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Research on the Configuration of Specialized and Sophisticated SMEs to Achieve High Innovation Performance in the Context of Digital Transformation

Gaokun Liu*

School of Business Administration, Anhui University of Finance and Economics, Bengbu 233030, China

*Corresponding Author

Abstract

Improving innovation performance is an important source for enterprises to enhance their competitiveness, especially in the context of digital transformation, how to achieve high innovation performance and enhance the hard power of core technologies has become an urgent problem to be solved. Based on the sample data of 26 Specialized and Sophisticated SMEs, this study uses a mixed method of NCA and fsQCA to explore the combination of antecedents that lead to the high innovation performance of Specialized and Sophisticated SMEs. The results show that: (1) The NCA method is used to identify a single antecedent condition, which is not a necessary condition for the high innovation performance of Specialized and Sophisticated SMEs. (2) High digital transformation and non-high supply chain concentration are the key factors for high innovation performance of enterprises, when the level of enterprise digitalization is high and the supply chain concentration is lacking, even if other conditions are incomplete, enterprises can achieve high innovation performance. (3) High digital transformation is not the only condition for Specialized and Sophisticated SMEs to achieve high innovation performance. In the case of incomplete digital transformation, there is still a high innovation performance path, and the R&D background and marketization level of senior executives have a substitution effect on digital transformation. Based on the configuration perspective, this study explores the full causal relationship of the high innovation performance of Specialized and Sophisticated SMEs, enriches the research on the antecedents of enterprise innovation performance, and provides a method and theoretical reference for related research.

Keywords

Digital Transformation; Specialized and Sophisticated; Innovation Performance; Necessary Condition Analysis; Fuzzy-set Qualitative Comparative Analysis.

1. Introduction

Specialized and Sophisticated small and medium-sized enterprises(Specialized and Sophisticated SMEs) are the representatives of the most market competitiveness and innovation vitality among China's small and medium-sized enterprises, and they are also the key subjects to enhance economic resilience and improve the modernization level of industrial and supply chains. There are more than 140,000 Specialized and Sophisticated SMEs in China, and many explorations have been carried out in the field of digitalization and intelligence, which are the main force to promote the high-quality development of China's digital economy. Based on this, this paper explores the impact path and mechanism of innovation performance of Specialized and Sophisticated SMEs in the context of digital transformation, which is of great significance for promoting high-quality economic development.

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Current scholars have explored the paths and influencing factors for Specialized and Sophisticated SMEs to achieve high innovation performance from multiple aspects. For instance, academic executives can promote the continuous innovation of Specialized and Sophisticated SMEs [1]. The innovative development, coordinated development and open development in the process of high-quality regional development can also positively promote the innovation performance of Specialized and Sophisticated SMEs [2]. In the context of digital transformation, scholars have gradually studied the relationship between digital transformation and enterprise innovation performance, which can promote organizational change and technological innovation, improve enterprise total factor productivity, and promote the growth of enterprise innovation performance [3]. However, the digital transformation of enterprises is not achieved overnight, it is often a long-term process, and the impact of digitalization on enterprise performance in the early stage is often not significant, and it faces many uncertainties, such as the rupture of the internal capital chain and the intensification of market competition, which will delay the process of enterprise digital transformation and even lead to failure. Qi and Cai (2020) [4] found that the increase in the degree of digitalization will increase the management cost of enterprises, which in turn weakens the positive effect of business model innovation on enterprises. It can be seen that under the digital transformation of enterprises, the innovation performance of enterprises will not necessarily improve. Guo et al. (2023) [5] conducted a study on 311 national-level Specialized and Sophisticated enterprises and found that the concentration of the enterprise supply chain has a negative moderating effect on the relationship between digital transformation and innovation performance. The R&D background of senior executives also has a significant impact on the innovation performance of enterprises. In addition, enterprise scale, R&D investment, and shareholding structure all affect firms' technological innovation activities and performance [6]. Scholars have explored the factors of enterprise innovation performance from different perspectives, but most of the previous studies have studied the innovation performance of Specialized and Sophisticated SMEs through single or dual factors. Few studies have been conducted on the impact of multi-factor configuration effect on enterprise innovation performance, especially in the context of enterprise digital transformation, to explore the influence mechanism and necessity of digital transformation and multi-factor configuration on enterprise innovation performance.

Based on this, this paper proposes the following research questions: (1) What are the paths for Specialized and Sophisticated SMEs to achieve high innovation performance in the context of digital transformation? (2) Is digital transformation a necessary condition for improving the innovation performance of Specialized and Sophisticated SMEs? How necessary is it? (3) Is there a conditional substitution and complementarity relationship in different configuration paths? This study will help enrich the existing empirical research results and help Specialized and Sophisticated SMEs find a suitable development path in the context of digital transformation.

2. Theoretical Review and Model Construction

2.1. Specialized and Sophisticated SMEs

Small and medium-sized enterprises are the main body of technological innovation in China, which focuses on a certain link in the industrial chain, has strong innovation ability, innovation vitality and anti-risk ability, and has the characteristics of specialization, refinement, specialization and novelty. As of December 2024, a total of 14,600 small and medium-sized enterprises across the country have been selected into the cultivation list of Specialized and Sophisticated "little giant" enterprises (hereinafter referred to as "little giant" enterprises). In recent years, domestic scholars have studied Specialized and Sophisticated enterprises from different perspectives, and Liu and Mei (2015) [7] studied the cultivation path of Specialized

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and Sophisticated enterprises through a questionnaire survey of small and micro enterprises in Jiangsu Province. Dong and Li (2021), Lu and Gao (2022) [8, 9] believe that the quality of "specialized, refined, special and new" development should be improved in terms of institutional mechanisms, basic investment, business environment, internationalization, and digitalization. Then, scholars explored the innovation performance and digital transformation of Specialized and Sophisticated enterprises [10, 11], and believed that the innovation performance of Specialized and Sophisticated enterprises is an important embodiment of the breakthrough of key core technologies and the acquisition of core competitiveness of Specialized and Sophisticated enterprises, and digital transformation is an important factor for Specialized and Sophisticated enterprises to achieve high innovation performance.

