A Configurational Study on Enhancing Sustainable Development Capabilities of "Little Giant" Enterprises under the Dual Transformation Challenge

Wenlian Li and Yuyang Wu*

Qingdao University of Technology, Qingdao, China

*Corresponding author: tjywyy2024@163.com

Abstract. Confronting the challenges and opportunities of dual digital-green transformation, how specialized, refined, unique, and innovative ("Little Giants") enterprises can achieve steady improvements in sustainable development capabilities has become pivotal for driving high-quality economic growth. Grounded in the "Resource-Capability-Environment" framework and leveraging fuzzy-set Qualitative Comparative Analysis (fsQCA), this study examines the configurational effects of antecedent variables—including digital technology application, smart manufacturing, greening practices, digital absorptive capacity, organizational adaptability, government subsidies, and market competition—on sustainable development capabilities across a sample of 332 listed "Little Giants" in China. Key findings reveal: (1) Four distinct pathways to high sustainable development capability: Technology Resources-Policy Symbiosis (Y1), Ambidextrous Technology Resources-Capability Alignment (Y2, Y3), Technology Resource Dominance (Y4), and Ambidextrous Technology Resources-Policy Catalysis (Y5); (2) Low-capability configurations exhibit technology isolation and policy drift, highlighting configuration traps of "prioritizing hardware over software" and "emphasizing external over internal factors"; (3) Digital technology application serves as a foundational condition for most high-capability configurations, while the interaction between policy and market competition demonstrates context dependency. By deconstructing the asymmetric relationships among resources, capabilities, and environmental factors, this study offers practical pathways for enterprises to achieve sustainable leaps under dual transformation pressures.

Keywords: Specialized, Refined, Unique, and Innovative ("Little Giants"); Sustainable Development Capability; Digital Technology Application; Smart Manufacturing; Greening Practices.

1. Introduction

Against the backdrop of deep integration between the "Dual Carbon" goals and the digital economy, the Central Economic Work Conference has explicitly identified advancing the digital and green transformation of the manufacturing sector as pivotal to achieving high-quality economic development[1]. Specialized, Refined, Unique, and Innovative ("Little Giants") enterprises, serving as innovation leaders within niche segments of China's manufacturing industry, are regarded as pioneers in this dual transformation due to their technological focus and market agility. The Ministry of Industry and Information Technology (MIIT) has emphasized enhanced policy coordination to support these enterprises in cultivating new growth drivers, tackling cutting-edge technologies, and developing innovative products, thereby reinforcing their leadership role[2]. However, the SME Development Report (2023–2024)[3] reveals that approximately 20% of "Little Giants" exit the market within 3–5 years after certification due to technological rigidity, organizational inertia, or environmental adaptation failures, indicating that short-term policy incentives and technological investments alone cannot sustain long-term development. Consequently, this study investigates the generative mechanisms through which "Little Giants" achieve high-level sustainable development capabilities amid the dual pressures of digitalization and greening.

Existing research primarily examines the innovative growth of "Little Giants" through three lenses: First, from a macro-policy and environmental perspective, studies focus on how policy incentives (e.g., incubation policies stimulating innovation vitality [4]) and financial support (e.g., supply chain finance enhancing total factor productivity [5][6]) drive high-quality development. Second, from an internal firm perspective, scholars explore mechanisms such as executive characteristics (e.g., academic CEOs[7], entrepreneurial risk-taking propensity[8]) and knowledge management (e.g., knowledge search enabling green innovation[9]), predominantly using regression models to isolate net effects of single factors. Third, a configurational perspective leverages QCA to analyze synergistic effects of digital transformation, resource slack, capability building, and external environments on enterprise resilience[10], ambidextrous capabilities[11], and innovation performance[12].

While these studies provide valuable insights, research remains scarce on how "Little Giants" achieve sustainable development through the coordinated interaction of internal and external factors under dual transformation pressures. Addressing this gap, our study employs text mining (via NLP) and fuzzy-set Qualitative Comparative Analysis (fsQCA) on a sample of 332 national-level "Little Giants" in the Yangtze River Economic Belt. Moving beyond single-factor analysis, we integrate technological resources, organizational capabilities, and external environmental factors to reveal how these enterprises leverage digital technology applications, smart manufacturing, and greening practices to attain sustainability. By uncovering pathways that synergize transformative innovation with environmental responsibility, this research offers theoretical and empirical foundations for strategic decision-making and policy design, proposing actionable measures grounded in multiplex synergy strategies.

2. Theoretical Analysis and Framework Development

2.1. Theoretical Analysis of Resource, Capability, and Environment Interplay

The Resource-Based View (RBV), initially proposed by Wernerfelt, emphasizes that firms build competitive advantage through unique and valuable resources. Wernerfelt defined resources as "anything which could be thought of as a strength or weakness of a given firm," encompassing both tangible resources (e.g., equipment, capital) and intangible resources (e.g., brand, technology). It was proposed that the uniqueness and inimitability of resources constitute key sources of a firm's competitive advantage. Building upon this foundation, Barney (1991) systematized the theory by introducing the VRIN framework. This framework posits that resources must possess the characteristics of being Valuable, Rare, Imperfectly Imitable, and Non-substitutable to establish a sustainable competitive advantage. Barney further argued that a firm's competitive advantage hinges not only on the static attributes of its resources but also on the efficiency of their dynamic deployment and utilization. This entails how the firm integrates resources and builds capabilities to respond to changes in the external environment.

