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Configurational Paths to Enhancing Innovation Performance in SRDI Enterprises under Digital Transformation

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Abstract: *This paper examines how SMEs can use digital tools to strengthen innovation capacity. Departing from traditional single-factor or single-case analyses, it draws on data from 105 listed Chinese "Little Giant" firms, using a comparative configurational approach to explore how technological, organizational, and external factors shape innovation. Our main findings are threefold:(1) No single factor alone explains innovation performance differences. (2) We identify three effective configurations for high innovation: internal capability-centered, technology-led, and policy-supported.(3)A configuration marked by rigid routines and low adaptability is associated with weaker innovation. This study enriches digital transformation literature by highlighting strategic resource combination importance for SMEs, and offers practical implications for "Little Giant" firms to leverage digitalization for better innovation.*

Keywords: *Digital Transformation; SRDI Enterprises; Innovation Performance; fsQCA; Configuration Paths*

1. Introduction

Amid global economic shifts and industrial chain restructuring, boosting breakthrough innovation in critical technologies is a strategic priority for high-quality development and reducing bottlenecks. The 20th CPC National Congress report calls for a modern economic system with stronger industrial chain resilience and security [1], and supports SSDI enterprises in advancing high-end, intelligent, and green manufacturing [2]. Defined by deep specialization, precision, distinctiveness, and novelty, SSDI firms are key to both industrial chain resilience and new-quality productive forces [3].

Through policy improvements, China has established a three-level SME cultivation system ("innovative – specialized and distinctive – little giant") and boosted innovation capacity through annual recognition [4]. Digital transformation is becoming a key driver of firm innovation and industrial chain modernization. The Ministry of Industry and Information Technology issued the "Action Plan for Digital Empowerment of SMEs (2025–2027)" to support SME digitalization [5]. Therefore, against the backdrop of strong policy support and digital transformation, exploring how specialized SMEs can improve innovation performance by coordinating technology, organization, and environment is both a theoretical extension of innovation-driven theory and a practical step for advancing manufacturing power and industrial chain self-reliance.

2. TOE Framework

2.1 Technical Factors

As the digital economy grows, how digital transformation affects firm innovation has become a key research topic. For "Little Giant" firms, digitalization improves innovation performance through two channels: capability enhancement and resource utilization. On the capability side, digitalization optimizes internal structures and governance [6], supports cross-functional knowledge sharing and value co-creation. It also enables innovation in production and business models, raising efficiency and driving continuous upgrades [7]. On the resource side, digital platforms help integrate data, facilitate inter-firm data sharing, improve managers' access to specialized information, and enhance internal resource

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allocation [8]. Meanwhile, digital transformation brings in external funding, easing resource constraints [9].

2.2 Organizational Factors

Organizational redundancy means idle resources within a firm [10] and can drive green innovation. It falls into two types: absorbed and unabsorbed. Absorbed redundancy is embedded in daily operations, hard to identify and reallocate. A moderate level helps R&D spending, but too much slows it down [11]. Unabsorbed redundancy refers to extra, flexible resources not yet used, easier to shift across uses. It can be quickly put into green innovation for new product development and also helps manage risks [12].

The executive team plays a key role in securing resources, reducing risks, and improving performance. Their background traits shape firm operations, decisions, and outcomes. Executives with technical backgrounds tend to have a stronger "technical mindset" and are more eager to explore new technological opportunities and drive innovation [13].

2.3 Environmental Factors

Government subsidies offer direct financial support for innovation, which helps specialized and distinctive SMEs. Digital transformation often brings high costs, fast tech changes, and market risks. As a "visible hand," government subsidies can boost R&D spending and support digital product development. Studies show that firms with more resources tend to innovate more. Subsidies ease resource pressure during transformation, encourage tech exploration and real-world use, and clearly promote digital transformation in these SMEs [14].

The market environment doesn't directly shape firm innovation but strongly guides executives' choices. Intense competition pushes firms to embrace digital transformation. Using data intelligence, they can better understand users, spot unmet needs, and improve products or business models, boosting service quality and market competitiveness. For "little giant" firms with strong positions in specific fields, higher market concentration often leads them to increase innovation spending to keep their edge [15].

