

Exploring the Influencing Factors of Digital Transformation Effectiveness of Specialized and Sophisticated SMEs

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Abstract: *Digital transformation is a significant strategy for enterprises to implement long-term business growth and high-quality development. This paper identifies the factors affecting the effectiveness of digital transformation of specialized and sophisticated SMEs; explores the configuration path of the six antecedent factors that jointly drive the enterprise to achieve high-effective digital transformation by using fuzzy-set qualitative comparative analysis. The findings illustrate no single factor can be a necessary and sufficient condition for the formation of the outcome variable; There are three main configuration paths that lead to a high-impact corporate digital transformation, which can be categorized as total factor driven, organization-environment oriented, and organization-environment dominated. As the most energetic and high-quality group of SMEs, Specialized and sophisticated SMEs plays an exemplary leading role in the direction of digital transformation. Therefore, the research sample in this paper is representative and provides some reference indicators for the government to formulate support policies, and also enlighten the thinking of other small and medium-sized enterprises on digital transformation. In addition, this paper explore concludes the key factors and configuration paths that influence the transformation effectiveness of Specialized and Sophisticated SMEs, which could provide practical guidance for managers to formulate digital transformation strategies and paths.*

Keywords: Digital Transformation, Specialized and Sophisticated SMEs, fuzzy-set qualitative comparative analysis(fsQCA), TOE Theory.

1. Introduction

With the vigorous development of digital technologies such as artificial intelligence, Internet of Things, cloud computing and big data, digital transformation has become an inevitable requirement for the development of digital economy, a necessary path for enterprises to achieve high-quality development, and an essential manifestation for enterprises to realize long-term development through technological innovation. Specialized and sophisticated SMEs refer to small and medium-sized enterprises with specialization, refinement, differentiation and innovativeness, which usually have unique technical advantages and market positioning, and are able to provide high-quality services and products concentrated in a certain segmented field [1]. Therefore, as the most dynamic and high-quality group within SMEs, the direction of digital transformation of specialized and sophisticated SMEs is representative and plays an exemplary leading role. Against the backdrop of the severe and complex domestic and international economy, Specialized and sophisticated SMEs with strong innovation ability can make technological breakthroughs and market development around the key aspects of the major industrial chain, which can effectively solve the "bottleneck" problem and play an important role in improving the resilience of the industrial chain and the supply chain. Therefore, it can be seen that specialized and sophisticated SMEs empowered by digitalization are an effective way to enhance the competitiveness of China's advanced manufacturing industry, and is of great significance in leading small and medium-sized enterprises to achieve efficient transformation.

Enterprise digital transformation refers to the process of innovation and upgrading through the introduction and application of intelligence technologies to optimize all aspects of enterprises. With the rapid development of emerging

digital technologies, the diversification of consumer demand and the fierce competition in the global market, companies are undergoing profound changes in their production, operation and management modes. Digital technology empowers all parts of the organization, laying the foundation for efficient operation and transformation, providing new tools and platforms, and then driving the digital transformation of companies to meet the personalized needs of consumers and improve their core competitive advantages to cope with market risks and challenges. Therefore, if specialized and sophisticated SMEs could effectively use digital technology to promote high-effective digital transformation, they can not only enhance their competitiveness, but also occupy an advantageous position in the unstable external environment and market competition, achieving long-term development of enterprises. However, specialized and sophisticated SMEs are facing a lot of problems and challenges in the process of digital transformation, including insufficient continuous innovation capability, mismatch of employees' digital capability, inadequate financial security and business environment to be improved, etc. Consequently, it can be argued that digital transformation is a systematic change for enterprises, which is not simple, and the effectiveness of its transformation is attributed to a number of factors, which requires finding key factors affecting the transformation of enterprises from multiple dimensions.

There are a few researches in academics on the sub-segment of digital transformation of specialized and sophisticated SMEs, and the existing results mainly focus on the paths and modes of their digital transformation [2,3], which lacks a systematic analysis of the determinants of high-performance transformation. This paper takes the specialized and sophisticated SMEs of 20 digital transformation pilots of the Ministry of Industry and Information Technology of China as the research object, uses the fsQCA method to construct the

research framework from the three dimensions of technological, organizational, and environmental, explores the factors affecting the effectiveness of their digital transformation, so as to obtain the high-performance configuration, which can provide insights for the digital transformation of other small and medium-sized enterprises.