Against the backdrop of digital and green transformation, this theoretical logic has been extended. A firm's sustainable development capability relies on the multidimensional synergy among technological resources, organizational capabilities, and the external environment. Specifically, digital technology applications, smart manufacturing, and green practices—serving as the core technological resources underpinning this dual transformation—exhibit VRIN characteristics. Digital absorptive capacity and organizational adaptability, constituting the core of dynamic capabilities, determine the efficiency with which firms translate technological resources into tangible outcomes. Government subsidies and market competition, as pivotal elements of the external environment, propel the enhancement of firms' sustainable development capabilities through resource support and competitive pressure, respectively.

2.2. Development of the Resource-Capability-Environment Framework

Based on the preceding analysis, this study constructs a "Resource-Capability-Environment" (RCE) synergistic framework. This integrated theoretical model elucidates the multi-dimensional interaction mechanisms among technological resources, organizational capabilities, and the external environment, revealing how technological innovation, organizational capabilities, and external environmental factors collectively shape the formation mechanism of corporate sustainable development capabilities (as illustrated in Figure 1).

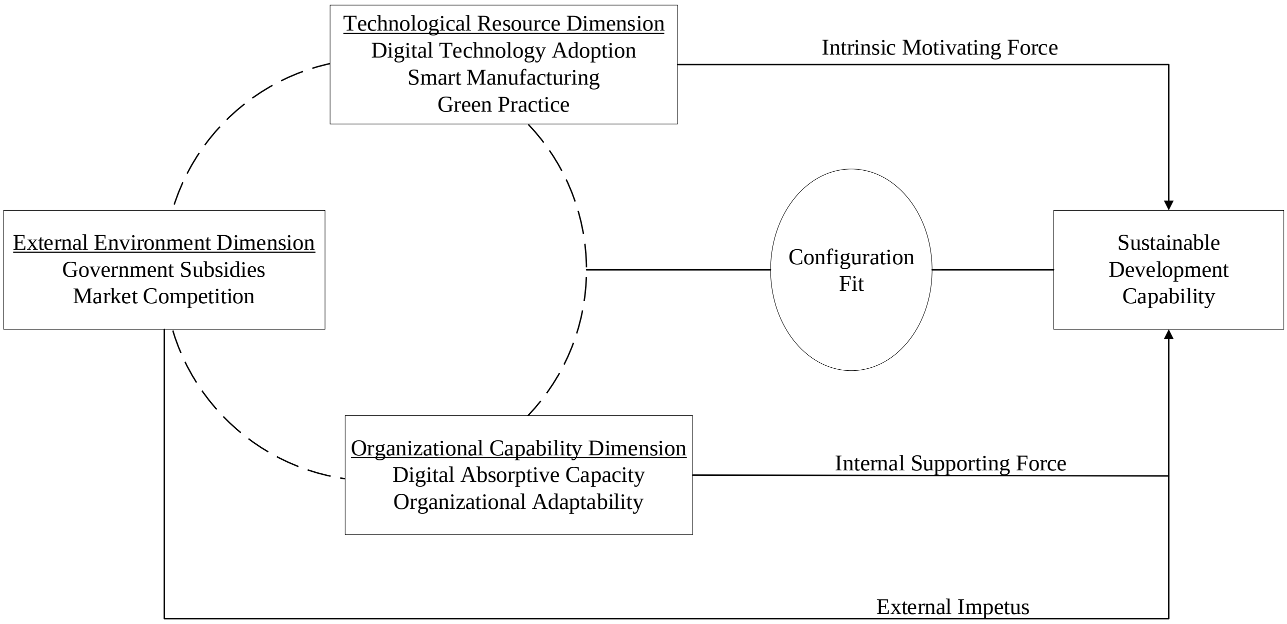

Fig. 1 Two or more references

First, the technological resource dimension comprises three conditional variables: digital technology application, smart manufacturing, and green practices. Digital technology application, serving as the core resource of digital transformation, provides technological foundations for green innovation while reducing environmental burdens[13]. The deep integration of digital technologies offers comprehensive support for highly specialized small and medium-sized enterprises (SMEs) to explore new business models[14], expands their market reach, enhances international market penetration, and facilitates scalable growth alongside sustainability[15]. Smart manufacturing functions as the "technological engine" of production processes. Through the automation and intellectualization of production, it accelerates new product development[16], improves production efficiency and flexibility[15], reduces resource waste and environmental impacts, thereby providing technological underpinnings for sustainable development. Green practices focus on resource efficiency and environmental stewardship by implementing lifecycle-oriented green production[17]. Deepening green practices enables specialized SMEs to access new markets and attract environmentally conscious consumers[15]. Concurrently, leveraging policy incentives (e.g., tax relief, subsidies) strengthens market competitiveness and elevates their position within global supply chains, fostering synergistic development[18].

