



ISSN: 2617-6548

URL: www.ijirss.com



Unpacking the green entrepreneurial orientation–sustainable performance nexus: A conceptual framework for SRDI SMEs in China

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Abstract

Amid escalating global environmental challenges and China's "dual carbon" strategic goals, the green transformation of small and medium-sized enterprises (SMEs), particularly "specialized, refined, distinctive, and innovative" (SRDI) firms, has become a critical pathway to achieving high-quality economic development and ecological sustainability. Drawing on the resource-based view, dynamic capabilities theory, and contingency theory, this study develops an integrated conceptual framework to examine the mechanisms and boundary conditions through which green entrepreneurial orientation (GEO) influences sustainable performance in SMEs. Specifically, green innovation (GI) and green supply chain management (GSCM) are conceptualized as parallel mediating variables, while green technology dynamism (GTD) is introduced as a moderating variable. Based on a systematic review of the literature, this study proposes that GEO enhances sustainable performance through two complementary pathways GI and GSCM, while GTD significantly moderates the strength of these indirect effects, thereby forming a moderated mediation mechanism. By integrating multiple theoretical perspectives, this study provides a parsimonious and systematic explanation of the underlying mechanisms and boundary conditions linking green technology dynamism to sustainable performance. The findings not only enrich the literature on green transformation but also offer important implications for SMEs in formulating and implementing green strategies, as well as for policymakers in designing targeted policies to facilitate enterprise-level sustainability transitions.

Keywords: Green entrepreneurial orientation, Green innovation, Green supply chain management, Green technology dynamism, SRDI SMEs, Sustainable performance.

DOI: 10.53894/ijirss.v9i4.11584

Funding: This study received no specific financial support.

History: Received: 11 February 2026 / **Revised:** 10 April 2026 / **Accepted:** 16 April 2026 / **Published:** 29 April 2026

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Competing Interests: The authors declare that they have no competing interests.

Authors' Contributions: Yuling He: Conceptualization, Data analysis, Writing-Reviewing and Editing

Poh Kiong Tee: Validation, Supervision, Resources, Reviewing and Editing.

Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

Institutional Review Board Statement: The study was conducted according to the guidelines of the APA Ethical Principles of Psychologists and Code of Conduct (American Psychological Association), and approved by the Research Management Centre, University Tun Abdul Razak, Malaysia.

Publisher: Innovative Research Publishing

1. Introduction

Global ecological and environmental challenges are intensifying, prompting the international community to urgently pursue green, low-carbon transformation and coordinated ecological development [1]. In response, China has committed to reaching a carbon peak by 2030 and achieving carbon neutrality by 2060. This commitment not only reflects China's role in global climate governance but also serves as a strategic catalyst for transforming its domestic economy and society [2]. Within this strategic framework, SMEs, which make up over 99% of all enterprises and contribute more than 60% of GDP, play a crucial role in advancing green and sustainable development [3, 4]. The green transformation of SMEs is essential for addressing global climate challenges and offers strategic opportunities for accessing new markets, enhancing resilience, reducing costs, and boosting competitiveness [5]. Among these SMEs, "Specialized, Refined, Distinctive, Innovative SMEs" (SRDI SMEs) are pivotal in modernizing industrial and supply chains and building competitive advantages in manufacturing. They achieve this through niche market exploration, mastery of key technologies, and strong innovation capabilities [6]. However, SRDI SMEs often face challenges such as resource constraints, limited economies of scale, and low returns on environmental investments. Their reliance on specialized technological paths can lead to "green technology lock-in," increasing costs and uncertainties in green transformation [2, 7]. Therefore, researching the green transformation paths of Chinese SMEs under the "dual carbon" framework is both theoretically valuable and practically urgent. This research aims to uncover the green strategic choices and performance transformation mechanisms of SRDI SMEs under resource and institutional constraints.

Green entrepreneurial orientation (GEO) is the strategic approach enterprises adopt to proactively identify eco-friendly opportunities, embrace ecological innovation risks, and phase out polluting assets early. It is recognized as a crucial strategy for achieving economic, environmental, and social performance advantages [8, 9]. As an integral part of organizational culture, green entrepreneurial orientation enables companies to build sustainable competitive advantages through pollution prevention, product management, and green market development. However, most research has focused on the direct relationship between green entrepreneurial orientation and performance, lacking a systematic exploration of its internal transformation mechanisms and contextual boundary conditions. In the context of rapid institutional changes and increasing market uncertainties in emerging economies, significant theoretical ambiguities and empirical disagreements persist regarding how green entrepreneurial orientation translates into sustainable performance [10, 11].

To uncover how green entrepreneurial orientation transforms into sustainable performance, researchers have increasingly focused on mediating mechanisms and boundary conditions. Green innovation serves as a key internal mechanism in this transformation, showcasing an enterprise's ability to convert environmental strategies into technological advancements and market competitiveness through innovations in green products and processes [12]. Meanwhile, green supply chain management represents the enterprise's capability to integrate external collaborative networks, acting as another crucial mechanism in this transformation [13]. Essentially, green innovation highlights an enterprise's internal green technology capabilities, whereas green supply chain management emphasizes its external collaboration and integration abilities. Understanding the mediating roles of innovation and green supply chain management in linking green entrepreneurial orientation to sustainable performance is vital. It not only clarifies the implementation logic of green strategies for SMEs under resource constraints but also offers valuable management insights for optimizing green resource allocation and capability development.

Furthermore, green technology dynamism defined as the speed, frequency, and unpredictability of green technology development and replacement, serves as a critical boundary condition influencing the efficiency of performance transformation from green entrepreneurial orientation [14, 15]. Investigating green technology dynamism moderating role in this relationship helps reveal the strategic effectiveness in dynamic environments. This exploration holds significant theoretical and practical value for establishing a sustainable competitive edge for SMEs. This study addresses the following core research questions based on the preceding analysis:

Q1: Does green entrepreneurial orientation directly influence the sustainable performance of SRDI SMEs?