2.2. Digital Transformation

With the rise of the new round of technological revolution and industrial transformation, digital transformation has become an important driving force for the economy. More and more enterprises have embarked on the path of digital transformation. Previous studies mostly regarded enterprise digital transformation as the application of digital technology in a certain link of the enterprise [12]. In recent years, some studies have held that enterprise digital transformation is not only the application of digital technology, but also a process of organizational change, that is, enterprises comprehensively utilize digital technologies such as the Internet of Things, big data, and artificial intelligence, and apply them to process, product and service innovation [13]. Digital transformation of Specialized and Sophisticated enterprises can better connect the entire chain of business flows and data flows such as supply and demand matching, factor allocation, and transaction circulation, empower high-quality enterprise development, and gain new competitive advantages. Through digital empowerment, Specialized and Sophisticated enterprises can climb to high value-added links and grasp the dominance and discourse power of the global industrial chain and value chain.

2.3. Enterprise Innovation Performance

Enterprises are the main body of innovation and development, and the innovation performance of enterprises can reflect the innovation results achieved by enterprises, and play a key role in improving the core competitiveness of enterprises and sustainable development. Existing scholars have studied the innovation performance of enterprises from different perspectives. Generally speaking, digital transformation can promote the transformation and upgrading of enterprises, improve the value chain of enterprises, and have a positive impact on the innovation performance of enterprises[14]; Academic executive teams with relevant research and development background will also promote the innovation performance of enterprises [15]; The scale of an enterprise will affect the R&D investment and innovation activities of an enterprise, and thus the innovation performance of an enterprise. The improvement of regional marketization can enhance entrepreneurial innovation spirit, and improve enterprise innovation performance [16]; Excessive supply chain concentration will restrict the search and use of external knowledge information, which may inhibit the innovation behavior of enterprises [17]. In addition, research and development investment, network structure, etc., will also have an impact on enterprise innovation performance.

2.4. The Impact of Single Factors on the Innovation Performance of Enterprises

2.4.1. Digitalization and Enterprise Innovation Performance

Digital transformation integrates information technology, communication technology, computing technology and connectivity technology, which is connected with organizational structure and business process, and contributes to the development and play of organizational dynamic capabilities, and becomes the key for enterprises to continuously evolve, create and maintain their competitiveness in the era of digital economy. Digital transformation can

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promote the integration of traditional production factors and digital factors. With the help of underlying technologies such as artificial intelligence, blockchain, cloud computing and big data, enterprises can broaden resources, innovate production technologies and methods, and improve communication efficiency and innovation efficiency [18]. Therefore, digital transformation can improve the innovation performance of enterprises.

2.4.2. Executive R & D Background and Enterprise Innovation Performance

Personal experience, values, and personality characteristics of corporate executives can greatly affect their behavior patterns and choices, and thus affect corporate management behaviors [19]. The R & D background of senior executives refers to the fact that senior executives have engaged in scientific research in universities, scientific research institutions or associations or have had R & D experience in enterprises. R & D background affects the personal characteristics and decision-making style of senior executives. Personnel with research and development background participate in enterprise management, which can promote the transformation of scientific research results and improve the innovation ability of enterprises. In addition, the academic experience of senior executives will also promote the digital transformation of enterprises [20].

2.4.3. Enterprise Scale and Enterprise Innovation Performance

Enterprise scale is an important factor affecting the innovation performance of enterprises. The larger the enterprise scale, the more resources it has for innovation activities, and the relative and absolute scale of R&D investment of larger enterprises will be larger [21]. According to the innovation scale advantage theory of enterprise scale heterogeneity, innovation R&D investment increases with the expansion of enterprise scale. On the one hand, enterprises have the ability to improve competitive advantage through innovation; on the other hand, enterprises will increase innovation investment to disperse project risks [22]. Larger enterprise scale also means that enterprises have more resources for digital transformation.

2.4.4. Supply Chain Concentration and Enterprise Innovation Performance

Supply chain concentration is an important part of enterprise supply chain management, and the connection with upstream and downstream partners of supply chain is an important external path for enterprises to realize innovation. With the blessing of digital technology, enterprise supply chain can connect resources and information more effectively. The more social groups connected to an enterprise and the larger the scale of the social network, the more convenient the interaction of internal and external information will be [23], but the strong connection with other groups will restrict the search for new information, thus inhibiting the innovation activities of the enterprise [17]. Therefore, too high supply chain concentration may inhibit the innovation performance of enterprises.

2.4.5. Marketization Level and Enterprise Innovation Performance

A high degree of marketization can promote the transformation of enterprise innovation results, accelerate the exchange and allocation of enterprise innovation factors, expand enterprise innovation capabilities, and stimulate the innovative spirit of entrepreneurs [16]. In addition, a higher level of marketization can also enable enterprises to break through the restrictions of geographical location, expand the scope of organizational search, find more suitable cooperation objects, and improve the performance of exploratory innovation. Areas with a high level of marketization often have a higher degree of market competition, which stimulates enterprise innovation.