Second, the organizational capability dimension encompasses two conditional variables: digital absorptive capacity and organizational adaptability. Digital absorptive capacity drives technological innovation and green practices by assimilating external knowledge with existing knowledge bases. This enhances resource utilization efficiency and bolsters sustainable development capabilities[19], while simultaneously enabling firms to accumulate experience within complex and volatile market and technological environments to mitigate operational risks. Organizational adaptability manifests as the capacity to flexibly allocate resources and optimize production and supply chain management in response to market dynamics and policy adjustments. This allows firms to achieve environmental objectives while improving operational efficiency[19]. Moreover, robust adaptability enhances organizational resilience against disruptions and market volatilities, ensuring stability in production and operations.

Third, the external environment dimension includes two conditional variables: government support and market competition. Government support (e.g., fiscal subsidies, tax incentives, special funds) alleviates resource constraints[20], lowers the costs associated with greening and technological innovation, creates opportunities for specialized SMEs within the green economy, and augments their sustainable development capacity. Market competition exerts external pressure that compels firms to integrate sustainable elements. This involves developing eco-friendly products, optimizing supply chains, and improving production efficiency[20] to meet consumer expectations regarding environmental responsibility. Furthermore, competitive pressures incentivize increased investment in technological and managerial innovation, enhancing operational flexibility and resource utilization efficiency.

3. Research Design

3.1. Research Methods

This study employs the fuzzy-set Qualitative Comparative Analysis (fsQCA) method for the following reasons:

First, fsQCA examines complex causal relationships between antecedent conditions and outcomes by analyzing their interdependencies, aligning with the multifaceted reality of corporate sustainable development capabilities. Second, diverse combinations of antecedent variables may constitute distinct "pathways" leading to high-level sustainable development capabilities, while multiple concurrent causal pathways can generate equivalent outcomes—a methodological strength of fsQCA in addressing such complexities[21].

Using fsQCA, this research identifies configurations that generate high sustainable development capabilities, designates them with conceptual labels, and examines exemplar cases to elucidate how firms coordinate technological resources, organizational capabilities, and external environments to operationalize sustainability through practical pathways.

3.2. Sample and Data Collection

This study selects nationally designated highly specialized small and medium-sized enterprises (SMEs) listed in the Yangtze River Economic Belt as the research sample. The sample covers 11 provincial-level regions (Jiangsu, Zhejiang, Anhui, Jiangxi, Hubei, Hunan, Sichuan, Yunnan, Guizhou, Shanghai, and Chongqing), which constitute critical pillars of China’s new development paradigm[22]. The data collection and screening procedure followed these steps:(1) Exclusion of delisted ST and *ST firms;(2) Removal of enterprises with incomplete information;(3) Extraction of 2023 annual reports for each firm from the Inspur Info platform;(4) Quantification of digital technology application, smart manufacturing, and green practices through Python-based text mining;(5) Elimination of enterprises with zero observed activity in all three technological dimensions (i.e., aggregate keyword frequency count of zero for "digital technology application," "smart manufacturing," and "green practices").

All data were sourced from the CSMAR database, WIND database, and official disclosures of mainboard-listed firms provided by the Shanghai and Shenzhen Stock Exchanges. Accounting for regional and industrial diversity, data availability, and information consistency, the final sample comprises 332 firms across 11 provincial-level regions and 13 subsectors.

3.3. Variable Measurement and Calibration

3.3.1 Variable Measurement

(1) Outcome Variable

Sustainable Growth Capability (SGR) denotes a firm’s long-term profitability and enduring competitiveness. Adopting the measurement approaches of Yang et al.[23] and Xu & Dong[24], SGR is calculated using Van Horne’s static sustainable growth model.

(2) Conditional Variables

①Digital Technology Application (Dig): Building on keyword extraction frameworks from Zhao et al.[25] and supplementary literature, Dig is measured as the natural logarithm of (total keyword frequency + 1) in corporate disclosures. ② Smart Manufacturing (Int): Following keyword classification systems in Zhao et al.[25], Li & Wang[26], and Xu et al.[27], Int is quantified as the natural logarithm of (total keyword frequency + 1). ③Green Practices (Gre): Drawing on Zhou et al.’s[28]

113 keywords across five dimensions (advocacy, strategy, technology, emission control, monitoring), Gre is measured as the natural logarithm of (total keyword frequency + 1). ④Absorptive Capacity (Abs): Consistent with Yang et al.[29]and Li & Chang[20], Abs is operationalized as R&D intensity (annual R&D expenditure divided by operating revenue). ⑤Adaptability (Ada): Adapting Yang et al[29] and Zhang et al.[30], Ada is measured by the negative value of the coefficient of variation (CV) in annual expenditures across R&D, capital, and advertising. Higher adjusted CV values indicate greater adaptability. ⑥Government Support (Gov): Following Chen[31], Gov is calculated as the natural logarithm of government subsidy amounts. ⑦Market Competition (Mar): Adopting Jing et al.'s[21] approach, Mar is proxied by the Herfindahl-Hirschman Index (HHI). Higher HHI reflects lower competition (market concentration), while lower HHI indicates intense competition.