Q2: Does green innovation play a mediating role in the relationship between green entrepreneurial orientation and the sustainable performance of SRDI SMEs?

Q3: Does green supply chain management play a mediating role in the relationship between green entrepreneurial orientation and the sustainable performance of SRDI SMEs?

Q4: How does green technology dynamism moderate the relationships between green entrepreneurial orientation, green innovation, green supply chain management, and the sustainable performance of SRDI SMEs?

This study develops an integrated "strategy-capability-performance" theoretical framework. It examines how green entrepreneurial orientation influences sustainable performance through two mediating paths: green innovation and green supply chain management. The study also tests the moderating effect of green technology dynamism on these paths to uncover the performance transformation mechanism of green strategies in SMEs in emerging economies. The study's conclusions provide empirical support for expanding green entrepreneurship theory, offer decision-making guidance for SMEs' green transformation, and contribute academic insights for policy optimization under the "dual carbon" goal.

2. Literature Review

This study employs the resource-based view, dynamic capability theory, and contingency theory to develop an analytical framework. It investigates how green entrepreneurial orientation influences the sustainable performance of SMEs through internal innovation and external collaboration, considering boundary conditions. Building on this theoretical foundation, the paper systematically reviews literature on key constructs like green entrepreneurial orientation, green innovation, green supply chain management, and green technology dynamism. The goal is to clarify the theoretical meanings, current research status, and logical relationships of these variables, establishing a basis for formulating subsequent hypotheses.

2.1. Theoretical Foundation

2.1.1. Resource-Based View

The Resource-based view (RBV) is an important extension of the traditional resource-based view [16]. This theory emphasizes that in the context of increasingly prominent ecological and environmental issues, a firm's ability to respond to and shape environmental requirements can itself become a new source of competitive advantage. Hart [16] proposed three key green strategic capabilities: pollution prevention reduces costs by minimizing waste and emissions; product management extends environmental considerations throughout the entire product value chain; and the sustainable development strategy aims to meet the needs of the present generation without compromising the ability of future generations to meet their own needs.

This study, green entrepreneurial orientation, can be regarded as a strategic resource embedded in organizational cognition and culture. It represents a set of strategic logics and decisions - making frameworks centered on environmental sustainability and green value creation. This orientation is scarce, as it requires management to have the vision to transcend short - term economic interests and the courage to take risks in ecological innovation. Meanwhile, it is difficult to imitate, as it is deeply rooted in the firm's values, learning history, and path dependence [17].

Green entrepreneurial orientation directly drives the formation and accumulation of two types of key strategic resources by guiding the firm's resource allocation. Firstly, internal green technology resources. Driven by the green entrepreneurial orientation, the firm invests resources in the research and development of green products and processes, accumulating unique green patents, technological know - how, and knowledge bases, which form the basis of green innovation capabilities with distinct VRIN attributes. Secondly, external green relationship resources. The green entrepreneurial orientation promotes the firm to implement green supply chain management, establishing in-depth collaborative relationships with upstream and downstream partners based on common environmental values and trust. This supply - chain network relationship, based on long - term commitment and green knowledge sharing, has path dependence and social complexity and is a key external resource that competitors find difficult to replicate [2].

The resource-based view provides crucial theoretical support for explaining the strategic resource attributes of green entrepreneurial orientation. Karikari Appiah, et al. [18] pointed out in the application and development of the Resource-Based View that green entrepreneurial orientation, as a strategic resource, can drive enterprises to achieve environmental sustainability through green innovation practices. Mondal, et al. [12] conducted a study on small and medium-sized manufacturing enterprises based on the RBV, which confirmed the key role of green entrepreneurial orientation in promoting enterprises' sustainable development performance. Zhang, et al. [19] carried out an empirical study on Chinese enterprises based on the RBV, indicating that green entrepreneurial orientation significantly affects sustainable performance.

2.1.2. Dynamic Capability Theory

The resource-based view explains the sources of static resource advantages. However, in the context of green transformation characterized by rapid technological iterations and continuous policy evolution, understanding how enterprises can maintain and renew their green competitive advantages requires the perspective of the dynamic capabilities theory (DCT). The dynamic capabilities theory is an important complement to the resource-based view, emphasizing that to adapt to the rapidly changing external environment, enterprises must possess high-order capabilities to integrate, build, and reconfigure internal and external resources and capabilities. Teece [20] further deconstructs dynamic capabilities into three key micro-foundations: sensing, seizing, and transforming. This framework is highly consistent with green entrepreneurship activities: Sensing refers to the ability to identify green opportunities and technological trends; seizing refers to the ability to convert green opportunities into specific actions through rapid decision-making; transforming refers to the ability to continuously adjust organizational resources and processes to obtain green value.

From the perspective of dynamic capabilities, green entrepreneurial orientation can be regarded as a high - order green dynamic capability, which enables enterprises to perceive green opportunities and threats in the external environment, capture emerging green market opportunities, and transform green strategic intentions into specific innovation outcomes and performance improvement through resource reconfiguration. Green innovation and green supply chain management are the two core operational capabilities through which the strategic tendency of green entrepreneurial orientation is "transformed" into specific organizational practices and performance: Green innovation requires enterprises to integrate internal and external technological knowledge for dynamic R&D; green supply chain management requires enterprises to dynamically adjust the relationship network and cooperation mode with suppliers and customers. The highly uncertain environment represented by green technology dynamism is the key context for activating and testing enterprises' dynamic capabilities. In an environment with high green technology dynamism, the window of technological opportunity is fleeting, and the risk of path dependence increases. At this time, a strong green entrepreneurial orientation can help enterprises more acutely "perceive" trends, more decisively "capture" opportunities, and more flexibly "transform" resources through green innovation and green supply chain management, thus turning environmental challenges into opportunities to build new advantages.

