technology Dynamism.

4.5. Assessing Moderating Effects

Table 8 presents the results of the moderating effect test for green technology dynamism (GTD). All three interaction paths were statistically significant, indicating that GTD consistently and positively moderated the examined relationships. The interaction of GTD × GEO had a significant positive effect on sustainable performance (β = 0.121, t = 2.370, p = 0.018), supporting hypothesis H8 that green technology dynamics positively moderate the relationship between green entrepreneurial orientation and sustainable performance. The GTD × GI interaction term also had a significant positive effect on sustainable performance (β = 0.113, t = 2.303, p = 0.021), supporting hypothesis H9. Similarly, the interaction term GTD × GCSM also shows a significant positive effect on sustainable performance

(β = 0.127, t = 2.653, p = 0.008), indicating that green technology dynamism significantly strengthens the relationship between green supply chain management and sustainable performance. Thus, the moderating hypothesis H10 was supported.

Table 8: Results Of Moderating Effects.

Path	Path Coefficient (β)	Std. Deviation (STDEV)	t- value	p-value	Decision
GTD x GCSM->SP	0.127	0.048	2.653	0.008	Supported
GTD x GEO -> SP	0.121	0.051	2.370	0.018	Supported
GTD x GI ->SP	0.113	0.049	2.303	0.021	Supported

Note: SP = Sustainable Performance; GEO = Green Entrepreneurial Orientation; GSCM = Green Supply Chain Management; GI = Green Innovation; GTD = Green Technology Dynamism.

5. DISCUSSION

This study shows that green entrepreneurial orientation acts as a strategic asset, embedding ecological objectives into corporate strategies and operations through environmental proactiveness, innovation, and risk-taking. Based on resource-based view theory, dynamic capabilities theory, and contingency theory, this study proposes a hypothetical model to evaluate several key aspects: first, the effect of green environmental orientation on the sustainable performance of SMEs in China; second, the mediating roles of green innovation and green supply chain management practices in the relationship between green environmental orientation and sustainable performance; and third, the moderating effect of green technology dynamism within this framework.

Empirical findings indicate that a green entrepreneurial orientation significantly boosts the sustainable performance of SMEs. This aligns with the resource-based view, suggesting that green entrepreneurial orientation, as a rare and strategically aligned resource, provides SMEs with unique competitive advantages. Unlike prior studies focused mainly on large enterprises, this research shows that SMEs, despite facing greater resource constraints, can achieve coordinated economic, environmental, and social growth by embedding environmental sustainability into their core strategies and making strategic decisions characterized by innovation, proactiveness, and risk-taking (Sidorenko et al., 2025). These results offer new empirical evidence for SMEs to tackle the "green paradox" and emphasize the importance of green strategies for sustainable growth (Sinn, 2012).

The results further demonstrate that green innovation and green supply chain management play significant mediating roles in the relationship between green environmental orientation and sustainable performance, indicating that green environmental orientation promotes sustainable outcomes through a dual mechanism of internal innovation and external collaboration. Specifically, green environmental orientation encourages firms to engage in green innovation activities, such as developing eco-friendly products and optimizing production processes, thereby effectively translating green strategic orientation into tangible technological and operational improvements. As a critical strategic resource, this transformation process is highly consistent with the resource-based view (RBV), which emphasizes innovation capability as a key source of firms' core competitive advantage. Existing empirical evidence provides strong support for this interpretation. For instance, Rong et al. (2025) show that green entrepreneurial orientation enhances firm performance by strengthening green innovation capability, while Sulaiman (2025) finds that green product innovation mediates the relationship between green market orientation and sustainable performance. Moreover, systematic review studies highlight the central role of green innovation in achieving sustainable innovation performance (Harsono et al., 2024). Taken together, these findings underscore green innovation as a key transmission mechanism through which strategic orientations are converted into sustainable performance.

Externally, enterprises with a strong green environmental orientation are more likely to adopt green supply chain management practices, such as green procurement, resource recycling, and supply chain collaboration. These practices foster green synergies across the value chain, thereby enhancing sustainable performance. The study's findings are consistent with those of Junejo et al. (2025), Nafisah and Ratnamurni (2025), and Nazir et al. (2024), which show that green-oriented enterprises can effectively enhance both environmental and economic performance through supply chain integration.

This study found that the mediating effect of green innovation is significantly stronger than that of green supply chain management. This indicates that for SMEs with limited resources, strengthening internal green innovation capabilities is more crucial than expanding external green collaboration. SMEs often lack extensive knowledge bases and have limited technology absorption capabilities.

Therefore, they should focus on building core competitiveness by investing in green research and development and improving ecological design and technological capabilities. Once these internal innovations are established, they can be shared with supply chain partners to achieve broader green collaboration. Additionally, this study integrates the linkage mechanism between internal innovation and external collaboration, addressing a significant research gap.