3. Research Design

3.1 Research Methodology

Using fsQCA, this study examines how digital transformation affects innovation performance of "little giant" firms. The method fits for three reasons: (1) it captures interactions among technology, organization, and environment, revealing multiple paths to high performance; (2) it handles continuous variables via fuzzy set calibration; (3) it explains separate paths to both high and non-high performance, offering practical insights.

3.2 Data Sources

The sample covers 105 national-level "Little Giant" firms listed on the Shanghai and Shenzhen A-share main boards. These firms were taken from the first to fifth batches announced on the MIIT website between 2019 and 2023, with data from 2023. "Little Giant" firms are a core group of high-quality innovative SMEs that receive policy support and market attention. Their innovation activities are worth studying. Also, these firms are relatively large, with mature operations and standard governance. Their public and reliable data avoids the common data quality problems seen in studies of startups or unlisted companies.

3.3 Variable Measurement

Digital Transformation. Following Wu Fei et al. [16], we used text analysis to build the measure. Annual reports of listed firms were collected via Python web scraping. We counted how often digital transformation keywords appeared in each report, added 1 to the total, and took the natural log.

Organizational Redundancy. Based on Wu Jianzu et al. [11], we used the current ratio (current assets / current liabilities) as the measure. A higher ratio means more idle resources that the firm can flexibly use.

Executive Technical Background. Following Yuan Rongli et al. [17], we measured this as the share of

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executives with an IT background among all executives of listed firms.

Government Subsidies. Drawing on Tang Xuan et al. [14], we used the total government subsidies reported in the notes to financial statements. This figure was also log-transformed.

Market Competition. We used the Herfindahl-Hirschman Index (HHI). A larger HHI means a more concentrated industry market share and thus weaker competition [15].

Innovation Performance. Based on annual report disclosures and prior studies [18], we measured innovation performance by the number of invention patent applications.

3.4 Variable Calibration

The variables were calibrated using fsQCA 3.0. Based on the data distribution, the 95th, 50th, and 5th percentiles were set as anchors for full membership, crossover point, and full non-membership [19]. Following prior practice, any value calibrated exactly to 0.5 was adjusted to 0.499 or 0.501 to avoid ambiguous membership . Table 1 reports the calibration results for each variable.

Table 1 Variable Calibration

Variable	Fuzzy value calibration		
	Completely non-subordinate point	Intersecting subordinate point	Completely subordinate point
Digital transformation	0.693	1.946	4.341
Organizational redundancy	0.975	2.322	6.495
Executive technical background	0.000	0.195	0.427
Government subsidy	0.001	0.004	0.015
Degree of market competition	0.057	0.091	0.590
Innovation performance	0.173	2.441	4.155

4. Analysis Results

4.1 Analysis of Necessity and Result

Before running the configuration analysis, a check was performed to see if any antecedent condition is necessary for the outcome. The necessity analysis using fsQCA 3.0 (Table 2) shows that all consistency levels are below 0.9. Thus, no single condition is a necessary prerequisite for high innovation performance. These results confirm that the drivers of enterprise innovation performance are complex: high performance depends on the coordinated interaction of multiple technology, organization, and environment conditions, not on any one factor alone.

Table 2 Analysis of Necessity of Antecedent Conditions

Variable	High innovation performance		Non-high innovation performance	
	Consistency	Coverage	Consistency	Coverage
Digital transformation	0.661	0.746	0.576	0.561
~ Digital transformation	0.612	0.626	0.739	0.653
Organizational Redundancy	0.621	0.710	0.673	0.664
~ Organizational Redundancy	0.706	0.714	0.706	0.616
Executive's Technical Background	0.686	0.738	0.663	0.615
~ Executive's Technical Background	0.642	0.688	0.718	0.664
Government subsidies	0.673	0.746	0.647	0.619
~ Government subsidies	0.656	0.683	0.734	0.659
Degree of market competition	0.612	0.763	0.618	0.665
~ Degree of market competition	0.732	0.690	0.780	0.635

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4.2 Configurational Analysis of High Innovation Performance

Following the configurational analysis approach, fsQCA 3.0 software was used. The truth table was built with a case frequency threshold of 3, raw consistency of 0.8, and PRI consistency of 0.7. Conditions present in both parsimonious and intermediate solutions were defined as core; those only in the intermediate solution were peripheral [19]. The intermediate solutions were mainly interpreted, with parsimonious solutions as a reference. Table 3 shows the configurational paths leading to high innovation performance.