The dynamic capability theory provides an important analytical perspective for understanding the relationships among green entrepreneurial orientation, green innovation, green supply chain management, and performance. Baquero [21] research on manufacturing enterprises points out that green entrepreneurial orientation, as a dynamic capability, can drive enterprises to implement exploration and exploitative green innovation, thereby improving green performance. Karikari Appiah, et al. [18] also emphasizes that green dynamic capabilities can strengthen the relationship between green entrepreneurial orientation and green innovation performance, helping enterprises to respond promptly to the environmental needs of stakeholders. The research by Coelho, et al. [22] from the perspective of dynamic capabilities shows that green entrepreneurial orientation, as a high-order dynamic capability, affects sustainable performance by driving green innovation (including product innovation and process innovation), and green supply chain management is an important manifestation of such operational capabilities.

2.1.3. Contingency Theory

The resource-based view and the dynamic capabilities theory mainly start from the internal perspective of enterprises. However, the effectiveness of any strategy is inseparable from the specific environment in which it is located. The Contingency Theory (CT) provides a crucial supplement for this. The core proposition of this theory is that effective management is not fixed, and the organizational effectiveness depends on the degree of match between its strategy, structure and specific situational conditions [23]. This perspective is widely used in entrepreneurship and environmental management research to explain the differences in the strategy-performance relationship.

The theoretical foundation of green technology dynamism is mainly rooted in the contingency theory. Green technology dynamism reflects the speed and unpredictability of green technology changes, which constitutes the core external uncertainty of the green strategy of SMEs. In an environment with high green technology dynamism, where technology and the market change rapidly, a forward-looking and innovative green entrepreneurial orientation is highly compatible with the environment. This strengthens the driving effect of green entrepreneurial orientation on green innovation and green supply chain management and enhances the contribution of green innovation and green supply chain management to sustainable performance. In an environment with low green technology dynamism, the technology trajectory is relatively stable, the strategic urgency of green entrepreneurial orientation decreases, and its impact on green practices and performance is correspondingly weakened.

The contingency theory emphasizes that the effectiveness of a strategy depends on its degree of alignment with the external environment. In the field of green entrepreneurship research, Jiang, et al. [24] pointed out that the relationship between green entrepreneurial orientation and firm performance may vary depending on different environmental conditions. The analytical study by Öztürk, et al. [25] further confirmed that the positive association between green entrepreneurial orientation and sustainable firm performance is consistent across different contexts, but its strength is moderated by contingency factors such as environmental dynamism.

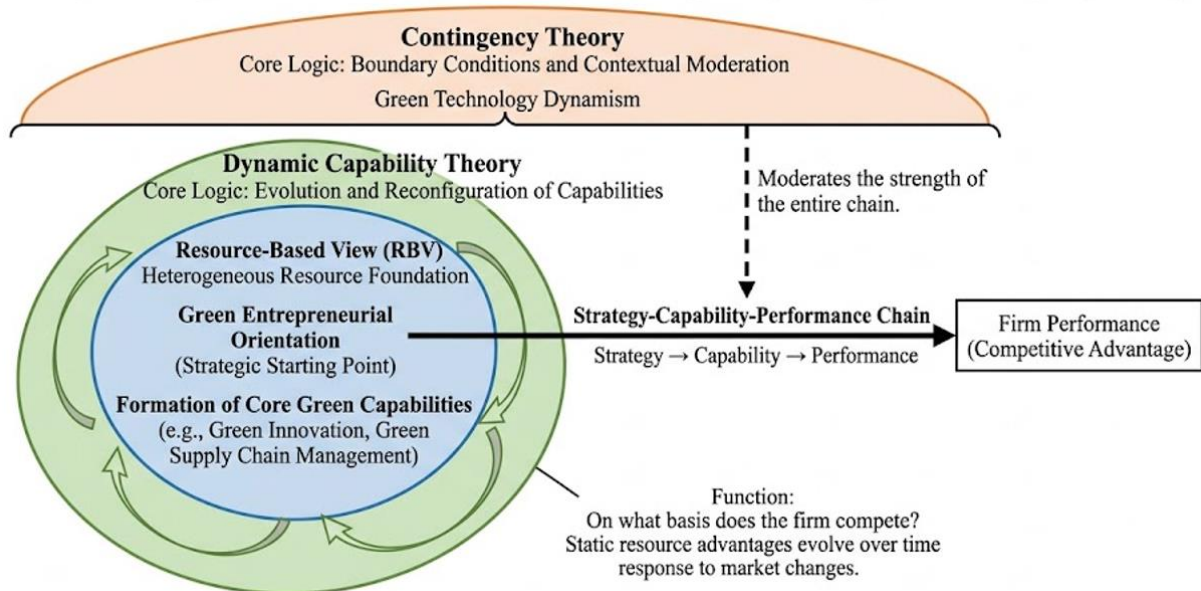


Figure 1.
Theoretical Framework.

In summary, the Resource-based View, Dynamic Capabilities Theory, and Contingency Theory together form the integrated theoretical support system for this study. The resource-based view explains why green entrepreneurial orientation can serve as the starting point for strategic resources and give rise to core green capabilities (green innovation, green supply chain management). The dynamic capabilities theory explains how these capabilities are constructed, integrated, and reconfigured in a dynamic environment to maintain advantages. The contingency theory clarifies how the external technological environment (green technology dynamism) acts as a boundary condition to moderate the effectiveness of the entire "strategy-capabilities-performance" transmission chain. This integrated theoretical framework presented in Figure 1 provides systematic theoretical support for the research model.

2.2. Green Entrepreneurial Orientation

2.2.1. Connotation and Dimensions of Green Entrepreneurial Orientation

Green entrepreneurial orientation stems from the cross-integration of green entrepreneurship theory and entrepreneurial orientation theory, and it is a theoretical product of the green transformation of entrepreneurial orientation [26]. Scholars have defined it from different perspectives: Zhang, et al. [19] emphasized that green entrepreneurial orientation is the tendency to pursue potential opportunities through initiating green activities, highlighting the dynamic process of green opportunity identification and development; Muangmee, et al. [8] pointed out from the perspective of strategic integration that green entrepreneurial orientation is a strategic commitment of enterprises to integrate environmental goals and ecological values into entrepreneurial activities, which helps to form unique advantages in resource allocation and market positioning; Asadi, et al. [9] emphasized from the functional perspective that green entrepreneurial orientation is a strategic approach for enterprises to identify green opportunities, bear the risks of ecological innovation and eliminate polluting assets, and it is a key factor driving triple performance; The analytical research of Öztürk, et al. [25] further confirmed that green entrepreneurial orientation encourages green strategic investment, enabling the coordinated improvement of economic, environmental and social benefits through first - mover advantages even under short - term uncertainty.