2. Literature Review

2.1 Digital Transformation

Domestic and international research on the connotation of digital transformation is relatively rich, we divide the digital transformation described in the relevant literature into three perspectives: First, based on the technology perspective, digital transformation is regarded as an organizational change triggered by the use of digital technology, and the all-around change initiatives taken by enterprises based on digital technology can create opportunities or avoid losses; Second, based on the organizational perspective, digital transformation is defined as a transition of the organization from the traditional type to the digital management mode, the ultimate goal is to build a data-centric value creation system and achieve the transformation process of the company business model; Third, based on the strategic perspective, digital transformation is viewed as the process of continuous strategic updating of the corporate, which constantly changes the organizational model, culture, management and other aspects of the enterprise through digital technology. This paper organizes them as shown in Table 1.

The level of digital transformation is the result of long-term integration that is unique to the enterprise and positively contributes to its development, so it matches the view of resource-based view that "value, scarcity, imitability and

irreplaceability are the necessary conditions for an enterprise to obtain competitive advantage". Therefore, by combing and summarizing the literature, this paper defines enterprise digital transformation as: Digital transformation is based on the enterprise's all-round strategic change in products and services, human resources, customers and operational processes, etc., Company use digital technologies that are appropriate to their development to improve organizational business processes and operational efficiency, reshape organizational structure and business models, and then achieve increased customer value and corporate performance growth.

With the gradual attention and cultivation of specialized and sophisticated SMEs in China, scholars begin to explore related digital transformation research. Zhu (2023) illustrates the necessity of digital transformation of specialized and sophisticated SMEs from four aspects: meeting the challenges of the times, reducing costs and increasing efficiency, intelligent manufacturing, and refined features [10]; Other scholars attribute the problems faced by the digital transformation of specialized and sophisticated SMEs from different perspectives, ranging from insufficient corporate cognition of digital transformation [2] to weak technological infrastructures and shortage of core digital professionals[11] to poor digital management level [12] and many other aspects.

2.2 Digital Transformation Effectiveness

The purpose of corporate digital transformation is to achieve value growth and sustain long-term development. By reviewing the literature, this paper classifies the positive effects of digital transformation into three aspects: achieving cost reduction and increase efficiency, improving corporate performance, and enhancing organizational innovation, which are shown in Table 2.

Table 1: Definition of digital transformation in the existing literature

Perspectives	Author	Digital Transformation Connotation
Technology Perspective	Wu et al. (2019)	Digital transformation refers to the business model transition process in which enterprises analyze and utilize the generated data after converting physical products into symbols through the use of digital technologies such as big data, cloud computing, the Internet of Things, and artificial intelligence, thereby improving the efficiency of corporate operations [4].
	Lu and Wang (2021)	Digital transformation is the process of using IT technology as the driving force and data as the core to promote changes in the production and management modes of an enterprise [5].
Organizational perspective	Vial (2019)	Digital transformation is the process of enabling an organization to increase operational efficiency, improve business processes, and reshape value creation by developing digital technologies that match its business [6].
	Wang (2018)	The digital transformation of enterprises drives the integration of digital technologies into the daily operations and management of organizations, which helps to facilitate the flow of information between the market, enterprises and consumers, and helps enterprises to design products and services that meet consumer needs [7].
Strategic perspective	Nambisan et al. (2019)	Enterprise digital transformation requires the deep integration of digital technology and enterprise strategy until the organizational competition mode, business model, business logic and other aspects are changed in continuous iteration [8].
	Pei et al. (2023)	Digital transformation as a strategic choice for enterprises is conducive to building organizational core competencies and achieving higher quality development [9].

Table 2: Existing literature on the effectiveness of digital transformation

Dimensionality	Enterprise digital transformation effectiveness
Cost reduction and increase efficiency	He and Liu [13] argue that enterprises promote the implementation of digital transformation could facilitate the improvement of their business conditions in terms of cost reduction, efficiency and innovation paths.
	Agarwal et al. [14] suggest that digital transformation reduces the cost of information search and improves the effectiveness of business decision making by upgrading the information technology of the organization.
Corporate performance	Yoo et al. [15] conclude that if companies would like to improve their performance levels, it could be achieved by implementing innovative strategies for digital products to create value for consumers during the transformation process.
	Teece [16] depict that digital transformation conducted by companies helps them to flexibly respond to the risk of uncertainty caused by environmental changes, which improves business performance.
Organizational innovation capability	Xie et al. [17] propose that the application of digital technology is able to enhance the efficiency of enterprise innovation and R&D, expand the boundary of value creation, enrich the way of value creation, which contributes to the improvement of cross-border integration capability.
	Based on the perspective of digital empowerment, Chi et al. [18] indicate that SMEs could promote the new product development performance through R&D utilization and exploration capabilities in the process of digital transformation.