3.3.2 Variable Calibration

Based on the distributional characteristics of the sample data, this study employs the direct calibration method using the 95th, 50th, and 5th percentiles as anchor points. The calibration procedure comprises three steps: First, we determine three critical values (full membership, crossover point, full non-membership) for the outcome variable and seven antecedent conditions. Second, we transform variables into fuzzy-set membership scores using the Calibrate(x, n1, n2, n3) function in fsQCA 3.0 software. Third, we verify calibrated data by replacing crossover scores of exactly 0.500 with 0.501 to prevent case deletion, while applying 0.499 in robustness checks following Du et al.[32]. Calibration results for all variables are documented in Table 1.

Table 1. Calibration of Condition and Outcome Variables

Condition Variables and Outcome Variables	Full Membership	Crossover Point	Full Non-Membership
Sustainable Development Capability	0.428	0.129	-0.020
Digital Technology Application	1.774	0.602	0.000
Condition and Outcome Variables	1.936	1.114	0.301
Smart Manufacturing	3.348	2.398	1.099
Green Practices	0.212	0.056	0.027
Digital Absorptive Capacity	0.212	0.056	0.027
Organizational Adaptability	17.561	15.915	14.165
Government Subsidies	0.167	0.032	0.017
Market Competition	1.936	1.114	0.301

4. Results and Analysis

4.1. Analysis of the Necessity of Antecedent Conditions

Prior to configurational analysis, we assess whether any single antecedent condition constitutes a necessary condition for the outcome. Following conventional thresholds, a condition is considered necessary when its consistency exceeds 0.9 with non-trivial coverage. Using fsQCA 3.0 software, we test the consistency of individual antecedent conditions against the outcome variable. As summarized in Table 2, all consistency scores for single antecedent conditions fall below 0.9, indicating no individual condition is necessary for either high or non-high sustainable growth capability. This confirms that high sustainable growth capability cannot be achieved through isolated factors, necessitating further analysis of configurational effects.

Table 2. Analysis of Single Antecedent Variables as Necessary Conditions

Antecedent Variables	High Sustainable Development Capability		Not-High Sustainable Development Capability	
	Consistency	Coverage	Consistency	Coverage
Digital Technology Application	0.608	0.692	0.554	0.691
Absence of Digital Technology Application	0.729	0.599	0.753	0.678
Smart Manufacturing	0.621	0.700	0.558	0.690
Absence of Smart Manufacturing	0.725	0.600	0.757	0.686
Green Practices	0.671	0.639	0.663	0.691
Absence of Green Practices	0.676	0.647	0.653	0.685
Digital Absorptive Capacity	0.613	0.652	0.614	0.714
Absence of Digital Absorptive Capacity	0.731	0.634	0.701	0.665
Organizational Adaptability	0.613	0.652	0.614	0.714
Absence of Organizational Adaptability	0.731	0.634	0.701	0.665
Government Subsidies	0.685	0.673	0.624	0.671
Absence of Government Subsidies	0.665	0.618	0.696	0.707
Market Competition	0.614	0.685	0.580	0.709
Low Market Competition	0.739	0.616	0.742	0.678

4.2. Configuration Analysis Findings

Drawing on the research of Du Y. Z. & Jia L.or Du Yunzhou & Jia Liang, depending on journal style , the raw consistency threshold was set at 0.75, the case frequency threshold was set at 2, and the PRI (Proportional Reduction in Inconsistency) threshold was set at 0.5. Given that research on the sustainable development capability of Specialized, Sophisticated, Distinctive, and Novel "Little Giant" enterprises (Zhuan Jing Te Xin "Xiao Ju Ren" Qiye) remains exploratory, with diverse interpretations from multiple perspectives across different dimensions, the antecedent conditions in this study were configured as present or absent within the truth table. Subsequently, following the principle of "prioritizing the intermediate solution, supplemented by the parsimonious solution" for counterfactual analysis and solution nesting, the resulting configurations are presented in Table 3. In Table 3, large solid circles (●) denote core conditions, small solid circles (●) denote contributing (auxiliary) conditions, crossed-out circles (⊗) denote the absence of the condition, and blank cells indicate the condition could be either present or absent (i.e., a "don't care" state).