Green entrepreneurial orientation consists of three key dimensions: innovation, proactiveness, and risk-taking. Green innovation refers to the tendency and ability of enterprises to introduce environmentally friendly changes in products, processes, management, and business models. Asad, et al. [27] found that green entrepreneurial orientation can significantly enhance the radicalness of green R&D in SMEs, thereby improving environmental and market performance. Green proactiveness refers to the tendency of enterprises to actively predict the trends of environmental regulations, changes in green demand, and the direction of technological evolution, and to make strategic arrangements in advance. Zhang, et al. [2] discovered that a proactive green orientation can improve corporate performance by identifying sustainable opportunities. Green risk-taking refers to the tendency of enterprises to invest resources in green technology R&D, supply chain construction, and market development despite the uncertainties of eco-innovation investment. Öztürk, et al. [25] pointed out that appropriate risk-taking can help enterprises gain first-mover advantages and build industry barriers.

2.2.2. Green Entrepreneurial Orientation and Sustainable Performance

Green entrepreneurial orientation can transform a firm's existing green resources into low-carbon products, process improvements, and innovative practices, thereby enhancing the synergy between economic and environmental goals [28]. In recent years, a large number of empirical studies on the relationship between green entrepreneurial orientation and sustainable performance have emerged, providing rich empirical evidence for understanding the association between the

two. Past literature indicates that most studies support the view that green entrepreneurial orientation has a positive impact on sustainable performance. Mondal, et al. [12] based on a sample of small and medium -sized manufacturing enterprises, confirmed that green entrepreneurial orientation plays a crucial role in promoting corporate sustainable development and further revealed that it mediates the relationship between corporate social responsibility and sustainable performance. Karikari Appiah, et al. [18] surveyed green entrepreneurs and showed that green entrepreneurial orientation significantly drives green innovation performance and corporate performance, and green innovation performance significantly mediates the relationship between green entrepreneurial orientation and sustainable performance. Baquero [21] surveyed managers of manufacturing enterprises and found that corporate green performance is significantly affected by green entrepreneurial orientation, with green innovation playing a mediating role between them, and resource coordination ability having a strengthening effect on the relevant paths. Öztürk, et al. [25] conducted a comprehensive review of multiple literatures and found that green entrepreneurial orientation has a consistent and robust positive impact on corporate sustainable performance.

However, there are also some disagreements in the existing research conclusions. Some studies suggest that green entrepreneurial orientation can significantly improve the triple performance of enterprises by enhancing corporate reputation, meeting green consumption needs, obtaining policy support, and driving innovation [10, 29]. Other studies, from the perspective of cost burden, argue that environmental protection investment can increase operating costs and may exert pressure on financial performance in the short term [30]. This disagreement implies that the impact of green entrepreneurial orientation on sustainable performance may not be a direct linear relationship but is indirectly realized through a series of intermediate organizational practices and transformation paths, and its internal mechanism still needs to be further clarified.

2.3. Green Innovation

2.3.1. Connotation and Dimensions of Green Innovation

Green innovation (GI) refers to the innovation activities carried out by enterprises in products, processes, or management practices to reduce negative environmental impacts, improve resource utilization efficiency, and create sustainable value. It mainly includes two core dimensions: green product innovation and green process innovation [7, 31]. Green product innovation is committed to developing environmentally friendly products, creating a differentiated competitive advantage for enterprises through unique design and environmental value, and thereby enhancing economic performance [32, 33]. Green process innovation focuses on the optimization of production processes, directly contributing to the improvement of environmental performance by reducing resource consumption, waste, and pollution emissions [34]. In addition, positive green innovation practices can demonstrate an enterprise's commitment to fulfilling social responsibilities, which helps to enhance the corporate image and increase stakeholder trust, thus indirectly promoting the improvement of social performance [35, 36].

2.3.2. The Mediating Role of Green Innovation Between Green Entrepreneurial Orientation and Sustainable Performance

Green entrepreneurial orientation sets a strategic direction for enterprises' green development and, through the embedded willingness to take innovation risks, encourages enterprises to allocate resources to green R&D and innovation activities, thereby driving the generation and accumulation of green innovation [4, 10]. As the core transformation mechanism connecting strategic orientation and sustainable performance, green innovation has received extensive attention from the academic community in recent years, and empirical research has provided sufficient support for its mediating role.

Coelho, et al. [22] found in their research on SMEs that green entrepreneurial orientation indirectly improves sustainable performance by stimulating green process innovation and green product innovation. Khan, et al. [37] showed through an analysis based on a manufacturing sample that environmental innovation plays a mediating role between green entrepreneurial orientation and environmental performance, and this effect is positively moderated by stakeholder pressure. Baquero [21] found through a survey of manufacturing enterprise managers that both exploratory green innovation and exploitative green innovation play mediating roles between green entrepreneurial orientation and corporate green performance, revealing the differential transmission functions of different types of green innovation. Chen, et al. [11] showed through a cross-industry analysis of the manufacturing and service industries in emerging economies that green entrepreneurial orientation affects entrepreneurial success by enhancing green innovation capabilities. Karikari Appiah, et al. [18] also found in their research that green innovation performance plays a significant mediating role between green entrepreneurial orientation and sustainable corporate performance.