Table 3: Key factors affecting the effectiveness of digital transformation in specialized and sophisticated SMEs

Author	Factor	Digital Investment	R&D Investment Intensity	Organizational Culture	Digital Talent Capital	Organizational Dynamics Capability	Internal Financing Capacity	Industry Development Level	Government support	Market competition pressure
Li et al. [20]							√			
Lammers et al. [21]		√		√	√		√			
Jin et al. [22]			√		√			√	√	√
Bonnet et al. [23]		√			√					
Zhang [24]									√	√
Oztemel and Gursev[25]		√	√				√			
Liu [26]		√							√	
Chen et al. [27]						√				√
Llopis-Albert C et al. [28]					√		√			
Hanelt et al. [29]					√	√	√			
Lv [30]		√			√				√	√
Yu Dianfan et al. [31]					√				√	
Ben et al. [32]		√	√	√						
Liu et al. [33]		√	√		√				√	√
Zhang et al. [34]		√	√						√	√
Ma et al. [35]			√		√			√	√	√
Liu [36]			√		√				√	√
Pei et al. [37]		√	√		√		√		√	√
Factor Identity		0.5	0.44	0.11	0.61	0.11	0.33	0.11	0.56	0.44

2.3 Model Construction

The TOE theoretical framework describes the impact of technology application scenarios on effectiveness in different dimensions, and is a comprehensive model for analysis from three aspects: technology, organization and environment [19]. The theoretical model has good utility for analyzing and explaining the influencing factors behind complex phenomena, and thus can provide a reasonable analytical framework for recognizing the driving factors of enterprise digital transformation.

The effectiveness of digital transformation is not only driven by a certain factor or a certain dimension, but is also influenced by the socio-economic, market environment, organizational change and other aspects. If the research only focuses on the impact of a single factor, it is hard to reveal the complex causality of which factors have a high degree of impact on the transformation of specialized and sophisticated SMEs, and it is also impossible to characterize the interdependence and common effect of the relationship between a variety of factors. Therefore, the selection of fsQCA as the research method of this paper possesses rationality. Table 3 presents a summary of the antecedent factors affecting the effectiveness of digital transformation in specialized and sophisticated SMEs.

As shown in Table 3, "digital investment" "digital talent capital" and "government support" have a high impact on the effectiveness of digital transformation of specialized and sophisticated SMEs; "R&D investment intensity" "internal financing capacity" and "market competition pressure" have a moderate impact; "organizational culture" "organizational dynamic capability" and "industry development level" have a low impact on it.

Existing literature points out that the enterprise's digital investment capability has an important role in influencing the effectiveness of organizational transformation, and is also an inherent requirement for promoting enterprise transformation. The higher the level of digital investment in an enterprise, the higher the ability to optimize and iterate its internal operational processes [5], which is conducive to reducing the operating cost; The behavior of encouraging enterprises to

increase R&D investment can facilitate them to realize the transformation and upgrading of digital intelligence [38], and increasing investment in digital and innovation resources not only improves the corporate performance effectively, but also promotes the conversion and integration of resources [39], so the intensity of R&D investment brings about changes in the effect of the transformation of the enterprise; The imperfect digital talent reserve system leads to a serious lack of innovative talents and emerging technology talents on the supply side, which is the main factor affecting the digital transformation of enterprises [40]. Therefore, companies need to have more middle- and senior-level technicians, and improving the digital talent capital of enterprises is conducive to the application and promotion of enterprise digital technology, which has a better role in promoting the effectiveness of the transformation of enterprises; Specialized and sophisticated SMEs require adequate financial support if they intend to effectively push forward the digital transformation process. Compared with external financing, internal financing has lower financing risks and cost advantages, and it is also found that enterprises with higher internal financing capabilities are beneficial to improve the performance level [41], so the capability of companies' internal financing positively affects the effectiveness of digital transformation; The resources and capabilities of specialized and sophisticated SMEs are relatively weak compared with those of large enterprises, and they depend on the external support of the government to achieve digital transformation, and the government can provide support for enterprises through the implementation of helping policies [42]. Therefore, government financial support is an important factor in promoting enterprise transformation; Since market resources are limited, companies in the same industry appear competitive behaviors due to resource scarcity and uneven distribution [2], the competitive pressure of enterprises will propel them to transform in order to maintain their long-term competitive advantages [43]. Therefore, the competitive pressure has a driving effect on the implementation of digital transformation for enterprises to avoid falling behind their peers.