Table 3. Findings from the Configurational Analysis of the Sample Firms

Antecedent Conditions	High Sustainable Development Capability					Non-high Sustainable Development Capability		
	Y1	Y2	Y3	Y4	Y5	NY1	NY2	NY3
Digital Technology Application	●	●	●	●	●	⊗	●	⊗
Smart Manufacturing	●	●	●	●	⊗	⊗	●	⊗
Green Practices		⊗	⊗	●	●	⊗	●	●
Digital Absorptive Capacity	⊗	⊗	⊗	●	●	●	⊗	●
Organizational Adaptive Capacity	⊗	⊗	⊗	●	●	●	⊗	●
Government Subsidies	●			⊗	●	⊗	⊗	●
Market Competition	⊗	⊗	●		⊗	●	●	●
Raw Coverage	0.297	0.243	0.232	0.265	0.237	0.223	0.191	0.198
Unique Coverage	0.033	0.008	0.023	0.046	0.035	0.059	0.053	0.034
Consistency	0.875	0.902	0.887	0.862	0.877	0.916	0.896	0.937
Solution Consistency	0.829					0.893		
Solution Coverage	0.450					0.319		

4.2.1 Configurational Analysis for High Sustainable Development Capability

As indicated in Table 3, the consistency scores for individual configurations achieving high sustainable development capability all exceed 0.8, meeting the analytical standards for fsQCA. Among these, configurations Y2 and Y3 share identical core conditions, forming a second-order equivalent configuration, and are therefore consolidated into a single configuration for analysis. The detailed analysis is as follows:

(1) Technology Resource-Policy Symbiosis Pathway (Y1). his pathway is primarily driven by the core conditions of “digital technology application” and “intelligent manufacturing” within the technological resource dimension, alongside "government subsidies" in the external environment dimension. It reflects the synergistic effect between technological innovation and policy support. Digital technology and intelligent manufacturing provide the technical foundation for enhancing production efficiency and enabling green practices. Government subsidies, acting as external resource support, compensate for deficiencies in firms' digital absorptive capacity and organizational adaptability, thereby providing both the impetus and security for sustainable development.

Representative cases include SST, Ltd. and SICE. SST specializes in environmental pollution control, possessing multiple patented technologies, and provides industrial pollution treatment solutions for industries such as pan-semiconductors, fine chemicals, and automotive manufacturing. SICE focuses on the R&D and manufacturing of intelligent complete conveying equipment, offering systematic solutions for automated production lines to industries including automotive and engineering machinery, thereby advancing the development and application of intelligent manufacturing technology. These two companies, through the synergistic interplay of technological innovation and government subsidies, have accelerated the rapid development of intelligent manufacturing technologies, significantly enhancing their market competitiveness within their respective industries.

(2) Dual Technology Resource-Capability Matching Pathway (Y2, Y3). This configuration is primarily driven by the core conditions of “digital technology application” and “intelligent manufacturing” within the technological resource dimension. Leveraging technologies such as big data, cloud computing, the Internet of Things (IoT), and artificial intelligence (AI), it optimizes production processes and resource allocation, leading to significant efficiency gains and cost reductions. Despite exhibiting relatively weaker green practices, digital absorptive capacity, and organizational adaptability, the synergistic effect driven by technology still enables these firms to achieve sustainable development. A lenient competitive environment provides the conditions for concentrated resource allocation during their technological transformation. However, in the long term, the deficiency in green initiatives and organizational capabilities may constrain their sustained competitive advantage.

Representative cases include SLAC. and WT. SLAC specializes in the design and manufacturing of high-end specialized complete equipment, providing premium machinery and integrated solutions for clients in the metal packaging industry. The company has made significant strides in the digital and intelligent transformation of production lines for cans/lids and battery casings. By developing its SLAC Intelligent Platform, it has progressively advanced intelligent development, thereby enhancing the intelligence level of its production lines. WT, building upon sensor technology with a focus on communication technology, offers products including Telematics Management Platforms for the automotive Internet of Things (IoT). It is one of the earliest domestic companies in China to develop Tire Pressure Monitoring System (TPMS) sensors, ranking among the top three in the country for product shipments. Through technological innovations, such as integrating Near Field Communication (NFC) technology into its sensors, the company has bolstered its technological edge and market competitiveness. These two companies demonstrate that sustained development can be maintained through technology-driven approaches, even in contexts with less emphasis on green practices and organizational capabilities.

(3) Technology Resource-Dominant Pathway (Y4). This configuration is primarily driven by the core conditions of “intelligent manufacturing” and “green practices” within the technological resource dimension. Through the synergy between intelligent technologies and environmental practices, it achieves a win-win outcome of resource optimization and enhanced environmental performance. Firms exhibit high digital absorptive capacity and high organizational adaptability, enabling them to effectively integrate external resources and flexibly respond to environmental changes. Consequently, organizational capabilities serve as a crucial enabler for endogenous development. Notably, in the absence of government subsidies, these firms rely on internal drivers. By deeply integrating technological and green transformation, they maintain efficient operations and sustainable competitiveness, underscoring the importance of independent innovation and organizational resilience.

Representative cases include TYE. and RSE TYE, as a provider of operation and maintenance solutions for rail transit, specializes in the R&D, manufacturing, and sales of detection and monitoring systems for traction power supply, permanent way engineering, and rolling stock engineering, along with intelligent operation and maintenance information management systems for the rail transit industry. Through technological innovations, such as novel insulation functions, intelligent anti-pinch features, and machine vision-based intelligent foreign object monitoring, the company has enhanced its technological edge and achieved deep integration in intelligent manufacturing and green practices. RSE. provides intelligent solutions in areas including heating energy conservation, heat metering, smart heating networks, and energy services. Through its intelligent products and services, it exemplifies the synergistic development of intelligent manufacturing and green initiatives. RSE has achieved real-time data acquisition and automated control of heating operation data by deeply integrating automation, informatization, big data, and AI technologies, effectively reducing heat consumption and carbon emissions. These two companies demonstrate the ability to achieve sustainable development through internal drivers and the integration of technological innovation with green practices, even without relying on government subsidies.