The factors affecting the implementation of technological innovation by an enterprise or organization can be summarized into three categories: technical level, organizational level and environmental level, namely Technology-Organization-Environment (TOE) framework [24]. The technical aspect mainly refers to the technology that the enterprise has or has not been

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used by the enterprise. This study focuses on the digital transformation of the enterprise, specifically referring to the application of digital technology by the enterprise. The organizational level generally covers the scope, scale and characteristics of the organization. This study mainly focuses on the scale of the enterprise and the academic background of senior executives. The environmental aspect generally includes the relationship between the industry and partners, competitors. This study mainly focuses on the concentration degree of the supply chain and the marketization level of the region. In this paper, the TOE theoretical framework is applied to explore the configuration path and the multiple concurrency relationship of the configuration path affecting the realization of high innovation performance of Specialized and Sophisticated smes under the background of digitalization. The research model is shown in Figure 1.

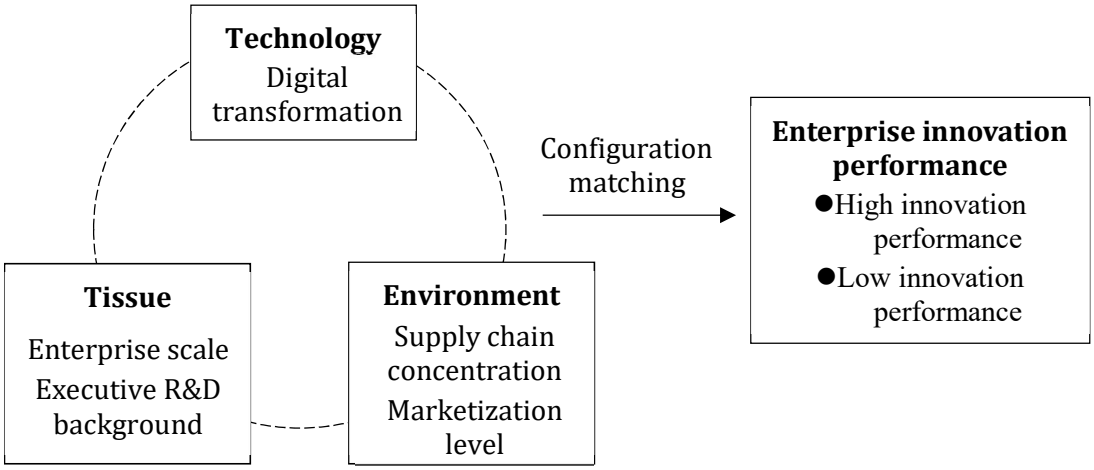

Figure 1. Research model

3. Research Methods and Data Processing

3.1. A Hybrid Method of NCA and fsQCA

Traditional data analysis methods, such as correlation and multiple regression, are not suitable for testing and concluding necessary and sufficient causality. fsQCA can break through the limitation of the symmetry of causality, focus on the equivalent substitution of multiple concurrent causality and conditions across cases, and aim to explain the comprehensive effect of multiple conditional variables instead of the net effect of a single condition, and explore "the same destination". And effectively circumvent the multicollinearity problem [25]. NCA can calculate the level of conditions required for a given result, that is, what level of a single condition is the necessary condition for a given result variable, and fsQCA can test the robustness of the analysis results of necessary conditions [26]. Therefore, this paper first analyzes the necessity relationship between digital transformation, executive academic background, enterprise scale, supply chain concentration, marketization level and enterprise high innovation performance through NCA method. Secondly, the robustness of the necessary condition analysis results is tested by fsQCA method. Finally, fsQCA method is used to identify the sufficient relationship between anthems and innovation performance of Specialized and Sophisticated enterprises, and to explore what path can lead to high innovation performance of enterprises.

3.2. Sample Selection

In this study, the listed companies of specialized and ultra-new "little giant" enterprises are taken as the research object, and the reasons are as follows: (1) As the most dynamic group of small and medium-sized enterprises, Specialized and Sophisticated "little giant" enterprises are

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located in the core link of the industrial chain and bear the key task of solving the "bottleneck" dilemma of core technology in key fields; (2) The anthems of different enterprises are different, the number of small and medium-sized enterprises in China is huge, the research coverage is wide, and the reality explanation is stronger; (3) There are both established and newly established smes listed companies, which helps to consider the path for enterprises to achieve high innovation performance under the background of different degrees of digital transformation.

Select the A-share listed companies of Specialized and Sophisticated "little giant" enterprises in the crosswise database as the initial enterprise sample, select the relevant data of enterprises in 2021, determine the relevant data from the Guotai 'an database, the annual report of listed companies and the statistical data of the State Intellectual Property Office, delete the ST class and the samples with more missing data, and finally get 26 listed companies.

3.3. Variable Measurement

3.3.1. Antecedent Variable

(1) Digital transformation. Referring to the research of Wu Fei (2021) [27] the word frequency related to enterprise digital transformation (including artificial intelligence technology, blockchain technology, big data technology, cloud computing technology, and the use of four types of keywords) is sorted out, and the word frequency is added by 1 and processed logarithmically.

(2) Senior management R&D background. According to the study of He Xinwen and Hong Lin (2021) [15], senior executives with research experience in universities, scientific research institutions, associations, and R&D work in enterprises are set as academic research-oriented executives, and the ratio of the number of academic research-oriented executives to the total number of senior executives is taken as the criterion to measure the R&D background of senior executives.