Based on the factor identity analysis and literature combing, this research selects the factors with an identity level of 0.33 and above, divides them according to the TOE theory and

takes them into the configuration analysis. At the technological level, "digital investment" and "R&D investment intensity" are selected as analytical variables; At the organizational level, "digital talent capital" and "internal financing capacity" are taken as analytical variables; At the environmental level, "government financial support" and "market competition pressure" are chosen as analytical variables. Therefore, this paper explores the multi-factor synergistic path of digital transformation effectiveness of specialized and sophisticated SMEs based on the mutual effect of six influencing factors under the "technology-organization-environment" framework. Figure 1 shows the theoretical model framework of this paper.

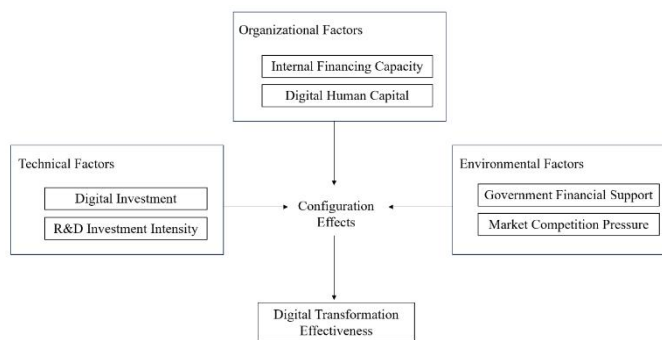


Figure 1: Theoretical model framework

3. Research Design

3.1 Research Method

This paper uses the fsQCA method to explore the configuration effect of factors influencing the digital transformation of specialized and sophisticated SMEs, mainly based on the following reasons: (1) fsQCA focuses on the study of "multiple concurrent causality", multiple paths are composed of different combinations of conditions, and could reveal the complexity and diversity of causality in the real world, which matches the aim of this paper; (2) Compared with regression analysis, fsQCA has the characteristics of non-linearity and non-probability, which can analyze the various configurations under different combinations of the influencing factors, this is hard to be accomplished by the traditional analysis method; (3) This paper takes the TOE theory as a research framework to classify multiple influencing factors into technical, organizational, and environmental dimensions, which is highly compatible with the fsQCA.

3.2 Data Collection

In order to ensure sufficient homogeneity of the overall cases and heterogeneity among the cases, this paper follows the case selection principle of the QCA methodology, the sample group is 20 specialized and sophisticated SMEs in the typical cases of enterprise digital transformation posted by the Ministry of Industry and Information Technology of the China. The case selection criteria are as follows: (1) The samples are selected from specialized and sophisticated SMEs scattered in various provinces and regions across the China and covering diverse industries in order to increase the credibility of the study; (2) The annual reports of the sample already disclose the firms' relevant digitalization investment and strategic initiatives for digitalization construction. Among

them, the raw data of the condition variables and outcome variables are mainly derived from the annual reports of the specialized and sophisticated SMEs.

3.3 Variable measurement

(1) Digital Investment (DI). Digital investment involves resource investment in various aspects such as organizational infrastructure construction, technology and innovation capabilities, corporate culture, risk management, and so on. These investments support the establishment of a strong technical support system, enhance the ability of data driven decision-making, and cultivate the establishment of digital cultural awareness, etc. They are the foundation for the formation of competitiveness and also the critical key to the success of enterprise transformation. Following the measurement method of Sun et al. [44], hardware investment and software investment are taken as indicators of corporate digitalization investment, the closing balance of "electronic equipment" in the fixed assets ledger disclosed in the annual reports of listed companies is regarded as the hardware investment, and the closing balance of "software" disclosed in the intangible assets ledger is regarded as the software investment, and the natural logarithm is taken after the two are added together..