(4) Dual Technology Resource-Policy Catalyzed Pathway (Y5). This configuration is primarily driven by the core conditions of “digital technology application” and “green practices” within the technological resource dimension, supplemented by “government subsidies” in the external environment dimension, to achieve sustainable development. Firms enhance resource allocation efficiency and environmental management capabilities through digital technologies, while simultaneously optimizing production processes and reducing environmental footprint via green practices. Government subsidies provide crucial financial support for green and digital transformation, thereby mitigating potential operational efficiency challenges arising from comparatively underdeveloped intelligent manufacturing technology and lower market competition pressure. This indicates that under conditions of substantial policy support and a lenient competitive environment, the synergy between digitalization and greening can effectively advance firms' sustainable development objectives.

Representative cases include AMT and NHE. AMT is a high-tech semiconductor materials company founded on independent innovation, integrating R&D, production, sales, and technical services. It specializes in the research, design, and production of materials for integrated circuits, providing related technical services and consultation. NHE operates in the capacitors and electronic components sector, committed to the green transformation and digital transformation of its products. Leveraging technological innovation and policy support, the company drives a win-win outcome in resource optimization and environmental performance. These two companies exemplify a dual-driver model combining internal digital-green synergy with external policy support, demonstrating a paradigmatic pathway through which firms achieve sustainable development via digital and green practices, underpinned by policy assistance.

4.2.2 Configurational Analysis for Non-High Sustainable Development Capability

All configurations leading to low-level sustainable development capability exhibited consistency scores exceeding 0.8, satisfying the analytical threshold of the fsQCA method. These configurations are identified as: Dynamic Capability Void (NY1), Green Drift Decoupling (NY2), and Competitive Squeeze Imbalance (NY3). The Dynamic Capability Void (NY1) configuration is characterized by organizational capability redundancy coupled with technological capability deficiency. In this scenario, a singular strength in organizational capacity proves insufficient to overcome overall developmental shortcomings. The Green Drift Decoupling (NY2) configuration reflects enterprises engaging in symbolic adoption of environmental practices. While achieving short-term optimization through partial technological application or organizational capability enhancements, these firms face constrained long-term competitiveness and sustainability due to mounting external environmental pressures, highlighting a decoupling between superficial actions and substantive sustainability integration. Finally, the Competitive Squeeze Imbalance (NY3) configuration depicts enterprises experiencing a loss of competitive focus (niche degradation) stemming from technological lag. Given insufficient internal innovation and capabilities, reliance solely on government support and fragmented greening initiatives is inadequate for sustaining long-term development.

4.3. Robustness Check

Robustness checks for the fuzzy-set qualitative comparative analysis (fsQCA) were conducted through multiple approaches, including adjusting case consistency thresholds, raising the PRI consistency threshold, and adding or deleting cases. Adopting the procedure established by Li and Chang[20], this study specifically recalibrated the crossover point data from 0.5 to 0.499, elevated the raw consistency threshold from 0.75 to 0.8, increased the PRI consistency threshold from 0.5 to 0.6, and performed repeated random subsampling with case removal. The core configurations remained consistent throughout all sensitivity analyses, confirming the robustness of the findings.

5. Conclusions and Future Research

5.1. Research Conclusions

Technological innovation serves as the core driver of sustainable development capability. Digital technology application and intelligent manufacturing, as fundamental elements of technological resources, constitute universal conditions for enterprises to achieve high-level sustainable development capability. Digital technology optimizes resource allocation and business processes, providing enterprises with informatization and data support. Intelligent manufacturing enhances production efficiency and resource utilization, facilitating green transformation and the attainment of environmental objectives. Technological innovation not only forms the foundation for efficient enterprise operations but also acts as a critical driver for addressing environmental challenges and securing long-term competitive advantage.

Organizational capability provides endogenous support for sustainable development capability. Digital absorptive capacity and organizational adaptability, as core organizational competencies, significantly enhance enterprises' resilience and adaptability in dynamic environments. Digital absorptive capacity enables enterprises to rapidly integrate and apply emerging technologies, while organizational adaptability maintains agility and innovation in complex markets through strategic adjustments and operational optimization. The synergistic interplay between organizational capabilities and technological innovation generates endogenous momentum for enterprises' digital and green transformations.

The external environment functions as both catalyst and constraint for sustainable development capability. Government subsidies and market competition, as pivotal external elements, enhance enterprises' sustainable development capability through resource provision and pressure mechanisms respectively. Government subsidies offer financial security for technological upgrading and green transitions, while market competition compels enterprises to optimize resource allocation and enhance innovation capacity through external pressures. The multidimensional synergy among external environments, technological resources, and organizational capabilities provides diversified pathway options for achieving sustainable development.