Empirical studies consistently indicate that green entrepreneurial orientation drives the generation and accumulation of green innovation by guiding enterprises to allocate resources to the field of green R&D. Green product innovation helps enterprises explore emerging markets and meet the demands of green consumption, thereby enhancing economic performance. Green process innovation directly contributes to the improvement of environmental performance by optimizing production processes, reducing resource consumption and pollution emissions. Meanwhile, green innovation practices can also shape a responsible corporate image and enhance stakeholder recognition, indirectly promoting the improvement of social performance. It is this unique functional attribute that can synergistically drive triple performance that makes green innovation the core transformation mechanism connecting green entrepreneurial orientation and sustainable competitive advantage [4, 10, 28].

2.4. Green Supply Chain Management

2.4.1. Connotation and Dimensions of Green Supply Chain Management

Green supply chain management (GSCM) integrates environmental protection throughout a product's life cycle, including design, procurement, production, logistics, sales, and recycling. It seeks to minimize environmental impact and maximize resource efficiency while fostering collaboration among supply chain entities for economic and environmental synergy [38]. Functionally, green supply chain management incorporates environmental considerations into traditional supply chain management, embedding these factors from material management to end customers. Process-wise, it includes green practices in design, procurement, manufacturing, logistics, warehousing, sales, and recycling, forming a systematic governance mechanism. This study defines green supply chain management as a strategic approach where enterprises embed environmental management into the entire supply chain. By transforming and optimizing key processes, green supply chain management reduces environmental impact, enhances resource efficiency, and shares environmental and economic benefits among supply chain participants.

Green supply chain management is a systematic approach that encompasses several core dimensions. These dimensions are often categorized from a process perspective. Green design integrates ecological concepts into product development, focusing on environmentally friendly materials and recyclability to minimize environmental impact from the outset. Green procurement evaluates suppliers' environmental performance to encourage upstream supply chain transformation. Green manufacturing involves clean production practices, such as controlling resource consumption and minimizing waste. Green logistics and warehousing optimize transportation routes, reduce and recycle packaging, and enhance energy efficiency in storage. Green sales and recycling include green marketing, product recycling and reuse, and waste disposal. These practices collectively optimize resource use, reduce environmental risks, improve compliance, and enhance supply chain collaboration. They directly boost environmental and operational performance and indirectly strengthen supply chain resilience and social reputation [13, 38].

2.4.2. The Mediating Role of Green Supply Chain Management Between Green Entrepreneurial Orientation and Sustainable Performance

Green Supply Chain Management links green entrepreneurial orientation to sustainable performance. Green Entrepreneurial Orientation is defined by proactive environmental strategies and innovation and aims to raise firms' levels of sustainable development. By embedding environmental criteria across all supply-chain stages and functioning as a key external coordination mechanism, green supply chain management facilitates the translation of green entrepreneurial orientation into tangible sustainable outcomes. Empirical evidence indicates that firms with a strong green entrepreneurial orientation are more likely to adopt green supply chain management practices and thereby attain simultaneous improvements in environmental and economic performance. Through measures such as green procurement, eco-design, and clean production, firms reduced waste emissions, optimized resource use, and lowered environmental impact, achieving sustainable development goals.

Empirical studies have repeatedly confirmed that green supply chain management serves as a principal external pathway linking green entrepreneurship orientation to firm outcomes. Firms that strongly embrace green entrepreneurship typically coordinate supply-chain greening by selecting environmentally responsible suppliers, advancing green procurement, and reinforcing partners' environmental accountability. For example, Habib and Bao [29] found that green supply chain management partially mediated the relationship between green entrepreneurship orientation and firms' sustainable performance. Zhang, et al. [39] corroborated this result for Chinese firms, showing a pronounced mediating effect of green supply chain management between green entrepreneurship orientation and sustainable performance, while finding no comparable effect along the market-oriented pathway—underscoring a distinct mechanism associated with green entrepreneurship orientation. Similarly, Al Karim, et al. [40] show that green entrepreneurship orientation together with green information systems improved firms' environmental performance via green supply chain management, with managerial support strengthening this chain of influence. Anin, et al. [41] further demonstrate that green entrepreneurship orientation exerts a stronger effect on environmental and financial performance through green procurement, particularly when suppliers and customers are highly integrated, thereby emphasizing green procurement's central role within green supply chain management.

Existing research consistently indicates that green supply chain management serves as a crucial external mechanism linking green entrepreneurship orientation to firm performance. From the perspective of dynamic capability theory, green supply chain management functions not only as a governance instrument for fulfilling environmental responsibilities but also as a manifestation of firms' dynamic capacity to integrate and reconfigure green resources across the supply chain. By fostering collaborative greening, optimizing resource allocation, and reducing environmental risks, green supply chain management has enabled the joint creation of environmental and economic value and thus operates as an important external conduit for translating green entrepreneurship orientation into sustainable performance. Unlike green innovation, which centers on internal technological change, green supply chain management extends environmental responsibility across the entire supply-chain network and emphasizes building sustainable competitive advantage through cross-organization collaboration.

2.5. Green Technology Dynamism

2.5.1. Connotation and Dimensions of Green Technology Dynamism

Green technology dynamism (GTD) are crucial external factors that capture the pace, frequency, and unpredictability of green technology development and replacement in enterprise environments Jiang, et al. [24] and Yu, et al. [42]. Yu, et al.

[42] identified environmental dynamics as a crucial moderating variable in the link between green entrepreneurial orientation and corporate sustainable performance. They emphasized that these dynamics reflect changes' speed and unpredictability in an enterprise's external environment. In such dynamic settings, enterprises must rely more on strategic orientation to navigate uncertainties. Asad, et al. [14] highlighted that green technology dynamism entails rapid and unpredictable shifts in green technologies and the innovation landscape. This dynamic environment accelerates technology iteration and replacement, offering innovative opportunities while introducing uncertainty and performance volatility. Ye, et al. [43] also underscored the moderating role of technology dynamics when examining the impact of green entrepreneurial orientation on sustainable performance through cross-boundary research.