(3) Enterprise scale. Based on the study of Li Xu and Xiong Yongqing (2021) [21], the logarithm of total assets at the end of the year is standardized.

(4) Supply chain concentration. Existing studies divide supply chain concentration into two dimensions: supplier concentration and customer concentration. With reference to the studies of Gu Xiaoan et al. (2021) [28], the supply chain concentration is calculated based on the average value of supplier concentration and customer concentration, where: Supplier concentration is measured by the proportion of the total purchase amount of the company's top five suppliers in the total annual purchase amount, and customer concentration is measured by the proportion of the total sales amount of the company's top five customers in the total annual sales amount.

(5) Marketization level. The total score of each province's marketization process in Fan Gang's Marketization Index was used to measure it [29].

3.3.2. Result Variable

Innovation performance. In this paper, referring to the practices of Yuan Feifei et al. (2022) [30], the number of patents in the current year is taken as the proxy variable of innovation performance. Considering the distribution trend of patent data skew to the right and the situation that the number of patents in the enterprise is 0, the number of patents is increased by 1 and logarithmic standardization is carried out.

3.4. Variable Calibration

fsQCA calibration is a data processing process in which the values of all variables are converted into fuzzy values in the range of 0 to 1, and the case is assigned a degree of attribution, so that it is converted into a set [31]. It follows mainstream QCA research and takes objectively divided

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values as the calibration basis. According to 75%, 50% and 25%, the full membership points, crossing points and completely non-membership points of antecedent variables and result variables are numerically divided. The details are shown in Table 1:

Table 1. Variable calibration

Variable name	Threshold value		
	Full affiliation	Crossing point	Full unaffiliated
Digital transformation	3.367	2.013	1.099
Executive R&D background	0.482	0.333	0.2
Enterprise scale	3.560	3.040	2.725
Supply chain concentration	51.43	28.59	19.684
Marketization level	12.001	27.705	22.650
Innovation performance	12.296	12.001	10.140

4. Empirical Analysis

4.1. Necessity Analysis

NCA can identify necessary conditions by analyzing the necessity effect size of antecedent conditions and their significance, and evaluate the necessary level value of antecedent conditions by analyzing the level of bottleneck analysis. The range of necessity effect size (d) is [0.1], and the larger the value, the larger the necessary effect. NCA provides two estimation methods, Ceiling Regression (CR) and Ceiling Envelopment (CE), which can be used to deal with continuous and discrete variables respectively.

Table 2. Variable calibration

Variable	Method	Precision	Upper limit area	Radius	Effect size(d)	P
Digital transformation	CR	100%	0.008	0.99	0.008	0.291
	CE	100%	0.016	0.99	0.016	0.182
Executive R&D background	CR	100%	0.000	0.99	0.000	1.000
	CE	100%	0.000	0.99	0.000	1.000
Enterprise scale	CR	96.2%	0.012	1.00	0.012	0.193
	CE	100%	0.011	1.00	0.011	0.271
Supply chain concentration	CR	92.3%	0.001	1.00	0.001	0.803
	CE	100%	0.002	1.00	0.002	0.811
Marketization level	CR	80.8%	0.150	0.97	0.155	0.023
	CE	100%	0.037	0.97	0.038	0.042

Note: 1) The condition is the value of fuzzy membership degree after calibration; 2) $0 \leq d < 0.1$ is a low level; 3) The reextraction coefficient of permutation test in NCA analysis was 10,000 times.

Table 2 reports the results of NCA's necessity analysis for a single condition, including the accuracy, upper limit region, range, effect size and P-value obtained by CR and CE estimation methods respectively. In the NCA method, the necessary conditions must be satisfied: the effect size (d) is greater than 0.1 [32], and the Monte Carlo simulation displacement test ($p < 0.05$) is significant. Overall, digital transformation (d=0.008; d=0.016), senior R&D background

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(d=0.000; d=0.000), enterprise size (d=0.012; d=0.011), supply chain concentration (d=0.001; The effect size of d=0.002) is too small (d < 0.1), and none of them pass the Monte Carlo simulation replacement test (p < 0.05), that is, they are not significant, indicating that these four factors are not necessary conditions for enterprise innovation performance. Marketization level passed the significance test, but (d=0.155; d=0.038) The effect size is low, indicating that it is not a necessary condition for enterprise innovation performance.

Table 3 further reports the bottleneck analysis results of enterprise innovation performance. Bottleneck level (%) refers to a level that reaches the maximum observation range of the result, and the level value (%) that needs to be met within the maximum observation range of the antecedent condition. It can be seen from Table 3 that when the innovation performance level reaches 60%, the marketization level first reaches the bottleneck level. To reach the 100% innovation performance level, 80.8 level of digital transformation, 90.8% of enterprise scale, 4.2% of supply chain concentration and 75.5% level of marketization level are required, and there are no bottlenecks in the R&D background of senior executives.

Table 3. The bottleneck level analysis results of NCA method for enterprise innovation performance

Innovation performance	Digital transformation	Executive R&D background	Enterprise scale	Supply chain concentration	Marketization level
0	NN	NN	NN	NN	NN
10	NN	NN	NN	NN	NN
20	NN	NN	NN	NN	NN
30	NN	NN	NN	NN	NN
40	NN	NN	NN	NN	NN
50	NN	NN	NN	NN	NN
60	NN	NN	NN	NN	2.0
70	NN	NN	NN	NN	20.4
80	NN	NN	NN	NN	38.7
90	NN	NN	NN	NN	57.71
100	80.8	NN	90.8	4.2	75.5

Note: 1) The analytical method was CR; 2) NN means "unnecessary".