(2) R&D Investment Intensity (RD). R&D investment is particularly important for specialized and sophisticated SMEs that take technological innovation as their development strategy. R&D intensity represents a company's R&D capability and its competitive advantage. In accordance with previous measurements, this paper adopts the ratio of R&D investment to main business revenue as a measure of R&D investment intensity.

(3) Internal Financing Capacity (IFC). For specialized and sophisticated SMEs, stronger internal financing capability could reduce the enterprise's dependence on external financing, and minimize the risks caused by exogenous financing. Meanwhile, companies are able to decide more flexibly on the direction of funds and investment, subsequently expanding financial support for digital technology, infrastructure, digital talent training, etc., so as to improve the success rate and sustainability of enterprise digital transformation. Therefore, according to the research method of Duan [45], this paper takes the ratio of net cash flow from operating activities to three-year average total assets as a measure of the firm's internal financing capability.

(4) Digital Human Capital (DHC). Digital talents have a more important impact on enterprise transformation, these human capitals determine the application and promotion ability of enterprise technology, the capability of problem solving and innovation, and are the main driving force for organizational change. Their ability to continuously learn and adapt quickly ensures that companies can keep up with technological changes and rapid market developments, playing an indispensable role in the corporate digital transformation. Therefore, this paper takes the ratio of R&D personnel with technical skills to total employees as a measurement basis.

(5) Government financial support (GOV). It could alleviate the financing pressure of specialized and sophisticated SMEs

and decrease the financial risks incurred by the companies due to digital transformation, which plays the function of sharing the financial pressure for the enterprises, thereby enabling the enterprises to have more energy to devote themselves to the work related to the digital transformation, and guaranteeing the implementation effect of the transformation. Therefore, this paper refers to the measurement method of Wu et al. [46], it takes the ratio of local financial investment in science and technology to general public budget revenue as a measure of the intensity of government financial support.

(6) Market competition pressure (MKT). It could compel enterprises to accelerate the search for innovation to maintain their competitive advantages, and also promote the implementation of initiatives such as improving efficiency and reducing costs in order to cope with market competition, and then provide better products and services to meet market demand and achieve better transformation results. Based on the measurement method of Zhang et al. [47], this paper utilizes the improved entropy method to assign the composite index of accounts receivable turnover rate, inventory turnover and sales profit margin as an index to measure the competitive pressure in the market.

(7) Digital Transformation Effectiveness (DTE). The primary purpose of corporate digital transformation is to improve the operational efficiency, reduce costs and increase revenues.

Therefore, digital transformation effectiveness could be measured by the performance level and financial conditions of the company. Financial data has the characteristics of quantifiable and comparable, which could quantitatively evaluate the impact of digital transformation on the enterprise and be able to understand the relative position of the enterprise's digital transformation in the industry. Return on Equity (ROE) and Return on Assets (ROA) comprehensively reflect the profitability and asset utilization efficiency of an enterprise, demonstrate the return on investment and reveal the efficiency of business operations, which provide a reference basis for enterprise decision-making. Based on the measurement method of Sun [48], this paper adopts the sum of ROA*41% and ROE*59% as an indicator of the digital transformation effectiveness. The summary of measurement criteria is shown in Table 4.

3.4 Data Calibration

In this paper, the direct calibration method is adopted to calibrate the data into fuzzy sets, referring to the calibration method of Fiss [49], and according to the actual situation of the case, this research sets the three thresholds of full affiliation, intersection, and full non-affiliation to 0.75, 0.5, and 0.25 respectively, and the specific calibration anchors for each variable are set as shown in Table 5.

Table 4: Variable measurements

Variable Type	Variable Name	Variable Symbol	Calculation Method
Outcome Variable	Digital Transformation Effectiveness	DTE	Weighted approach to ROA and ROE
Antecedent Variable	Digital Investment	DI	Natural logarithm of the sum of the closing balance of "electronic equipment" and the closing balance of "software" in the annual report
	R&D Investment Intensity	RD	Ratio of R&D investment amount to main business revenue
	Internal Financing Capacity	IFC	Ratio of net cash flows from operating activities to corporate 3-year average total assets
	Digital Human Capital	DHC	Ratio of R&D staff with technical skills to total employees
	Government Financial Support	GOV	Ratio of local financial investment in science and technology to general public budget revenue
	Market Competition Pressure	MKT	The comprehensive index of accounts receivable turnover rate, inventory turnover and sales profit margin are calculated by using the improved entropy method