The research findings reveal that green technological dynamism significantly enhances the positive effects in three core pathways: GEO→SP, GI→SP, and GSCM→SP. Firstly, in the GEO→SP pathway, green technological dynamism significantly amplifies the positive influence of green entrepreneurial orientation on sustainable performance. This indicates that in rapidly evolving technological environments, enterprises with strong green entrepreneurial orientation demonstrate greater strategic agility and opportunity recognition, effectively translating environmental commitments into performance outcomes. These findings align with Zhang et al. (2024) reinforcing the dynamic capabilities theory, which emphasizes the importance of innovation orientation and environmental perception in sustaining competitive advantages. Secondly, green technological dynamism intensifies the positive impact of green innovation on sustainable performance. Frequent technological advancements require enterprises to continuously refine eco-innovation and green technology applications, enabling swift adaptation to market and policy changes, thereby achieving coordinated improvements in environmental and economic performance (Zhang et al., 2025; Khan et al., 2024). Lastly, in the GSCM→SP pathway, green technological dynamism enhances the flexibility and collaborative effectiveness of green supply chain management practices. This improvement allows enterprises to enhance responsiveness in green procurement, standard integration, and resource recycling, achieving a win-win for environmental and economic performance (Nazir et al., 2024). The high-tech dynamic environment accelerates rather than hinders the implementation of green strategies. As green technology development increases, the benefits from knowledge and technological innovation outweigh the costs of absorption (Asad et al.,2023). Implementing green entrepreneurship requires enterprises to uphold environmental ethics, often with the aim of enhancing economic returns (Ameer & Khan, 2022). Consequently, green technological dynamism significantly boosts the performance returns of green entrepreneurship, innovation, and supply chain practices by strengthening enterprises' capabilities in innovation, collaboration, and adaptation. This finding reinforces the application of contingency theory in green management, highlighting environmental dynamism as a crucial contextual factor in strategic implementation. Thus, the flexibility and adaptability of enterprises have become essential strategic resources for achieving synergistic environmental and economic benefits.

6. CONTRIBUTIONS

This study makes significant contributions to theory, management practice, and social policy. Theoretically, it develops and validates a dual-mediation model incorporating green innovation and green supply chain management, advancing beyond the traditional single-path focus. This model systematically demonstrates how green entrepreneurial orientation influences sustainable performance through “internal capacity building” and “external collaborative integration”, thereby enriching the theoretical understanding of the green strategy-performance relationship. Furthermore, the study identifies green technology dynamism as a crucial boundary condition, emphasizing its role in enhancing the effectiveness of green strategies in dynamic environments. This finding not only addresses the research call to consider contextuality and boundary conditions but also extends contingency theory to green entrepreneurship, strengthening the theoretical framework's capacity to explain enterprises' green behaviours in dynamic settings.

This study revealed that green innovation (has a significantly stronger mediating effect than green supply chain management at the management practice level. This finding indicates that SMEs with limited resources should prioritize enhancing their internal green innovation capabilities. Once these capabilities are strengthened, they can be extended to supply chain collaboration, leading to broader performance spillovers. Furthermore, considering the moderating effect of green technological development, the study suggests that governments should implement differentiated “stepped” green subsidies based on the level of technological change in various industries. In sectors with high technological turbulence, increased support for green research and development should be prioritized to transform technological uncertainties into innovation momentum. Core enterprises within the supply chain should establish a technological

fluctuation early-warning system and a green collaboration mechanism. By utilizing technological empowerment and order incentives, they can motivate upstream SMEs to engage in green innovation and collaboration, thereby reducing overall carbon emissions and environmental risks in the supply chain. As a result, the applicability of green strategies in the context of Chinese SMEs is expanded.

This study showed that at the social level, a green strategy can simultaneously boost economic, environmental, and social performance. It provides a replicable model for SMEs in China aiming for green transformation under the "dual carbon" goal. This strategy fosters regional green employment, enhances social welfare, and creates synergistic benefits among the economy, ecology, and society.

7. CONCLUSION AND LIMITATIONS

This study presents and validates an integrated model to explain how green entrepreneurial orientation affects sustainable performance through the dual mediation of green innovation and green supply chain management. Additionally, it investigates the moderating role of green technology dynamism. By integrating the resource-based view, dynamic capabilities theory, and contingency theory, the model provides a contextual framework for understanding sustainable entrepreneurship, particularly pertinent for SMEs with limited resources. The empirical results indicate that: (1) Green entrepreneurial orientation directly and indirectly improves a firm's environmental, social, and financial performance; (2) Green innovation and green supply chain management are essential mediators in the relationship between green entrepreneurial orientation and sustainability performance, with green innovation having a more significant impact; (3) Green technology dynamism enhances the positive effects of green entrepreneurial orientation, green innovation and green supply chain management on sustainable performance, suggesting that green technology dynamism can increase the value-creation potential of green strategies.

Despite the theoretical and empirical contributions of this study, several limitations remain. First, the sample primarily consists of specialized SMEs in China, which may restrict the research context. Differences in institutional environments, market structures, and resource endowments across various emerging or transitional economies could result in diverse experiences and outcomes when implementing green entrepreneurial orientation. Therefore, future research should conduct cross-context comparisons in different countries or regions to evaluate the universality and external validity of these findings.

Secondly, this study conducted an empirical analysis using cross-sectional questionnaire data. This method limits the ability to fully understand the dynamic changes in corporate green strategies, innovation, and performance over time. Future research should employ a longitudinal design or tracking data analysis to better capture the time-series effects among strategic orientation, capability building, and performance changes. Such an approach would help uncover their causal mechanisms.

The research focused on variables such as green innovation, green supply chain management, and green technology dynamism. However, other mediating factors may influence the impact of green entrepreneurial orientation on sustainable performance. Future studies should consider incorporating variables like green organizational culture, digital empowerment, market competition intensity, and policy support. This approach could help build a more comprehensive theoretical model, deepen the understanding of green entrepreneurial orientation's effect on sustainable performance, and expand the theoretical framework of green strategy research.

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