Table 4. fsQCA necessity analysis results for a single condition

Conditions	High innovation performance	Non-high innovation performance
Digital transformation	0.525903	0.549774
~Digital transformation	0.554160	0.527149
Executive R&D background	0.544035	0.500980
~Executive R&D background	0.567425	0.6061.9
Enterprise scale	0.645212	0.484917
~Enterprise scale	0.436421	0.593514
Supply chain concentration	0.450549	0.661388
~Supply chain concentration	0.684458	0.468326
Marketization level	0.657771	0.390799
~Marketization level	0.508634	0.769080

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Further, this paper adopts fsQCA method to conduct necessity test, as shown in Table 4. In the enterprise innovation performance, the necessity of a single condition is not more than 0.9, that is, it fails to pass the consistency test. This is consistent with the NCA results, suggesting that no single variable constitutes a necessary condition for enterprise innovation performance.

4.2. Configuration Analysis

In this paper, fsQCA3.0 software is used to analyze the configuration paths that lead to high or low level innovation performance. The result of fsQCA analysis will produce three kinds of solutions, namely complex solution, reduced solution and intermediate solution. We refer to the research of Du Yunzhou and Jia Liangding (2017) [25], and use the intermediate solution and the reduced solution to distinguish the core and edge conditions of the grouping state: If a condition appears in both the reduced solution and the intermediate solution, it is considered to be the core condition; If a condition occurs in the intermediate solution but not in the reduced solution, it is considered an edge condition.

4.2.1. High Innovation Performance Path

In this paper, fsQCA3.0 software was used to process the data of Specialized and Sophisticated SMEs. By using the truth table algorithm, deletion and coding operations were used to set the case frequency threshold and consistency threshold to 1 and 0.8. The final output results are shown in Table 5. There are five paths for high innovation performance, and the consistency rate of the overall solution is greater than 0.8, indicating that the set of five configurations has strong explanatory power to the results. If the interpretation rates of all five sub-paths are greater than 0.8, all paths pass the QCA test.

Table 5. High innovation performance configuration

Variable	High innovation performance				
	H1	H2	H3	H4	H5
Digital transformation		⊗	●	●	•
Executive R&D background	●	●	•	⊗	●
Enterprise scale	⊗		•	•	●
Supply chain concentration	Ⓧ	Ⓧ	Ⓧ	Ⓧ	•
Marketization level	●	●	⊗	•	●
Original coverage	0.20	0.18	0.07	0.14	0.09
Unique coverage	0.10	0.09	0.04	0.12	0.06
Consistency rate	0.87	0.90	0.86	0.96	0.87
Coverage of solution	0.51				
The consistency of the solution	0.91				

Note: ● indicates that the core condition exists in the configuration; • indicates that the edge condition exists in the configuration; Ⓧ indicates that the core condition is missing; ⊗ indicates that the edge condition is missing; and blank indicates that the variable is dispensable in the configuration.

H1 (Executive R & D background * ~Company scale *~ Supply chain concentration * Marketization level). Configuration H1 indicates that high innovation performance can be achieved when strong R&D background of senior executives, non-high supply chain concentration and high marketization level are the core conditions, and non-high enterprise scale is the edge conditions. This configuration reflects that in the absence of supply chain concentration conditions, regardless of the degree of digital transformation, strong executive R

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& D background and high marketization level can also achieve high enterprise innovation performance.

H2 (~Digital transformation * Executive R&D background *~ Supply chain concentration * Marketization level). Configuration H2 points out that high innovation performance can be achieved when strong executive R&D background, non-high supply chain concentration and high marketization level are the core conditions, and non-high digital transformation is the edge condition. This configuration reflects that in the absence of supply chain concentration conditions, regardless of the scale of the enterprise, a strong executive R & D background and a high marketization level can also achieve high enterprise innovation performance.

H3 (Digital transformation * Executive R & D background * Company scale *~ Supply chain concentration *~ Marketization level). Configuration H3 points out that high innovation performance can be achieved when high digital transformation and non-high supply chain concentration are the core conditions, and senior executives' R & D background, enterprise scale, and non-high marketization level are the marginal conditions. This configuration reflects that in the absence of supply chain concentration conditions, high digital transformation can also achieve high enterprise innovation performance.

H4 (Digital transformation *~ Executive R & D background * Enterprise scale *~ Supply chain concentration * Marketization level). Configuration H4 points out that high innovation performance can be achieved when high digital transformation and non-high supply chain concentration are the core conditions, and non-high-management R&D background, enterprise scale, and marketization level are the marginal conditions. This configuration reflects that in the absence of supply chain concentration, high digital transformation can also achieve high enterprise innovation performance.

H5 (Digital transformation * Executive R & D background * Enterprise scale * Supply chain concentration * Marketization level). Configuration H5 points out that high innovation performance can be achieved when strong executive R&D background, high enterprise scale and high marketization level are the core conditions, and digital transformation and supply chain concentration are the edge conditions. This configuration reflects that high enterprise innovation performance can also be achieved under the background of strong executive R & D background, high enterprise scale and high marketization level.