5.2. Research Implications

Firms must strengthen synergistic innovation between digital intelligence technologies and green initiatives by deeply integrating digital applications, intelligent manufacturing, and environmental practices. This integration enhances production efficiency and environmental performance, thereby building sustainable technological advantages. Concurrently, enterprises should enhance organizational capabilities—particularly digital absorptive capacity and organizational adaptability—to improve external resource integration and market volatility responsiveness, providing foundational support for long-term development. Strategic optimization requires selecting context-appropriate development pathways (technology-driven or policy-guided) to achieve high-quality sustainable growth.

Governments should implement targeted subsidy allocation by formulating specialized policies with expanded fiscal support and tax incentives for critical domains including digital technology adoption, intelligent manufacturing, and green transition to facilitate enterprise-level technological upgrading. Meanwhile, establishing dedicated incentive programs for green development and smart manufacturing can stimulate corporate innovation breakthroughs in technological advancement and environmental practices, promoting coordinated progress in economic and environmental benefits through institutionalized support mechanisms.

Collective action should establish green supply chain ecosystems by fostering inter-firm collaboration within industries, leveraging shared green technologies and optimized logistics to collectively reduce resource consumption and environmental impacts. Concurrently, market guidance mechanisms require development through industry-wide standards and robust green certification frameworks to advance high-standard environmental practices and elevate sectoral sustainability performance. Furthermore, supporting small and medium enterprises (SMEs) necessitates coordinated efforts between industry associations and financial institutions to provide essential transformation resources, enabling competitive positioning during digital-green upgrading initiatives.

5.3. Future Research Directions

This study employs qualitative comparative analysis to reveal multiple pathways for sustainable development capability among specialized, refined, unique, and innovative "little giant" enterprises, providing practical insights for firms and policymakers. However, the static nature of cross-sectional data analysis imposes limitations in interpreting long-term enterprise development dynamics. Future research could extend this work through longitudinal tracking to investigate strategic realignment and evolutionary trajectories across varying policy and market contexts, thereby offering more robust theoretical and empirical grounding for constructing dynamic frameworks of corporate sustainability.

References

[1] Chao Luan. Central Economic Work Conference held in Beijing, Xi Jinping delivered an important speech__Chinese Government Website[EB/OL]. [2025-03-19]. https://www.gov.cn/yaowen/liebiao/202412/content_6992258.htm.

[2] Wang Yang. China will explore the establishment of a specialized, sophisticated, distinctive, and novel empowerment system_Department News_Chinese Government Website[EB/OL]. [2025-03-20]. https://www.gov.cn/lianbo/bumen/202412/content_6990605.htm.

[3] Development Report on Small and Medium - sized Enterprises (2023 - 2024)_Pishu Database[EB/OL]. [2024-11-18]. https://www.pishu.com.cn/skwx_ps/bookdetail?SiteID=14&ID=15566685.

[4] Ding Yongjian, Wu Xiaomeng. Does the cultivation of "little giant" enterprises help enhance the innovation vitality of small and medium - sized manufacturing enterprises——Evidence from the "specialized, sophisticated, distinctive, and novel" policy[J]. Science & Technology Progress and Policy, 2023, 40(12): 108-116.

[5] Feng Xueliang, Zhou Zhen, Qi Xinyu. Development of financial technology and growth of small and medium - sized technological enterprises——Evidence from specialized, sophisticated, distinctive, and novel "little giant" enterprises[J]. Technology Economics, 2023, 42(11): 103-112.

[6] Wen Chuanhao, Zeng Yanmei, Li Yi, et al. Supply chain finance and high - quality development of specialized, sophisticated, distinctive, and novel "little giant" enterprises——A discussion from the perspective of "capital + technology" dual - wheel drive[J]. East China Economic Management, 2024, 38(10): 72-82.

[7] Cai Shuangli, Guo Qiang. Academic executives of specialized, sophisticated, distinctive, and novel enterprises and sustainable innovation of enterprises——Dual regulatory effect of enterprise incentive mechanism and risk - taking level[J]. Journal of Zhejiang Gongshang University, 2023(1): 120-134.

[8] Guo Qiang, Cai Shuangli. Impact of entrepreneurs' risk - taking tendency on sustainable innovation of specialized, sophisticated, distinctive, and novel "ittle giant" enterprises and its mechanism[J]. Science and Technology Management Research, 2024, 44(10): 212-222.

[9] Li Jinsheng, Ke Wen. How knowledge search and reconstruction promote green technology innovation of specialized, sophisticated, distinctive, and novel small and medium - sized enterprises——Regulatory role of strategic flexibility and incentive environmental regulation[J]. Science & Technology Progress and Policy, 2024, 41(7): 111-121.

[10] Cao Yuhua, Zhang Yanli, Shi Rongrong, et al. Attention: A study on the antecedent configuration of organizational resilience of specialized, sophisticated, distinctive, and novel "little giant" driven by digital transformation——fsQCA analysis based on text mining of annual reports of listed companies[J]. Foreign Economics & Management, 2023, 45(10): 68-83.