The green technology dynamism manifests in three core dimensions: speed, frequency, and unpredictability. Speed denotes the pace of green technology updates. In a high-speed environment, enterprises must continuously monitor technological advancements. Frequency pertains to how often technological changes occur. Frequent changes require enterprises to have agile learning and response capabilities. Unpredictability involves the challenge of forecasting technological development, increasing the risk associated with green investments. Together, these dimensions shape the external environment for implementing green strategies. In a highly dynamic setting, technologies iterate rapidly and are frequently replaced. This scenario offers enterprises the chance to adopt new technologies early, gaining a first-mover advantage, but also presents risks of innovation failure and performance fluctuations [14].

2.5.2. The Moderating Effect of Green Technology Dynamism Between Green Entrepreneurial Orientation, Green innovation, Green supply chain management and Sustainable Performance

Green technology dynamism, regarded as a key contingency factor, influences the transformation from green entrepreneurship orientation to sustainable performance and are widely treated as a critical moderating variable in green entrepreneurship research [14]. Studies examining how green-technology dynamics regulate the link between green entrepreneurship orientation and green practices have identified two mechanisms of action, each of which can either strengthen or weaken that relationship.

Empirical evidence suggests that green technology dynamism strengthens the link between green entrepreneurship orientation and green innovation. Yu, et al. [42] showed that environmental dynamics positively moderate the indirect effect of green entrepreneurship orientation on sustainable performance via cross-border research. Öztürk, et al. [25] reported that moderate environmental dynamics increase the positive association between green entrepreneurship orientation and performance. Al-Swidi, et al. [44] further confirmed that volatility in green technologies positively moderates the effect of green entrepreneurship orientation on green innovation. When technological-environment volatility is high, firms with a strong green entrepreneurship orientation are better able to detect emerging technological trends and to invest boldly in innovation, thereby maximizing the strategic value they realize.

Green technology dynamism also positively moderates the relationship between green entrepreneurship orientation and green supply chain management. Antony, et al. [45] found that environmental dynamics significantly strengthened the effect of green entrepreneurship on supply chain resilience, prompting firms to address uncertainties by deepening supply chain collaboration and thus more effectively translating green entrepreneurship-oriented strategic intentions into green supply chain management practices. Most studies hold that medium-to high-level dynamics in green technologies enhance the positive link between green strategy orientation and performance by bolstering firms' adaptive innovation and supply chain response capabilities [25, 43].

The research results show that the green entrepreneurship orientation emphasizes an active environmental strategy that attracts greater support in a dynamic green-technology context and, consequently, encourages firms to pursue more innovative solutions. By steering firms to adopt cutting-edge green technologies, this strategic orientation fosters green innovation, enabling the development of new products and processes that meet environmental objectives and strengthen competitive advantage. Likewise, green supply chain management-an essential mechanism for embedding environmental considerations into supply chain operations-is strongly shaped by technological progress. Green technology dynamism improves resource-use efficiency and reduce waste, thereby advancing sustainable performance. Firms that rapidly adapt to technological change can optimize supply-chain operations, lower environmental impact, and reduce operating costs.

In conclusion, green technology dynamism, as a key regulatory factor, strengthened the relationships among green entrepreneurship orientation, green innovation, green supply chain management, and sustainable performance. Firms that effectively leveraged this dynamic were more likely to achieve superior sustainable development performance.

3. Research Gaps and Unexplored Areas

This study, through a systematic review and critical evaluation of literature on green entrepreneurial orientation, green innovation, green supply chain management, green technology dynamism, and sustainable performance, identifies three core theoretical gaps. These gaps are interrelated and urgently require attention. They limit the explanatory and predictive power of green entrepreneurship theory in emerging economies and hinder academic research from offering precise and actionable insights into policy-making and corporate practices.

First, there is an obvious bias in context selection in existing studies. Most studies focus on large enterprises in developed economies or building theoretical models using macro data. While these studies have expanded the concept of green entrepreneurial orientation, they often overlook the green strategies of SMEs in emerging economies. In particular, Chinese SRDI SMEs deserve attention. These enterprises possess deep tacit knowledge and expertise in specific technological areas, characterized by specialized resources, refined management, and path-dependence. Consequently, their approaches to green technology development, innovation, and supply chain management may differ from those of

traditional SMEs or large enterprises. However, existing research frequently treats SMEs as uniform entities, neglecting their diverse characteristics and complex institutional contexts [3]. This generalized analysis weakens the theory's ability to explain the green transformation practices of specific SME types in emerging economies and limits the global applicability of green entrepreneurial orientation theory.

Secondly, the existing research shows a tendency towards fragmentation in mechanism analysis. Existing studies often treat green innovation as a standalone mediating variable or separately evaluate the performance effects of green supply chain management, neglecting the interconnectedness of these internal and external collaborative practices. Few have integrated green entrepreneurial orientation, green innovation, and green supply chain management within a single analytical framework to explore how green entrepreneurial orientation influences sustainable performance through these channels. This oversight also makes it difficult to assess potential synergies or progressive relationships between green supply chain management and green innovation. According to dynamic capabilities theory, a firm's internal innovation capabilities and external network collaboration capabilities are complementary and co-evolve [20]. For instance, green product innovation within a firm can prompt upstream suppliers to innovate in green materials, while green technology knowledge from supply chain partners can enhance the firm's internal process innovation, creating a virtuous "innovation-collaboration" cycle. However, this chain-mediated or interactive effect is largely overlooked in empirical research. Most studies employ a single-mediation model, disrupting the organic link between "internal capability building" and "external network embedding." This lack of integrated mechanisms not only results in an incomplete understanding of how green entrepreneurial orientation achieves sustainable performance but also complicates explanations for performance variations among firms with similar strategic orientations. Therefore, developing an integrated dual-mediation model to test the synergistic mechanisms between green innovation and green supply chain management is crucial for advancing research in this area.