Based on the above five path analysis, the types of enterprises with high innovation performance can be divided into high digital transformation type, high marketization level type, and complete type, which correspond to paths H3 and H4, H1 and H2, and H5 respectively. (1) High digital transformation can bring new productivity and production mode to enterprises, and improve the value chain of enterprises. Even if other conditions are incomplete, having high digital transformation and non-high supply chain concentration can improve the innovation performance of enterprises; (2) Strong executive R & D background and high marketization level can help executives stimulate innovation spirit and obtain more innovation resources. Even if digital transformation and enterprise scale are uncertain, strong executive R & D background, high marketization level and non-high supply chain concentration can improve enterprise innovation performance; (3) Strong executive R & D background, strong enterprise scale and high marketization level bring innovation spirit and innovation resources to enterprises, but also have more funds to support enterprise innovation activities, even if the concentration of enterprise supply chain is not missing, it can also support high innovation performance of enterprises.

4.2.2. Low Innovation Performance Path

The final output results are shown in Table 6. There are four paths for low innovation performance, and the consistency rate of the overall solution is greater than 0.8, indicating that

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the set of four configurations has strong explanatory power to the results. If the interpretation rates of all four sub-paths are greater than 0.8, all paths pass the QCA test.

Table 6. Low innovation performance configuration

Variable	Low innovation performance			
	H1	H2	H3	H4
Digital transformation	●	ⓧ	•	ⓧ
Executive R&D background	ⓧ		•	●
Enterprise scale		Ⓧ	ⓧ	Ⓧ
Supply chain concentration	●	●	•	ⓧ
Marketization level	Ⓧ	●		Ⓧ
Original coverage	0.37	0.17	0.22	0.11
Unique coverage	0.19	0.03	0.03	0.07
Consistency rate	0.97	0.97	0.97	0.81
Coverage of solution	0.54			
The consistency of the solution	0.93			

Note: ● indicates that the core condition exists in the configuration; • indicates that the edge condition exists in the configuration; Ⓧ indicates that the core condition is missing; ⓧ indicates that the edge condition is missing; and blank indicates that the variable is dispensable in the configuration.

H1 (Digital transformation *~ Executive R&D background * Supply chain concentration *~ Marketization level). Configuration H1 indicates that non-high innovation performance can be achieved when the core conditions are high digital transformation, high supply chain concentration, and non-high marketization level, and the R&D background of non-strong executives is marginal conditions. This configuration reflects that in the absence of marketization level conditions and high supply chain concentration, no matter what the scale of the enterprise, even if the enterprise has digital transformation, it will ultimately be a non-high enterprise innovation performance.

H2 (~ Digital transformation *~ Enterprise scale * Supply chain concentration * Marketization level). Configuration H2 points out that non-high innovation performance can be achieved when non-high enterprise scale, high supply chain concentration and high marketization level are the core conditions, and non-high digital transformation is the edge condition. This configuration reflects that in the absence of enterprise scale conditions, no matter what the R&D background of senior executives is, even if they have a high marketization level, as long as the supply chain concentration is high, the innovation performance of non-high enterprises will ultimately be.

H3 (Digital transformation * Executive R & D background *~ Company scale * Supply chain concentration). Configuration H3 indicates that low innovation performance is achieved when digital transformation, senior management R&D background, non-high enterprise scale, and supply chain concentration are marginal conditions. This configuration does not reflect the core conditions, but reflects that in the case of digital transformation, the background of senior management R & D is not obvious, and the marketization level is not clear, the enterprise will ultimately be non-high innovation performance.

H4 (~ Digital transformation * Executive R & D background *~ Company scale *~ Supply chain concentration *~ Marketization level). Configuration H4 points out that non-high innovation performance can be achieved in the case of strong executive R&D background, non-high enterprise scale and non-high marketization level as the core conditions, and non-high digital

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transformation and non-high supply chain concentration as the edge conditions. This configuration reflects that in the absence of enterprise scale and marketization level, even with a strong R & D background, the innovation performance of the enterprise is ultimately non-high.

Based on the analysis of the above four paths, it is found that high supply chain concentration, non-high enterprise scale and non-high marketization level are the key conditions for enterprises to achieve non-high enterprise innovation performance. Even if the digital transformation level is high, the marketization level is short, and the supply chain concentration is too high, the final non-high innovation performance is also.

5. Conclusion and Enlightenment

5.1. Research Conclusion

In recent years, many small and medium-sized enterprises have embarked on the road of digital transformation and enterprise innovation. However, the development situation of different enterprises is different. Through the analysis of existing literature, it is found that digital transformation does not necessarily promote the innovation performance of enterprises, and the reasons for enterprises to achieve high innovation performance are also different. In view of this situation, based on the data of 26 Specialized and Sophisticated smes listed companies, this paper comprehensively uses NCA and fsQCA methods to identify 5 paths leading to high innovation performance and 4 paths leading to non-high innovation performance. This paper draws the following conclusions:

5.1.1. No Single Variable is Necessary for High Innovation Performance

The realization of high enterprise innovation performance is the result of multiple factors. The study found that there are five pathways leading to high innovation performance. Among them, high digital transformation is the key factor affecting high innovation performance of enterprises, and non-high supply chain concentration is the key factor of high innovation performance of enterprises. When enterprises have high digital level and lack of supply chain concentration, enterprises can achieve high innovation performance even if other conditions are incomplete. It shows that high digital transformation can help enterprises bring high innovation performance, and non-high supply chain concentration can reduce the inhibitory effect of relationship network with partners on enterprise innovation performance.