Table 5: Data Calibration and Descriptive Statistics

Variable	Calibration			Descriptive Analysis			
	full affiliation	intersection	full non-affiliation	Average Value	Standard Deviation	Minimum value	Maximum value
Digital Transformation Effectiveness (DTE)	0.09	0.06	0.01	0.03	0.22	-0.64	0.57
Digital Investment (DI)	19.04	18.15	17.37	18.40	2.04	15.20	25.41
R&D Investment Intensity (RD)	0.13	0.07	0.04	0.10	0.10	0	0.42
Internal Financing Capacity (IFC)	0.14	0.03	0	0.05	0.09	-0.12	0.18
Digital Human Capital (DHC)	0.42	0.26	0.15	0.30	0.17	0.10	0.59
Government Financial Support (GOV)	0.20	0.09	0.06	0.14	0.11	0.01	0.35
Market Competition Pressure (MKT)	2.97	2.34	1.21	2.68	1.89	0.57	8.27

4. Results

4.1 Necessary Condition Analysis

The purpose of the necessary conditions analysis is to test

whether the condition variable is necessary for the outcome variable, which examines whether cases with the same outcome have consistent antecedent conditions. Therefore, individual factors are analyzed for necessity prior to the configuration analysis. Referring to the research method of Du and Jia [50], a consistency level higher than 0.9 is usually

judged to be necessary for the generation of the outcome variable. In this paper, fsQCA3.0 software is utilized to analyze the data for necessity analysis, and the research results are shown in Table 6. The consistency level of all conditional variables is below 0.9, It is evident that no single pre-factor is a necessary condition for the generation of outcome variables, indicating that there is not only one

influential factor that makes the digital transformation of specialized and sophisticated SMEs effective, but the result of the interaction of multiple influential factors. The data results prove that the factors affecting the effectiveness of corporate digital transformation are intricate and diverse, which confirms the necessity of this paper to use the configuration analysis method to carry out research.

Table 6: Analysis results of necessary conditions

Variable	Implication	DTE		~DTE	
		Consistency	Coverage	Consistency	Coverage
DI	High Digital Investment	0.59	0.58	0.66	0.62
~DI	Low Digital Investment	0.53	0.52	0.73	0.72
RD	High R&D Investment Intensity	0.44	0.46	0.75	0.76
~RD	Low R&D Investment Intensity	0.70	0.64	0.62	0.57
IFC	High Internal Financing Capacity	0.82	0.79	0.58	0.50
~IFC	Low Internal Financing Capacity	0.28	0.28	0.76	0.82
DHC	High Digital Human Capital	0.43	0.42	0.78	0.78
~DHC	Low Digital Human Capital	0.72	0.69	0.57	0.52
GOV	High government financial support	0.64	0.60	0.74	0.68
~GOV	Low Government Financial Support	0.48	0.49	0.65	0.65
MKT	High Market Competitive Pressure	0.72	0.68	0.54	0.59
~MKT	Low Market Competitive Pressure	0.40	0.40	0.87	0.74

4.2 Configuration Analysis

In this study, the case frequency threshold is set to 1, and the consistency threshold is set to 0.8, and the core and edge conditions that affect the effectiveness of enterprise digital transformation are identified by comparing the simplified solution with the intermediate solution. The presence of a core condition is symbolized by ●, the presence of an edge condition is symbolized by ●, the absence of a core condition is symbolized by ⊙, the absence of an edge condition is symbolized by ⊙, and a blank space is indicated as the variable can be present or absent. The details are depicted in Table 7.

Table 7: Analysis results of highly effective configuration for digital transformation of specialized and sophisticated SMEs

Antecedent conditions	High digital transformation effectiveness				
	H1a	H1b	H2a	H2b	H3
DI	●	●	⊙	●	
RD	⊙	●		⊙	⊙
IFC	●	●	●	●	●
DHC		⊙	●	●	●
GOV	⊙	●	●		●
MKT	●	⊙	●	●	●
Consistency	0.91	0.99	0.98	0.91	0.98
Original Coverage	0.24	0.10	0.22	0.14	0.20
Unique Coverage	0.15	0.05	0.07	0.01	0.01
Overall Consistency	0.95				
Overall Coverage	0.50				

According to the results, the overall consistency of enterprise digital transformation configuration is 0.95, and the consistency of each single configuration path is much higher than 0.75, suggesting that 95% of the sample cases that meet

the three configuration paths achieve high digital transformation effectiveness, and that all of these configurations are sufficient conditions for the digital transformation of specialized and sophisticated SMEs. In addition, as shown by the overall coverage of the configuration paths, each path has a strong explanatory power, which collectively explains the influencing factors of corporate digital transformation effectiveness. Further detailed analyses of the configuration paths are developed as follows.