Table 3 Configurational paths to high/non-high innovation performance in "Little Giant" enterprises

Condition variables	High innovation performance			Non-high innovation performance
	H_1	H_2	H_3	NH_1
Digital transformation	●	●	●	⊗
Organizational Redundancy		⊗		•
Executive's Technical Background	•		⊗	⊗
Government subsidies	⊗	⊗	●	⊗
Degree of market competition	⊗	⊗	•	
Consistency	0.938	0.928	0.910	0.912
Raw coverage	0.350	0.344	0.303	0.367
Unique coverage	0.043	0.032	0.083	0.367
Overall consistency	0.905			0.912
Overall coverage	0.487			0.367

Note: ● indicates core present, ⊗indicates core absent, ●indicates peripheral present，⊗ indicates peripheral absent. Blank means no effect.

4.3 Configurational Paths to High Innovation Performance

4.3.1 Endogenous focused innovation

Path H_1 has digital transformation as a core condition and executives' technical background as a peripheral condition. These firms build strong endogenous drive by advancing technology with strategic focus from top management. This shows their strategic commitment to innovation through internal capability building, even under unfavorable or flat external conditions.

Shenzhen Hybio Pharmaceutical is a typical example of this path. As a leader in China's peptide drug sector, Hybio has built strong technical barriers through deep expertise in synthesis, formulation, and innovative R&D. In recent years, as the biopharma industry shifts toward innovation, Hybio has expanded into diabetes, obesity, and cancer therapies while maintaining its traditional strengths. This has led to a differentiated innovative drug pipeline [19]. Given the high entry barriers and relatively mild competition in peptide drugs, the firm can steadily strengthen its R&D foundation without facing intense market pressure.

4.3.2 Technology niche innovation

Path H_2 takes digital transformation as the core condition. Firms use technical capability as a substitute for scarce external resources. Through technical specialization, they build irreplaceability in specific niches and achieve steady growth.

Sunway Cable, a leader in specialty cables, is a typical case of technology niche innovation. Its core logic is deep specialization and technology-driven breakthroughs. The company focuses on high-end segments like cables for nuclear power plants and rail transit, building strong technical know-how. Despite weak supply chains and limited policy support, it has grown steadily. This is due to management's long-term focus on specialty cables, persistent R&D investment, and a specialized technical path.

4.3.3 Policy-enabled innovation

Path H_3 has digital transformation and government subsidies as core conditions, with market

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competition as peripheral. This forms a policy-guided, tech-supported, competition-reinforced innovation model.

Dahong Technology fits this path. As a CAS-backed firm, it benefits from strategies like "Digital China", building lasting capabilities in machine vision and digital TV. With deep expertise in image processing and multiple national research projects, the company receives ongoing state funding for R&D in high-end equipment and IT. These policy resources lower innovation risks and support breakthroughs. This policy-plus-technology path helps Dahong stay advanced while avoiding resource dilution from excessive competition, enabling steady progress in its technical fields.

4.4 Configurational paths to non-high innovation performance

Path NH_1 has only organizational slack as a peripheral condition. These firms can be called "rich failures". They lack core tech drive, executive commitment, and policy support. Internal resources are ample but not used for innovation, instead forming a comfortable but inefficient zone. To change, these firms need a clear tech strategy and leadership resolve. They should seek policy support and use external pressure to channel slack into valuable innovation.

5. Conclusion and prospects

Using fsQCA within the TOE framework, this study analyzed how technology, organization, and environment jointly drive high innovation performance in “Little Giant” firms. Key findings:(1) No single condition is necessary for high innovation performance. This confirms the multiple concurrency and causal complexity of innovation – high performance requires configurational matching of multiple conditions. (2) Three distinct paths lead to high performance: endogenous focused innovation, technology niche innovation, and policy-enabled self-driven innovation, showing equifinality. Core and peripheral conditions can substitute across paths, allowing firms to choose strategies based on their resources and context. (3)One path leads to non-high performance, highlighting the need for alignment among technology, leadership, and policy to activate slack resources and overcome innovation barriers.

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