5.1.2. High Digital Transformation is not the Only Condition for High Innovation Performance for Specialized and Sophisticated SMEs

In the case of incomplete digital transformation, there are two high innovation performance paths. (1) When the R&D background of senior executives is strong and the marketization level is high, if the supply chain concentration is not high, the enterprise can also achieve high innovation performance, and the R&D background of senior executives and the marketization level have a substitution effect on the digital transformation. This path indicates that the key condition for achieving high innovation performance is when the supply chain concentration of non-high enterprises is still the same. When the R&D background of senior executives is strong and the marketization level is high, enterprises need to reduce their dependence on the supply chain to achieve high innovation performance. (2) When the R&D background of senior executives is strong, the enterprise scale is high, and the marketization level is high, the enterprise can still achieve high innovation performance even if there is a certain concentration of supply chain, indicating that the enterprise scale is complementary to the R&D background of senior executives and the marketization level.

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5.1.3. Enterprise Scale, Supply Chain Concentration and Marketization Level are the Key Conditions for Non-high Innovation Performance

When the scale of the enterprise is short and the supply chain level is high, even if the marketization level of the enterprise is high, it will eventually be non-high innovation performance. The R&D background of senior executives and digital transformation are not sufficient conditions for enterprises to achieve high innovation performance. When the marketization level is not high, it is possible to achieve non-high innovation performance.

5.2. Research Contribution and Deficiency

5.2.1. Research Contribution

Based on NCA and fsQCA methods, this paper solves the configuration path and multiple driving factors that lead to high innovation performance of specialized and ultra-new smes. The theoretical contributions are as follows: (1) this paper combines NCA and fsQCA methods to provide an important method reference for further exploring the high innovation performance of specialized and ultra-new smes; (2) Based on the perspective of configuration, this study explores the sufficient causal relationship between the high innovation performance of Specialized and Sophisticated smes, which enriches the antecedent research on the innovation performance of enterprises. The results show that the influence of high innovation performance factors is different. (3) This study integrates five major factors, namely digital transformation, senior management R&D background, enterprise scale, supply chain concentration, and marketization level, and discusses the necessary causal relationship between the above factors and high innovation performance of enterprises in a more comprehensive way. (4) Compared five paths to achieve high innovation performance of enterprises, pointed out that in the context of differences in internal and external factors, enterprises should choose different paths, and expanded the research leading to high innovation performance of enterprises.

5.2.2. Under Research

(1) This study mainly considers five factors, namely, enterprise digital transformation, senior executives' R&D background, enterprise scale, supply chain concentration, and marketization level, but does not take into account factors such as enterprise R&D investment and knowledge network. In addition, the sample size used in this paper is small, so it is possible to conduct research on enterprise innovation performance based on more enterprise samples and antecedent variables in the future. (2) The high innovation performance of enterprises can further lead to the sustainable innovation ability of enterprises. Based on this study, the path affecting the sustainable innovation ability or sustainable development of enterprises can be further explored in the future.

5.3. Management Enlightenment

As the digital economy and digital technology gradually play a greater role in the development of enterprises, many Specialized and Sophisticated SEMs have embarked on the road of digital transformation and enterprise innovation. However, the development situation of different enterprises is different, and each enterprise has different technical level, organizational characteristics and external environment relations. For enterprises, digital transformation is important, but in order to achieve high innovation performance, it is necessary to reduce the concentration of the supply chain of enterprises, reduce the technology dependence on partners, and explore core technologies independently. In addition, the level of marketization is also very important in the development of enterprises, enterprises in areas with high marketization level are more competitive, which can force the development of enterprises, the business environment is more conducive to the development of enterprises, and the entrepreneurial spirit is more stimulated. In addition, the R&D background of senior executives is also an important factor in the high innovation performance of enterprises. In the case of a

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high marketization level, increasing the proportion of staff with academic R&D background in the senior management team can promote the transformation of academic achievements, increase enterprises' attention to R&D innovation behavior, and improve enterprise innovation performance.

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References

[1] CAI Shuangli, Guo Qiang. Academic Executives of Specialized and Sophisticated Enterprises and Enterprise Continuous Innovation: The Double moderating effect of enterprise incentive Mechanism and risk taking level ,Journal of Zhejiang Gongshang University, (2023) No1, p.120-134.

[2] Zhao Liyi, Dong Yuxuan, Ge Jing, et al. Research on spiral-type high-quality growth mechanism of Specialized and Sophisticated enterprises: A double case study from the perspective of two-way empowerment of industrial chain ,Research Management,(2024),p.1-16.

[3] Jiang Dianchun, Pan Xiaowang. The impact of digital economy development on enterprise innovation performance: Based on empirical evidence of listed companies in China, Journal of Shanxi University (Philosophy and Social Sciences Edition), Vol. 45 (2022)No. 1, p.149-160.

[4] Qi Yudong, CAI Chengwei. Research on the multiple effects of digitalization on Manufacturing enterprise Performance and its mechanism, Learning and Exploration, (2020)No. 7, p.108-119.

[5] Guo Tongmei, Li Qianyun, Zhang Yue et al. Research on the relationship between digital transformation and innovation performance of Specialized and Sophisticated enterprises, Journal of Technical Economics, Vol. 42 (2023)No. 5, p.68-78.

[6] Zhang Sifei, Chen Yongqi. Research on innovation performance improvement path of "Specialized and Sophisticated" smes, Scientific Research, (2023), p.1-16.

[7] Liu Changnian, Mei Qiang. Research on "Specialized and Sophisticated" and Growth path selection of small and micro enterprises, Science and Technology Management Research, Vol. 35 (2015)No. 5, p.126-130.