[11] Jing Hao, Qu Guimin. Research on the configuration effect of "specialized, sophisticated, distinctive, and novel" enterprises to achieve high performance——A combined analysis based on NCA and QCA[J]. Communication of Finance and Accounting, 2023(22): 88-95.

[12] Tang Xiaowen, Yao Xincen, Yu Lanting. Research on innovation path of "little giant" enterprises in the digital context[J]. Science Research Management, 2023, 44(12): 10-20.

[13] Li Jinchang, Lian Ganghui, Xu Aiting. The way to break through the green transformation of enterprises under the "double carbon" vision——An empirical study on digitalization driving greening[J]. Journal of Quantitative Economics and Technical Economics, 2023, 40(9): 27-49.

[14] Chen Shuyang, Li Yongfa. Business model innovation orientation in the digital context: Value or efficiency?——A comparative study on the paths of digital native and non - native enterprises[J]. Research on Economics and Management, 2024, 45(10): 126-144.

[15] Strategic Orientation, Digital Capabilities, and New Product Development in Emerging Market Firms: The Moderating Role of Corporate Social Responsibility[EB/OL]. [2024-11-05]. https://www.mdpi.com/2071-1050/13/22/12703.

[16] Liu Wei, Lu Hongfang, Yu Longzhen, et al. Intelligent transformation, economic policy uncertainty and manufacturing innovation——From the perspective of innovation motivation[J]. Journal of Guangdong University of Finance & Economics, 2024, 39(3): 4-19.

[17] Wan Panbing, Yang Mian, Chen Lin. How environmental technical standards affect the green transformation of China's manufacturing industry——From the perspective of technological transformation[J]. China Industrial Economics, 2021(9): 118-136.

[18] Arias - Pérez J, Velez - Ocampo J, Cepeda - Cardona J. Strategic orientation toward digitalization to improve innovation capability: why knowledge acquisition and exploitation through external embeddedness matter[J]. Journal of Knowledge Management, 2021, 25(5): 1319-1335.

[19] Yang Lin, He Xin, Gu Hongfang. Top management team experience, dynamic capability and enterprise strategic mutation: The moderating effect of management autonomy[J]. Management World, 2020, 36(6): 168-188, 201, 252.

[20] Li Tao, Chang Xiaoyi. Improvement of organizational resilience of "specialized, sophisticated, distinctive, and novel" enterprises in the context of digital transformation——Based on fsQCA method[J]. Finance and Accounting Monthly, 2024, 45(19): 111-116.

[21] Jing Hao, Qu Guimin. Research on the configuration effect of "specialized, sophisticated, distinctive, and novel" enterprises to achieve high performance——A combined analysis based on NCA and QCA[J]. Communication of Finance and Accounting, 2023(22): 88-95.

[22] Lyu Xin, Tang Chengli, Liu Yunlin, et al. Spatial distribution characteristics and influencing factors of national specialized, sophisticated, distinctive, and novel "little giant" enterprises in the Yangtze River Economic Belt[J]. Journal of Natural Science of Hunan Normal University, 2024, 47(3): 61-71.

[23] Yang Xudong, Peng Chenchen, Yao Ailin. Management capability, internal control and sustainable development of enterprises[J]. Audit Research, 2018(3): 121-128.

[24] Xu Huaining, Dong Birong. How digital transformation promotes sustainable development of enterprises——From the perspective of shaping enterprise core competitiveness[J]. Contemporary Economic Management, 2023, 45(7): 44-53.

[25] Zhao Chenyu, Wang Wenchun, Li Xuesong. How does digital transformation affect total factor productivity of enterprises[J]. Finance & Trade Economics, 2021, 42(7): 114-129.

[26] Li Wanhong, Wang Fan. Intelligent transformation, cost stickiness and enterprise performance——An empirical test based on traditional manufacturing enterprises[J]. Studies in Science of Science, 2022, 40(1): 91-102.

[27] Xu Yuyun, Wang Jun, Wang Xiaofei. Impact of intelligent transformation on technological innovation efficiency of manufacturing enterprises[J]. Statistics & Decision, 2024, 40(10): 184-188.

[28] Zhou Kuo, Wang Ruixin, Tao Yunqing, et al. Enterprise green transformation and stock price crash risk[J]. Journal of Management Sciences, 2022, 35(6): 56-69.

[29] Yang Lin, He Xin, Gu Hongfang. Top management team experience, dynamic capability and enterprise strategic mutation: The moderating effect of management autonomy[J]. Management World, 2020, 36(6): 168-188, 201, 252.

[30] Zhang Jide, Yuan Miaomiao, Quan Qian. Research on the impact of digital transformation on innovation performance of manufacturing enterprises——Based on the perspective of dynamic capability adjustment[J]. Communication of Finance and Accounting, 2024(18): 29-35.

[31] Chen Xiaoshan. Government subsidies and social responsibility of private enterprises[J]. Finance and Trade Research, 2021, 32(1): 83-95.

[32] Du Yunzhou, Liu Qiuchen, Chen Kaiwei, et al. Business environment ecology, total factor productivity and multiple models of high - quality urban development——Configuration analysis based on complex system perspective[J]. Management World, 2022, 38(9): 127-145.