Configuration I: Total factor driven. Because the core conditions of H1a and H1b are the same, they form a second-order equivalent configuration and merge into one path. According to H1a, without government financial support, no matter whether an enterprise has high digital human capital or not, it can realize mutual synergy among factors through investment in its digitization, improvement of internal source financing ability, and supplemented by certain market competition pressure, so as to promote the efficient transformation of enterprise digitization. From H1b, when specialized and sophisticated SMEs do not have digital talent capital and market competitiveness, it is possible to affect the proportion of investment in digitalization and the intensity of R&D investment through the government's financial support and the enhancement of the organization's internal financing capacity, resulting in higher digital readiness of the enterprise, and thereby promoting the high-effective transformation. The difference between H1a and H1b illustrates that government financial support and market competition pressure have a certain substitution. Companies have higher government support, such as a variety of subsidies, preferential policies, etc., which can reduce the cost of digital transformation, so that companies have more resources to invest in key aspects like technology development and innovation. Meanwhile, government support also assists enterprises in better

understanding and responding to market changes, and improve their strategic decision-making ability; In an environment of high competitive pressure, companies are able to raise funds through their internal financing capabilities and increase their investment in digitalization, so that they can optimize the quality of their products or services through continuous innovation, enhanced efficiency, and cost reduction, and thus achieve a highly effective transformation.

Configuration II: Organization-environment oriented. From H2a, with the lack of digital investment, corporates promote the effectiveness of enterprise transformation through the synergistic effect of internal financing capacity, digital human capital, government financial support and market competition pressure. From H3, if companies do not have a high level of R&D investment, they can smoothly transform themselves through the synergy of internal financing capacity, digital human capital, government financial support and market competition pressure. Both H2a and H3 are the transformation paths of technology-deficient enterprises, so they are named "organization-environment oriented", which indicates that many specialized and sophisticated SMEs do not have technological advantages in digital transformation due to their smaller scale and financial constraints, it emphasizes the importance of the interaction between organizational and environmental factors for the success of the corporate transformation. Without technical factors, corporations need to acquire more capital and technical talents to compensate for technological deficiencies. Therefore, corporations with higher internal financing capacity and digital human capital better meet and respond to the financial needs and risk challenges in the process of digital transformation, so as to strengthen the transformation effectiveness. In addition, the government's financial support is able to provide funding, policy and other support; market competition pressure could incentivize enterprises to accelerate the progression of digital transformation in order to maintain their own competitive advantage. To sum up, all these factors can offset the lack of technology and have a positive impact on business transformation.

Configuration III: Organization-environment dominated. From H2b, it is known that the companies are in the environment of higher market competitive pressure, but the intensity of R&D investment is not sufficient, so they can achieve the efficient corporate transformation through the interaction between digital investment, internal financing capacity and digital human capital. Therefore, this kind of synergistic effect with organization and environment as the core elements and technology as the complementary element is named as "organization-environment dominated". It demonstrates that despite the lack of R&D investment intensity, specialized and sophisticated SMEs can improve their operational efficiency and customer experience through digital investment, such as utilizing digital technology, purchasing external digital tools and platforms, or cooperating with technology providers; Meanwhile, the companies are able to obtain financial support through their internal financing capability, so that they can conduct talent training and knowledge sharing to enhance the digital skills of their employees, which provide the specialized and sophisticated SMEs with the resources and capabilities required for transformation; In addition, the pressure of market

competition could stimulate the companies' transformation motivation, prompting them to explore transformation more actively, combined with the mutual influence of technological and organizational factors, which contribute to improving the effectiveness of the corporate transformation.