[8] Dong Zhiyong, Li Chengming. Trend and path selection of high-quality development of "Specialized and Sophisticated" SEMs, Reform, (2021)No. 10, p.1-11.

[9] Lu Minfeng, Gao Xuyang. Research on the path to further promote the high-quality development of small and medium-sized enterprises in the new era -- based on the perspective of cultivating "Specialized and Sophisticated" SEMs, Social Sciences of Xinjiang, (2022)No.5, p.61-72+178-179.

[10] Xin Lin. Knowledge Network, financing constraints and innovation performance of "Specialized and Sophisticated" firms, Journal of Shanghai University of International Business and Economics, Vol. 29 (2022)No. 6, p.18-38.

[11] Zhu Xiaoyan. Digital transformation of "Specialized and Sophisticated" enterprises: Practical significance, constraints and promotion strategies, Journal of Enterprise Economics, Vol. 42 (2023)No. 1, p.53-59.

[12] Lee J, Bagheri B, Kao H A. A cyber-physical systems architecture for industry 4.0-based manufacturing systems, Manufacturing letters, (2015)No. 3, p.18-23.

[13] Ilvonen I, Thalmann S, Manhart M, et al. Reconciling digital transformation and knowledge protection: A research agenda, Knowledge Management Research & Practice, Vol. 16 (2018)No. 2, p.235-244.

[14] Song Jianing, Song Zaike. Digital transformation, technology spillover and innovation performance of manufacturing enterprises, Reform of Economic System, (2023)No. 4, p.114-122.

ISSN: 2692-7608 DOI: 10.6981/FEM.202501_6(1).0003

[15] He Xinwen, Hong Lin. The impact of R&D background of top management team on firm innovation performance: A moderated mediation effect test, Scientific Management Research, Vol. 39 (2021)No. 6, p.82-89.

[16] Hong Junjie, Shi Lijing. Independent research and development, regional institutional differences and firm innovation performance: Empirical evidence from 371 innovative firms, Research in Science of Science, Vol. 35 (2017)No. 2, p.310-320.

[17] Zhao Shuang, Ran Yining, Wu Yumei. Corporate governance, Supply chain relations and enterprise technological innovation, Friends of Accounting, (2022)No. 20, p.41-49.

[18] Matarazzo M, Penco L, Profumo G, et al. Digital transformation and customer value creation in Made in Italy SMEs: A dynamic capabilities perspective, Journal of Business Research, (2021)No. 123, p.642-656.

[19] Hambrick D C. Upper echelons theory: An update, Academy of management review, Vol. 32 (2007)No. 2, p.334-343.

[20] Yang Zhen, Chen Jin, Shang Huichen. What experiences drive digitalization: Executive academic experience and Enterprise digital transformation, Economic Issues, (2022)No. 10, p.1-11.

[21] Li Xu, Xiong Yongqing. Analysis on the impact of "double integral" policy on R&D investment of new energy vehicle enterprises, Research in Science of Science, Vol. 39 (2021)No. 10, p.1770-1780.

[22] Hu Bing, Qi Yudong. Digital Finance and Enterprise Technological Innovation: Is We media a stimulant or a depressant?, Financial Review, Vol. 15 (2023)No. 4, p.44-69+124-125.

[23] Nambisan S, Wright M, Feldman M. The digital transformation of innovation and entrepreneurship: Progress, challenges and key themes, Research policy, Vol. 48 (2019)No. 8, p.103773.

[24] Bai Xuejie, Wang Xinyue, Song Pei. Research on the influencing factors of Chinese Enterprises' digital transformation: An empirical analysis based on TOE framework, Research in Science of Science, Vol. 42 (2024)No. 11, p.2330-2341.

[25] Du Yunzhou, Jia Liangding. Configuration perspective and Qualitative Comparative Analysis (QCA): A New approach to management research, Management World, (2017)No. 6, p.155-167.

[26] Li Yongfa, Chen Shuyang, WANG Dong. Research on the Differentiation Path of AI Enterprise Business Model Innovation -- Leading to disruption or Perfection?, Economics and Management Research, Vol. 44 (2023)No. 5, p.3-20.

[27] Wu Fei, Hu Huizhi, Lin Huiyan et al. Corporate digital transformation and Capital market performance: Empirical evidence from stock liquidity, Management World, Vol. 37 (2021)No. 7, p.130-144+10.

[28] Gu Xiaoan, Wang Xiaojun, Li Wenqing. Supply chain concentration, property rights difference and earnings transparency, Journal of Technical Economics, Vol. 40 (2021)No. 1, p.107-117.

[29] Tao Ketao, Zhang Shudan, Zhao Yunhui. What determines the performance of government public health governance? Research on linkage effect based on QCA method, Management World, Vol. 37 (2021)No. 5, p.128-138+156+10.

[30] Yuan Feifei,Xie Yongzhen. Entrepreneurs' risk-taking tendency, regional risk-taking spirit and firm innovation: A moderated mediation model, Science and Technology Progress and Countermeasures, Vol. 39 (2022)No. 9, p.83-93.

[31] Du Yunzhou, Liu Qiuchen, Chen Kaiwei, et al. Multiple models of business environment ecology, total factor productivity and urban high-quality development: Configuration analysis based on complex system view, Management World, Vol. 38 (2022)No. 9, p.127-145.

[32] Dul J. Necessary condition analysis (NCA) logic and methodology of “necessary but not sufficient” causality, Organizational Research Methods, Vol. 19 (2016)No. 1, p.10-52.