Third, existing research presents disagreements about the dynamic regulatory role of green technology, and its underlying mechanism is still unclear. Contingency Theory and Dynamic Capabilities Theory both highlight the significance of environmental dynamism. However, empirical evidence on how green technology dynamism moderates the relationship between green entrepreneurial orientation and sustainable performance is inconsistent. Some studies support the "catalysis theory," suggesting that a dynamic environment enhances the positive impact of green entrepreneurial orientation on innovation and performance. This is because uncertainty compels enterprises to rely more on strategic orientation to navigate challenges [25, 42]. Conversely, other studies propose the "inhibition theory," where excessive technological turbulence surpasses enterprises' absorption and adaptation capabilities. This can lead to strategic defocus and dispersion of innovation resources, weakening green entrepreneurial orientation's effectiveness [46].

This divergence may arise from a non-linear "inverted U-shaped" relationship or multi-stage differential effects of green technology dynamism. In moderately dynamic environments, green technology dynamism might enhance the impact of green entrepreneurial orientation on exploratory green innovation. In contrast, in extremely turbulent environments, it may drive enterprises to focus on exploitative innovation and supply chain risk management. Unfortunately, most studies treat green technology dynamism as a linear moderator, neglecting its potential curvilinear effects and differential moderating paths for various innovations and supply chain practices [37]. Furthermore, the high-order interaction effects between green technology dynamism and organizational capabilities remain unexplored. These factors may jointly influence the performance conversion efficiency of green entrepreneurial orientation. Additionally, whether the unique effectiveness release mechanism of SRDI SMEs in China's highly dynamic green technology environment is unique is a pressing issue that requires further investigation.

In conclusion, current research on green entrepreneurial orientation reveals significant theoretical gaps in three areas: situational adaptability, mechanism integration, and external environment moderation. Regarding situational adaptability, the theory's applicability and explanatory power in emerging economies, particularly among China's SRDI SMEs, require further testing. For mechanism integration, the combined path of internal innovation and external collaboration lacks systematic theoretical support and empirical validation. Concerning external environment moderation, the boundary effect of green technology dynamism remains unclear, with its non-linear characteristics and path asymmetry needing urgent clarification. These gaps limit the universality and precision of the green entrepreneurial orientation theory and impede the integration of theoretical research with practical application.

4. Conceptual Framework

This study grounded in robust literature review, identified essential factors for developing the research model. Green entrepreneurship orientation acts as a strategic driver, steering enterprises toward sustainable development. Green innovation serves as an internal capability, allowing enterprises to convert strategic intentions into tangible actions. Green supply chain management represents an external collaborative mechanism, extending green practices beyond organizational limits. Green technology dynamism functions as a critical situational boundary condition, explaining variations in strategic effects across different technological environments.

This study develops an integrated research framework to systematically explain the relationship between green entrepreneurship orientation and the sustainable performance of SMEs in China. Within this framework, green entrepreneurship orientation serves as the core strategic driver, while sustainable performance is the outcome variable. Green innovation and green supply chain management form parallel mediating paths, with green technology dynamism acting as a key situational variable. The framework underscores in Figure 2 illustrates the multi-level interactions among strategic orientation, organizational capabilities, and performance outcomes, emphasizing the seamless integration of internal innovation and external collaborative practices within enterprises.

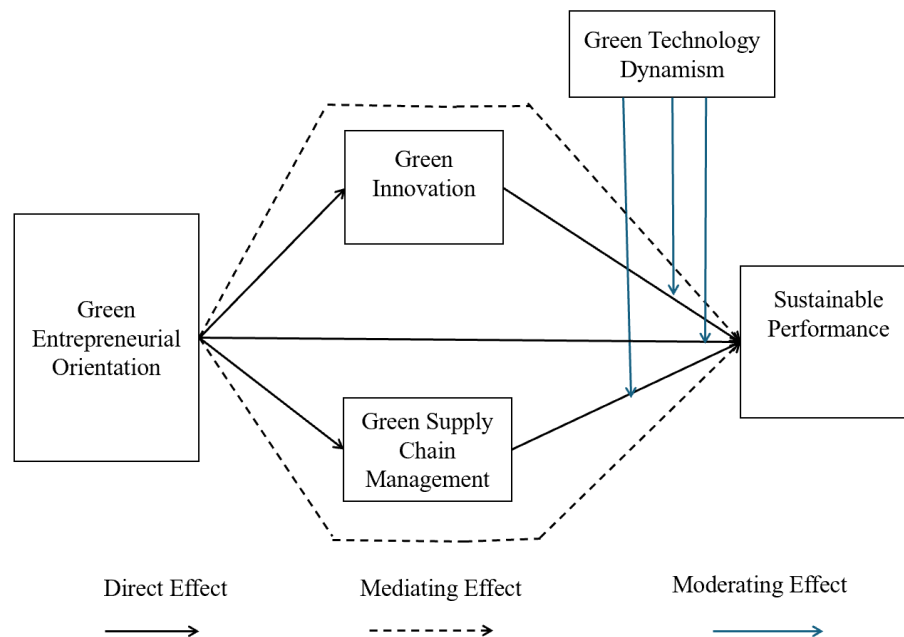


Figure 2.
Research Framework.

Green entrepreneurial orientation is central to the model. This strategic focus emphasizes identifying environmental opportunities, reconfiguring resources, and creating long-term value. It not only impacts a firm's innovative decisions but also reshapes its supply chain collaboration logic. Firms with a strong green entrepreneurial orientation are more likely to integrate environmental goals into their core strategies and promote green practices through institutional arrangements and resource allocation. Green innovation involves a firm's ability to enhance environmental performance at the product, process, or technology level, reflecting an upgrade in internal capabilities. Green supply chain management involves a firm's collaborative ability to integrate environmental goals at the inter-organizational level, optimizing external relationships. These two aspects represent the key dimensions of "internal improvement" and "external connection" in green transformation.

Variations in the strategic intensity of green entrepreneurial orientation result in distinct capability development paths. A heightened green entrepreneurial orientation encourages enterprises to engage in green innovation and enhance environmental collaboration with supply chain partners. Green innovation fosters sustainable value by improving resource efficiency, reducing emissions, and minimizing compliance risks. Concurrently, green supply chain management boosts overall enterprise performance by decreasing environmental uncertainty and enhancing supply chain transparency. Together, these paths constitute the core mechanism for transforming green entrepreneurial orientation into sustainable performance.