4.3 Robustness Check

In this research, the robustness test is performed by changing the consistency threshold and adjusting the calibration thresholds. Increasing the consistency threshold from 0.8 to 0.85, and keeping other operations unchanged, the results show that the configuration paths are basically consistent, and the path parameters have not been substantially changed; Using different full affiliation thresholds, intersections, and full non-affiliation thresholds for the antecedent and outcome conditions, increasing the calibration thresholds for the antecedent conditions to 95%, 50%, and 5%, with other operations remaining unchanged, the results suggest that the configuration paths and parameters have not been substantially changed. Therefore, the findings of this paper are stable.

5. Discussion

Firstly, this paper reviews the literature on the connotation and effectiveness of digital transformation, and summarizes the key factors that impact the success of corporate digital transformation. Secondly, it constructs a theoretical modeling framework; Finally, three paths are obtained through configuration analysis, so as to propose the research conclusions and practical enlightenment.

5.1 Conclusion

Based on the TOE theory, this paper explores the critical factors affecting the transformation effectiveness of specialized and sophisticated SMEs from the three dimensions of technology, organization and environment, and analyzes the corporate digital transformation paths in different configuration conditions. The research conclusions are as follows:

Through the analysis of necessary conditions, it is concluded that the achievement of highly effective digital transformation of enterprises is not driven by a single influencing factor, but rather by the synergistic interaction of multiple key factors. This also proves that corporate digital transformation is a systematic change, and its complexity determines that the driving factors of corporate transformation are characterized by diverse and interactive effects.

It is derived from the configuration analysis that the different combinations of the six influencing factors form three equivalent paths for enterprise digital transformation. Based on the similarities and differences of the core and edge conditions in each path, they are categorized into three types of transformation paths to achieve high corporate effectiveness: total factor driven, organization-environment oriented, and organization-environment dominated.

In the total factor driven path, specialized and sophisticated SMEs can achieve efficient transformation through the

synergy of digital investment, internal financing capacity and market competition pressure, and they can also be driven to transform through government financial support, internal financing capacity, digital investment and R&D investment intensity. It indicates that government financial support and market competition pressure are alternative; In the organization-environment oriented path, if an enterprise does not have the building capacity related to technological factors, such as information systems, infrastructure, R&D investment required for digital transformation, it is possible to cover the risks caused by lack of technology through the interactions of internal financing capability, digital human capital, governmental financial support, and market competition pressure, so as to achieve an improvement in the effectiveness of the transformation; In the organization-environment dominated path, specialized and sophisticated SMEs can achieve efficient transformation through the synergy of digital investment, internal financing capability and digital human capital in an environment of high market competitive pressure, even if they lack the intensity of R&D investment.

5.2 Implications

In the process of digital transformation, specialized and sophisticated SMEs need to accurately measure their scale size, financial level, operational capability, market position, core competitiveness and etc., and formulate a transformation path that is consistent with their own development. For example, under the situation of lack of technological capabilities, enterprises should focus on the interaction of organizational and environmental factors, and they can adopt an organization-environment oriented path to help them transform smoothly; If the enterprise has certain digital technology capability, it can take the organizational-environmental dominated path to achieve highly effective transformation through the mutual effects of market competition pressure, internal financing capability and digital human capital; If an enterprise has certain competitiveness in the market or receives more financial support from the government, it can select the total factor driven path to realize efficient transformation through the joint impacts of digital investment, internal financing capacity, market competition pressure, and government financial support. Therefore, companies should pay full attention to the interaction of influencing factors in technology, organization and environment when formulating strategies for digital transformation.

In addition, for the government, it should focus on supporting and guiding the digital transformation of enterprises. Specialized and sophisticated SMEs in the early stage of digital transformation are prone to face difficulties in capital turnover, technological deficiency and other issues, the government could help companies through financial support, technical guidance, and promoting resource sharing, ultimately enhancing the effectiveness of corporate digital transformation with the co-action of enterprises and the government.

6. Limitations

The limitations of this paper include: Firstly, the small size of the sample. In the case of pilot enterprises' digital transformation in China, because of the unavailability of

financial data in some enterprises, the research sample selected in this paper is 20 specialized and sophisticated SMEs with public financial reports. In future research, more sample could be acquired to deeply analyze the influencing factors affecting enterprise transformation and the configuration path. Secondly, more influencing factors are possible. Based on the TOE theory, this paper selects six influencing factors under three dimensions as the research object, but there are actually many potential factors affecting the effectiveness of enterprise transformation. In future research, additional influencing factors can be identified and analyzed to further explore the configuration effects.

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