The framework highlights how the dynamics of the technological environment shape the transmission mechanism. An increase in the renewal speed, substitution frequency, and diffusion of green technologies alters the benefit structure of enterprise strategy implementation. In environments with high green technology dynamics, green entrepreneurial orientation is more likely to lead to innovation achievements and supply-chain collaboration advantages, enhancing its positive impact on sustainable performance.

Based on the above theoretical arguments, this study proposes the following hypotheses:

H1: Green entrepreneurial orientation has a significant positive effect on the sustainable performance of SMEs in China.

H2: Green innovation mediates the relationship between green entrepreneurial orientation and the sustainable performance of SMEs.

H3: Green supply chain management mediates the relationship between green entrepreneurial orientation and the sustainable performance of SMEs.

H4: Green technology dynamism positively moderates the effects of green entrepreneurial orientation, green innovation, and green supply chain management on sustainable performance, such that these relationships are stronger under higher levels of green technology dynamism.

This study systematically connects strategic orientation, capability building, and contextual factors through an integrated conceptual model. This approach addresses the theoretical gap in existing research concerning mediation mechanisms and boundary conditions. The model outlines a structured logic for green transformation: strategy drives capability building, capabilities generate performance value, and environmental conditions either strengthen or weaken this process. Specifically, green entrepreneurial orientation influences sustainable performance via two paths: internal innovation (green innovation) and external collaboration (green supply chain management). The effect's intensity is moderated by the technological environment's dynamism (green technology dynamism). This model offers a

comprehensive theoretical framework for understanding the complex mechanisms of green development in SMEs, providing a solid analytical foundation for future empirical tests.

5. Contributions

5.1. Theoretical Implications

First, we initially developed a moderated double-mediator integrated model that combines green entrepreneurial orientation, green innovation, green supply chain management, and green technology dynamics into a single analytical framework. This model systematically revealed the complex transmission mechanisms by which green entrepreneurial orientation influences the sustainable performance of SMEs. It surpasses previous studies that concentrated on single mediators or direct effects, offering a more comprehensive theoretical perspective for understanding the value transformation process of green strategies.

Second, this study empirically tested the parallel mediating roles of green innovation and green supply chain management, this study elucidated the "black box" of how green entrepreneurial orientation creates value. It identified two distinct action paths: "internal capacity building" and "external network collaboration." These findings clarified the core mechanism by which green entrepreneurial orientation transforms into sustainable performance. Additionally, they revealed the complementary roles of internal innovation and external collaboration in facilitating green transformation.

Thirdly, this study empirically tested the moderating effect of green technology dynamics, clarifying key boundary conditions for the effectiveness of the green entrepreneurial orientation strategy. This addresses the ongoing debate about environmental dynamics in existing research. The findings expanded the application boundary of contingency theory in green management and offered a new interpretive perspective for the green contextual application of dynamic capabilities theory. Additionally, the study focused on Chinese SRDI SMEs. It provided a contextualized theoretical explanation for understanding the logic of green transformation in specific enterprise types within emerging economies.

5.2. Practical Implications

The conclusions of this study provide targeted practical insights for policymakers and corporate managers. For managers of SMEs, this study found that fostering green entrepreneurial orientation was crucial for long-term sustainable development. Managers should integrate environmental goals into their core strategies, increase investments in green innovation, and actively form green supply chain alliances with upstream and downstream partners. In the rapidly evolving green technology landscape, enterprises should maintain a strong green strategic focus. They should effectively convert this orientation into sustainable competitive advantages by enhancing internal innovation and external collaboration capabilities. To effectively promote the green transformation of SMEs, policymakers must design policies that incentivize internal green innovation and encourage green collaboration within the supply chain. Specific measures include offering subsidies and tax incentives for green research and development to boost innovation. Additionally, establishing a green supply chain collaboration platform can facilitate the greening of upstream and downstream enterprises. Policymakers should also develop green procurement standards to guide market consumption and strengthen public service platforms for green technologies. These initiatives help enterprises address the challenges posed by technological changes.

6. Conclusion and Limitations

This study develops an integrated framework to investigate how green entrepreneurial orientation influences the sustainable performance of SRDI SMEs. In this model, green innovation and green supply chain management act as parallel mediators that convert strategic intent into measurable environmental and economic outcomes, while green technology dynamism moderates the strength of these pathways. Sustainable performance thus emerges from the coordinated alignment of strategic orientation, internal capabilities, external collaboration, and prevailing environmental conditions, providing both theoretical contributions and practical guidance for implementing green entrepreneurship. This study has contributed both theoretically and empirically, yet several limitations remain, suggesting avenues for future research.

The samples in this study primarily originate from China's SRDI SMEs. Consequently, the research conclusions are highly context dependent. Variations in institutional environments, market structures, and resource endowments across different emerging or transitional economies may lead to differing experiences and performances in implementing green entrepreneurial orientation. Thus, future research should conduct cross-country or cross-regional comparative analyses to verify the universality and external validity of this study's conclusions.

This study used cross-sectional questionnaire data for empirical analysis, which limits its ability to fully capture the dynamic evolution among corporate green strategies, capability building, and performance changes. Future research should consider using a longitudinal design or tracking data to better understand the time-series effects among green entrepreneurial orientation, green innovation, green supply chain management, and sustainability. This approach would more effectively reveal the evolutionary logic of their causal relationships.

This study primarily examined key variables: green innovation, green supply chain management, and green technology dynamics. However, other significant mediating and moderating factors may influence how green entrepreneurial orientation impacts sustainable performance. Future research should consider incorporating variables like green organizational culture, digital empowerment, market competition intensity, and policy support. These additions could help build a more comprehensive theoretical model, enhance understanding of the value conversion mechanism of green entrepreneurial orientation, and broaden the theoretical scope of green strategy research.

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